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Investigating Changes to First Year, First-Generation Students' Visual Thinking and Learning in an Academic Success Course

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Abstract

This mixed-methods case study investigated changes to first year, first-generation (FYFG) college students' visual thinking and learning while enrolled in a 15-week academic success course (ASC) with a focus on meta-learning. The researcher found that a 5-week meta-learning intervention within the ASC helped six focal participants enact changes to support their visual thinking and learning processes. Focal and class participants integrated a number of metacognitive strategies into their learning, such as writing notes in their own words (e.g., voice), monitoring their understanding, drawing ideas in their notes, and visualizing new ideas to support their learning. As focal participants applied these strategies more over the course of the semester they began to develop metacognitive knowledge and skills for their learning. As a result, focal participants learned about themselves as visual thinkers and learners, specifically how they learned best. Six 'changes' are discussed as well as participants reports of improved academic performance and learning, feelings of empowerment, confidence, and control over their learning. Additionally, class participants saw a significant increase in metacognitive awareness, and 21 of 24 class participants reported positive metacognitive gains as measured by the metacognitive awareness inventory (MAI). Considerations are given to integrating metacognitive and meta-learning objectives into traditional curriculum as well as developing first-year interventions that support first-generation students' academic success and life-long learning capabilities.

Dedication

Thank you to my incredible wife, Emma, who managed the long days and nights, and the ups and downs of these last several years. You supported me in so many ways and I will spend the rest of my life showing you how much you are appreciated. We made it through and even had our beautiful baby boy in the process! I'm so blessed to have you and Bodie in my life. I like you and I love you. And to my parents, Tom and Paula, thank you for the unconditional love, the support, the advice, and the ability to pursue my dreams. I couldn't have done this without you. I love and appreciate you both so much. This is all our achievement.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

This study examined the thinking and learning of a group of first-generation college students, most of which identified as minorities, in an academic success course (ASC) their first year in college. Students with parents who did not receive a four-year college degree (i.e., "first-generation") face a myriad of personal and institutional challenges when entering college that can negatively impact their academic performance and completion of a college degree (Bui, 2002; Choy, 2001; Coffman, 2011; Pascarella et al., 2004; Redford et al., 2017; Sirin, 2005). Educational research on first-generation students points out how many arrive to college academically underprepared (Atherton, 2014; Cataldi et al., 2018; Engle & Tinto, 2008), lack confidence in their abilities and skills (Cushman, 2007; Robinson, 1996; Reid & Moore, 2008; Tao, 2021), and struggle to integrate into college life (Parnes et al. (2020); Schwartz et al., 2016; Aspelmeier et al., 2012; Collier & Morgan, 2008; Ward et al., 2012). Additionally, first year students have been shown to possess ineffective and limited strategies/skills to support thinking and learning in college (Allgood et al., 2000; Antonelli et al., 2020, Heikkilä et al., 2011; Schraw et al., 2006). As a result, the researcher of this study helped to co-design and co-teach the curriculum of the academic success course with a focus on supporting first year, first-generation students' academic learning and life-long learning capabilities.

Literature suggests impediments to academic learning and higher order thinking skills are tied to the rote memorization techniques (e.g., copying teachers' notes) taught and relied upon in K-12 schools (Cook et al., 2013; Karpicke et al., 2009; Muteti et al., 2020; Taraban et al., 1999; Zhao et al., 2014) which can create an academic 'mismatch' when first-generation students get to college (Wahleithner, 2020). Because of this misalignment first-generation students have reported not feeling prepared for the demands of college academics, particularly in science-based disciplines (Athanases et al., 2016; Reid, 2007; Reid & Moore, 2008). Ferguson (2008) argues that the achievement gap between groups of students is not the result of differences in abilities or affective dispositions (e.g., perseverance) but rather differences in the academic skills developed in public schools.

First year programs/interventions designed for FGCS can assist the transition to college by providing academic resources (e.g., strategies, skills, dispositions) as well as socialization opportunities, that mitigate achievement/preparedness gaps and support well-being (Atherton, 2014; Deng et al.; 2022; Dennis et al., 2005; Perna, 2002; Stebleton et al., 2014; Thayer, 2000). However, some practitioners argue that colleges too often frame challenges as resource-based deficits and overlook the cultural misalignment that occurs when these students step foot on a college campus (Bensimon, 2012; Chang & Wang, 2019; Castillo-Montoya & Ives, 2021; Yee, 2016). Stephens et al. (2012) for example, described the challenges FGCS experience when trying to balance their own interdependent (communal) values and the autonomous norms. For FGCS, the *cultural mismatch* between interdependent and independent norms, can contribute to a number of unfavorable outcomes, such as lower academic performance, help-seeking avoidance, heightened perceived difficulty of learning tasks, and greater academic stress (Stephens et al., 2012; Stephens et al., 2014a; Stephens et al., 2014b). Ives and Castillo-Montoya (2020) suggest educators should work to understand first-generation students' lived experiences to provide supports that structure academic learning within a broader sociocultural and historical context. Classrooms that frame students' experiences as a strength recognize the cultural knowledge, skills, motivations, relationships, and abilities they have upon entry to college (Yosso, 2005). Such strengths-based approaches have shown to be equitable and effective ways to engage students in their own academic learning and thinking (Castillo-Montoya & Ives, 2021; Schademan & Thompson, 2016; Yosso, 2005).

Meta-learning has scarcely been discussed as an avenue to improve the academic learning of first-generation students, though it's been highlighted as an equitable way for non-traditional students to develop metacognition (Bamber, 2005; Bamber et al., 2006). In this study, meta-learning is conceptualized as *learning about one's thinking and learning*. Metacognition refers to *language used to think about one's thinking*. Importantly, the process of meta-learning requires the development of metacognition for one's learning. Those who study and utilize metacognitive strategies in the classroom, understand how impactful it can be to student groups from all backgrounds. For instance, Saundra McGuire (2021), college educator and author of peer reviewed articles/books detailing the benefits of metacognitive strategies, proclaims the United States has a metacognition equity gap; "I posit that it is the gap in metacognitive strategies that contributes most to the persistent achievement gap and that all students must be taught how to learn (p.69)." Meta-learning is centered on becoming aware of oneself as a learner and taking control of one's learning (i.e., developing metacognitive knowledge and regulation for learning) (Biggs, 1985; Jackson, 2004). Facilitating metacognition in the classroom is one of the most effective ways to engage college students in a process of deeper learning (Rickey and Stacy, 2000; Cooper & Sandi-Urena, 2009; Delvecchio, 2011) and higher order thinking (Cook et al., 2013; Flavell, 1979, Rickey and Stacy, 2000; Sandi-Urena et al., 2012).

Although, programs exist for first year, first-generation students to boost their academic learning, none to date focus specifically on, a) building learning communities, and b) facilitating meta-learning through a neuroscience framework. As previously mentioned, first-generation students can benefit from programs that connect their lived experiences with their academic learning (Ives and Castillo-Montoya, 2021). Meta-learning from a neuroscience perspective, provides fruitful ground to integrate previous learning experiences within a broader context of how the brain functions. Such discussions may help to cultivate ongoing dialogue and reflection about the types of strategies that work best for each student's learning.

Furthermore, Arwood (2011) suggests most students today (95% or more) are visual learners, meaning they learn language-based concepts by, 1) processing new ideas through overlapping visual and motor patterns, 2) mentally 'seeing' the ideas form, and 3) layering concepts with language to develop and scaffold learning. If most learners are indeed visual learners, programs meant to support academic learning for first-generation students, should consider teaching first-generation students how to better utilize their visual thinking and language to improve academic learning.

Consequently, this study investigates 1) whether FYFG students use visual thinking to process auditory concepts, 2) how FYFG students understand their learning and thinking when entering college; 3) what strategies they utilize to support thinking and learning when entering college, and 4) what changes occur to their visual thinking and learning when engaging in an academic success course. The researcher follows first-generation students during their first semester in college as they engage in a course-curriculum that supports meta-learning through, a) integration of prior experiences with learning (i.e., strengths as opposed to deficits approach), b) building of learning communities, c) application of metacognitive strategies, d) journaling for reflective thinking, and d) discussion of visual thinking and learning (from a neuroscience framework).

The Role of Metacognition in Relation to First Year University Students

In Flavell's (1979) seminal research on human development, the term metacognition was used to describe how school children acquire "knowledge and cognition about cognitive phenomena" to progress in educational contexts (p. 906). Educational research has corroborated that metacognition can be explicitly trained and/or embedded in educational curriculum and is learnable in children (Schneider & Pressley, 1997) as well as adolescents (Veenman et al., 2005). Baker and Brown (1984) differentiated metacognition into two categories, 1) 'knowledge about cognition', which they described as a *monitoring* process, and 2) self-regulative mechanisms, including planning and evaluation, that utilize the monitoring process. To possess metacognitive *skill* as a learner is therefore dependent on procedural knowledge of one's learning processes, represented by the *active* monitoring and control of optimal strategies, attitudes, and behaviors in relation to goals (Azevedo, 2009; Pintrich, 2004; Van der Stel & Veenman, 2014). The development of metacognitive skill, or what Kluwe (1982) termed *executive processes*, can lead to high conceptual learning gains (Zepeda et al., 2019) and self-regulatory behaviors (Roebers, 2017) that act as strong or main predictors of academic achievement (Azevedo et al., 2010; Ohtani & Hisasaka, 2018; Schneider & Artelt, 2010; Zimmerman, 2002).

Research indicates that the development of metacognition guides positive cognitive and affective dispositions, skills, and behaviors, such as critical thinking (Halpern, 1998; Maclellan, & Soden, 2011; Magno, 2010; Pelton, 2014; Sandi-Urena et. al, 2012; Schraw, 1998), self-efficacy (Tao, 2021), and self-regulated learning (SRL) (Effeney et al., 2013; Follmer & Sperling, 2016; Hofmann et al., 2012). Students who possess a propensity for self-regulated learning, are more effective at developing attitudes, behaviors, and strategies (i.e., time-management), that lead to academic resilience and success (Ainscough et al., 2017; (Zimmerman, 2002; Zumbrunn et al., 2011). Self-regulated learners, according to Zimmerman

(2013), are those students who are “metacognitively, motivationally, and behaviorally active participants in their own learning process” (p. 137).

Developing metacognition for learning allows one to intentionally direct and manage cognition toward the completion of a learning task (Sinatra & Pintrich, 2003), which can bolster academic performance and higher-thinking abilities (Ku & Ho, 2010; Maclellan & Soden, 2011; Pelton, 2014; Rezvan et al., 2006). However, not all students develop metacognitive knowledge or skills independently (De Jager et al., 2005; Hargrove, 2007). K-12 education primarily focuses on rote learning (Bunch, 2013) (i.e., memorization of discrete concepts), rather than showing students how to think and learn with concepts. As a result, first year students in higher education may not be knowledgeable of their learning and thinking processes nor strategic ways to engage with disciplinary knowledge for learning (Cassidy, 2007, Reeves & Stich, 2011; Tao, 2021; Willingham, 2009). Many first year students get weeded out of STEM programs for instance, because they utilize ineffective learning strategies that focus more on rote memorization rather than strategies that promote higher order thinking (Muteti et al., 2020). Researchers have suggested metacognitive strategies be taught to students early in their programs of focus, because these strategies can optimize student learning (Halpern, 1998; Mutambuki et al., Muteti et al., 2020, 2020; Lawson et al., 2021; Schraw & Dennison, 1994).

Cognitive Processing Models and Disengagement From Learning

Metacognition is primarily developed in educational contexts which focus on meta-learning (Mytkowicz et al., 2014; Pelton, 2014) and through epistemic activities which focus on ‘reasoned ways of knowing’ in relation to task demands (Maclellan & Soden, 2011). Such learning environments promote an awareness of students’ thinking and learning (Rezvan et al., 2006), helping them become more independently self-reflective (Biggs 1985; Winters, 2011).

However, higher education still employs the didactic model or *lecture* as the primary form of instructional method, despite extensive findings of its limited impact on student learning (Schmidt et al., 2015; Stains et al., 2018). The cognitive processing framework that scientifically buttresses didactics in higher ed curriculum design, has historically viewed the learner as a "mechanistic (unconscious and/or unembodied) processor of information" (Ellis, 2008, p. 12)." Cognitive processing models represent learning as a process in which an *input* from the environment is mediated through a *theory of mind* (unseen mental event), invariably influencing an *output* or type of behavior (Jarecki et al., 2020). In this educational framework, knowledge is *transmitted* to students, predominantly as language structures (i.e., key terms) and learning is evaluated, not in its understanding within the students neurobiological learning system, but how well surface-level meanings can be recalled (i.e., rote memorization) (Biggs & Tang, 2009). Consequently, traditional lectures can be uninteresting for both student and teacher alike, and misunderstandings occur often, which can be problematic in required introductory courses, if students disengage from university curriculum (Bernstein et al., 2002).

To confront such negative learning experiences, some university educators have embraced students' *learning styles* (Dandy & Bendersky, 2014; Meyer & Murrell, 2014). The use of learning styles correlates with reliance on cognitive processing methods. Teachers focus on matching a modal input or *instructional style* (i.e., visual, auditory, kinesthetic) with the students' preferred 'learning style' (Newton & Miah, 2017; Pashler et al., 2009). The 'meshing' of these styles is thought to help learners cognitively process (i.e., encode) information more effectively; but to date, there's little evidence to suggest learning styles are beneficial to student learning or academic success (Knoll et al., 2017; Meyer & Murrell, 2014; Newton, 2015; Pashler et al., 2009; Rogowsky, et al., 2015).

Makina (2010) explains that some learners' difficulties in education stem from the restriction of mental representations that allow the mind to conceptualize meaning. Lecture-based methods for instance, press students to process acoustic information into ideas, which often conflicts with the ways their learning systems visually represents concepts and learns language to process meaning (Arwood, 2011). When visual elements such as pictures and drawings are encouraged in the classroom through cognitive processing frameworks, it's often to help students see and process information effectively (Mayer & Massa, 2003), rather than to help students metacognitively 'see' concepts (Arwood et al., 2009; Arwood & Meredith, 2018). Cognitive processing frameworks (i.e., learning styles) can therefore be inaccessible to students in the classroom because they create barriers to students' ability to engage with the learning process (Kirschner, et al., 2006; Kirschner, 2017) and actively construct meaning through visual mental representations or 'mental pictures'.

It's inevitable that learning contexts reflect learning outcomes, which affects learners' development (i.e., critical thinking, agency, problem-solving, metacognition) (Sipos et al., 2008). Alters and Nelson (2002) posit that the ability to develop higher-thinking skills is often circumvented by the processes in which educators teach and evaluate students. University and high school science courses, for instance, focus on teaching and evaluation approaches that promote surface-level processing of concrete ideas, which fails to promote deep learning (Biggs & Tang, 2011; Chin & Brown, 2000). Being metacognitive enhances the students' ability to develop and refine conceptual understandings, but this can be mediated by the students' current understanding of what learning constitutes, given prior conceptions and the epistemic demands of the learning environment (Clark & Schroth, 2010). Because teachers often tell students what to 'know' instead of how to represent their thinking with disciplinary concepts (Clement et al., 1980), students may not understand how to engage with the subject matter (Makina, 2010). Consequently, students often have misconceptions related to the depth of their understandings and may believe that the memorization of surface-level terminology passes for sufficient learning (Horrell et al., 2019). As a result, new students may not encounter instructional methods that facilitate the habits required to develop metacognitive skills (Bok, 2015). Despite unfavorable pedagogy and curriculum, many university educators still expect students to engage in deep conceptual learning, while consciously monitoring their own learning and thinking (Biggs, 1985, Craig, 1989).

The Connection Between Metacognition, Language, and Thinking

Metacognition as a psychological construct according to Piaget and Vygotsky's research on childhood development, is connected to the processes by which children acquire language to represent concepts (Piaget, 1964; Vygotsky, 1986). Since, "the development of concepts and the development of word meanings are one and the same process" the enumeration of semantic relationships between academic concepts represented as language, allows speech to give way to internal, conscious processes of higher order thinking by adolescence (Vygotski & Vygotsky, 1987, p.180). Learning language is consequently, both a neurobiological and socio-cognitive set of learning processes, which is mediated in contexts where teachers' assign meaning to students' perceptions and concepts (Blake, 2021; Robb, 2016).

If language and cognition are interdependent, as developmental literature suggests (Halliday, 1993; Vygotsky, 1978; Vygotsky 1986), and the brain uses language as a cognitive tool for learning, social communication, abstract thinking, and neurobiological function as Arwood (2011) has posited, then metacognition is a higher-level thinking process, where language is used to *think about* or *assign meaning* to one's own thinking. Metacognition thus, denotes an intricate connection an individual has to internal mental representations (Hacker et. Al, 1998; Kluwe, 1982). This connection can include, a) the knowledge one has gained about their thought processes, b) how those thought processes function, and c) affective states resulting from previous experiences (Borkowski et al., 1990; Flavell, 1979; Hacker et. Al, 1998). Consequently, metacognition may develop in humans to provide the basis for elaboration of conceptual understandings, thereby connecting knowledge structures for advanced thinking and social development (Arwood, 2011; Halpern, 1998). Students who are actively metacognitive show the ability to engage with academic tasks internally, to construct and/or reconstruct knowledge about their own learning processes, formations of self, and affective aspects of achievement (Butler & Winne, 1995).

While both educational practitioners and cognitive researchers have agreed that development of students' metacognitive abilities for independent/critical thinking is an ideal academic goal and should be a part of curriculum (Cummings, 2015; Maclellan & Soden, 2011; McKinney, 2007; Pelton, 2014), a practical foundation for metacognitive learning has yet to yield impactful results in North American higher education classrooms. Perhaps as a result, many students in higher education have difficulty demonstrating higher order thinking with disciplinary concepts and using academic language in traditional educational contexts (Pressley & McCormick 1997; Shields and Gredler, 2003). Considering college is the last stop for undergraduates before entering the workforce (or graduate school), it is imperative that students acquire (i.e., monitor and control) their own thinking and learning processes, to help them develop the higher-thinking capabilities that will help them succeed and continue learning (Colthorpe et al., 2018). The World Economic Forum reports that employers of the global market are seeking skills from new graduates that have to do with "the ability to work collaboratively in teams…” and other soft skills such as “critical thinking, problem-solving, attention to detail, and writing… (Sander, 2017).” The development of critical thinking skills (among others) in higher education is consequently linked to beneficial job-related outcomes (Arum & Roksa 2014).

Acquiring Metacognition for Visual Thinking

Although, educational psychology posits that students need multiple sensory inputs (i.e., kinesthetic, visual, auditory) to process information efficiently, research in neuroscience indicates that people use visual pathways, for forming and representing language-based concepts (Debreczeny; 2019; Gainotti et al., 2009; Gallistel & Matzel, 2013; Klemen & Chambers, 2012). Based on brain research, Arwood (2011) theorizes, that most people have adapted from auditory to *visual systems for learning* (i.e., sound to sight), in part due to changes to dominant inputs (e.g., digital media). Having a visual learning system means the brain functions with language through the layering of visual perceptual or motor perceptual patterns for learning and thinking (Arwood, 2009). People with visual learning systems need visual learning strategies to layer visual semantic-based inputs to ‘see’ their conceptual thoughts (e.g., mental images) to reach higher levels of cognition (Robb, 2006). Mental images (i.e., pictures in the mind’s eye) function as objects of knowledge, allowing people to acquire meaning through interaction with the external world (Pelaprat & Cole, 2011). Visualization strategies that focus solely on external representations (e.g., pictures, models, diagrams etc.) provided by the teacher, are unlikely to help students’ metacognitively ‘access’ and control their reasoning (Gilbert, 2005; Von Wright, 1992). In contrast, educational researchers refer to a ‘meta’ level of visualization in which learners engage in reflective processes of translation, actively constructing and reconstructing knowledge that has been communicated, allowing for a deeper understanding (Georghiades, 2004; Gilbert, 2005; Makarova & Mikhailovna, 2017; Šmajdek & Selan, 2017).

Arwood (2011) posits that students who understand and can use their visual thinking (i.e., thinking in a language of 'mental pictures') are better prepared to engage with academic concepts and develop higher-thinking capacities. However, there is still much we don't know about how prevalent visual thinking is in specific groups of students and how well mental imagery is understood as a source of thinking in learning contexts. More research is needed to understand the relationship between visual thinking and metacognition and whether meta-learning experiences lead college students to implement metacognitive strategies in academic contexts. First-generation students, for instance, face a myriad of academic and socioeconomic challenges when entering college and educators still have little conception of who these students are as 'academic learners' (Ives & Castillo-Montoya, 2020). To support first-generation students in their pursuit of academic and career success it will be important to help them develop ways of learning and thinking that support their social and cognitive development. Meta-learning has been discussed as being an effective and equitable way for non-traditional students to develop metacognition that supports their sociocultural identity (Bamber, 2005; Bamber et al., 2006).

First-generation Students and the Challenges They Face

Students whose parents have not earned a college degree have been classified as *first-generation*. First-generation college students' (FGCS) make-up somewhere between one-fifth and one-third of the national college student body (Harackiewicz et al., 2016; Skomsvold, 2014). Over half of FGCS identify as minorities (Lauff and Ingels, 2013; Saenz et al., 2007), with Hispanics making up 47.8% of all FGCS (Skomsvold, 2014). Growing up with parents that attended college is considered a source of *cultural capital,* valued as the 'knowledge, skills and tools necessary to represent oneself to the dominant culture to succeed' (Bordieu, 1986; Lamont & Lareau, 1988). Acquiring cultural capital has been shown to help FGCS manage the challenges of university life and academics (Collier & Morgan, 2008). However, FGCS have limited cultural capital upon entry to college, which corresponds with a myriad of challenges (Ishitani, 2006; Pascarella et al., 2004; Stephens et al., 2012). The demographic composition of FGCS students (e.g., low socioeconomic background) is correlated with increased risk of poor academic performance (Latino et al., 2020) and college attrition - (e.g., 28% - 35% more than 'traditional' students) (Choy 2001; Ishitani, 2006; Lohfink & Paulsen, 2005; Pascarella et al., 2004; Sirin, 2005; Stephens et al., 2012; Woosley & Shepler, 2011). Hispanic FGCS have the lowest odds of attaining a bachelor's degree among ethnic demographics, at just 18.8% (McCarron & Inkelas, 2006) and are the most likely to drop out after the first two years of college (Lohfink & Paulsen, 2005).

First-generation and Metacognition for Learning

In studying metacognition among first year, first-generation, Tao (2021) found that among the six students who identified as minority, four faced micro-aggressions and/or feelings of isolation, which made it difficult to reach out for help and continue with their studies. These students also experienced feelings of self-doubt, helplessness, and frustration. Metacognition was discussed as a psychological trait that many participants were not able to utilize, but when applied helped bolster self-efficacy and self-advocacy of their learning needs. Franklin et al., (2018) correspondingly showed that effective monitoring and regulation of one's learning among first-generation students, is associated with improved academic success and lower-dropout rates in STEM-related fields. Given that metacognition is not domain-specific - meaning it impacts affective, cognitive, and behavioral elements of human psychology (Schraw, 1998) - it can be extremely useful to introduce to new, especially underrepresented college students to help them overcome a range of academic and social challenges (Cummings, 2015; Mytkowicz et al., 2014, Tao, 2021; De Villiers, 1990*)*. Concurrently, Ives & Castillo-Montoya (2020) remind college educators that it's important to understand who first-generations students are as learners, to better support them based on their lived experiences, rather than measuring them against traditional standards which places the focus on their deficits (e.g., what they don't know). As Maxine Greene (1995) says, "to teach, at least in one dimension, is to provide persons with the knacks and know-how they need in order to teach themselves (p. 14)." If one of the primary goals of higher education is for students to develop a foundation upon which life-long learning and growth can be achieved, then it is imperative that all students be provided opportunities to gain knowledge of their own learning and thinking processes (Boud & Falchikov, 2006; Colthorpe et al., 2018).

Metacognition for Mental Imagery

The Arwood Neuroeducation Model (ANM) posits that 95% of students, in every age group, do not form concepts from sound, but rather use a visual system for learning language-based concepts at the neurobiological level (Arwood, 2011, p.111). Students who use a visual system learn concepts by processing the overlap of visual and/or motor patterns, such as articulatory (i.e., movement and shape of mouth/lips when talking) and/or light-based shapes (e.g., written words) in the environment, which become perceivable mental images or pictures. The mental image is a representation of the students' perceptual processing across sensory modalities (i.e., processed visual and motor patterns) (Arwood & Kaulitz, 2007; Krüger et al., 2020) that serves a key function in the organization and retrieval of verbal and visual thought during learning (Crespi et al., 2016, Sadoski et al. 1991; Sadoski & Paivio, 2013). A students' *imagery* comes in various forms (Arwood et al., 2009; Barsalou, 1999), given individual differences in visuospatial abilities and metacognition (Katz, 1983). For instance, the depth of (metacognitive) knowledge one has attained for their visual ways of thinking is correlated with the creation of highly vivid and accessible pictures (Algozzine & Douville, 2004; Antonietti & Baldo, 1994; De Koning & Van der Schoot, 2013). Students who are attuned to making mental images while reading, have been shown to be more proficient at reading comprehension (Snow, 2002; Hibbing & Rankin-Erickson, 2003).

The internal “knowing” of one’s learning system (or the way one learns to think with concepts mentally) is based in students’ language function (Arwood, 2011). Language that represents one’s thinking, functions to help people (metacognitively) access concepts (i.e., images) from memory, layer conceptual understandings, and plan for future events (Barsalou, 1999; Perlovsky, 2013). Students entering college should possess a full adult grammatic system (words and sentences) to support their thinking and communication but likely need help developing metacognitive knowledge to function with language at a level that allows them to access and refine their thinking and learning processes. For instance, a student who has learned that they can use their language to consciously represent their visual thinking for beneficial academic behavior, can visualize themselves walk into class at a specific time and take out a notebook and pen to get prepared for class.

Some authors in the neuroeducation field have suggested that a worthy educational goal is to explicate the need to transition from auditory methods of teaching English (e.g., phonics) to visual strategies that match the way students process language-based concepts to become literate (e.g., in reading and writing.) (Robb, 2016). Arwood (2011) in particular, contends that all academic learning should be a process of learning about academic concepts while simultaneously learning about how one thinks and learns best. Alt and Guttman (2009) suggest transitioning from auditory methods such as lecture, to opportunities for students to learn in environments that provide visual-spatial information. Such strategies should help students *represent* language-based concepts (cognitively) through mental pictures (Šmajdek & Selan, 2016). The *visualization of* concepts (as mental pictures) in the process of learning, has been shown to promote a) motivation, b) problem-solving, c) conceptual learning, d) representational understandings, e) and construction and retention of knowledge (Cetina, 1999; Latour & Woolgar, 1979; Lynch, 2006; Makina, 2010; Pauwels, 2006; Šmajdek & Selan, 2016). Learning environments that provide 'knowledge of' and 'access to' mental imagery, can be said to promote meta-learning for one's learning and thinking processes. Opportunities for underrepresented students (e.g., most first-generation students) to learn how to learn and self-reflect on their thinking and learning processes, can help them transition from *passive, listener-oriented roles*, to roles that promote self-directed learning (De Villiers, 1990) early in their college careers.

Purpose of Study

The purpose of this mixed-methods study is to investigate how first year, first-generation college students at a private, liberal arts university in the pacific northwest, assess the way they visually think and learn when entering college, and what changes occur to their visual thinking and learning in the context of an academic success course that facilitates meta-learning. In other words, the researcher seeks to understand what meta-learning within a neuroeducation framework contributes to FYFG students' visual thinking and learning. It will be advantageous to higher education research to understand whether FYFG participants identify metacognitive strategies and thought processes that show an understanding of how their neurobiological learning system functions with language. The researcher concurs with Ives & Castillo-Montoya (2020) that most literature examining first-generation students as *learners* has focused on their assimilation to college life, rather than ways of learning that support their individual and cultural growth. Therefore, this research fills a gap, by exploring ways in which FYFG students come to understand their learning and thinking processes in educational contexts to support their conceptual learning and development in higher education.

Research Questions

This mixed-methods study first seeks to establish whether participants, who are first year, first-generation college participants have a visual or auditory learning system (i.e., the neurobiological way they learn concepts). Next, the author will investigate how participants understand their thinking and learning in educational contexts, and what strategies they utilize to support their thinking and learning. The researcher seeks to understand, among other things, how participants metacognitively represent their visual thinking in learning contexts and if they match their way of thinking with optimal learning strategies. The researcher will utilize as qualitative data, participants' language from pre- and post-assessment interviews, as well as class assignments to analyze 'change' during participants' first semester in college. The researcher will also use a validated quantitative measure to assess changes in metacognition, particularly metacognitive awareness of learning, during participants' time in the academic success course.

To substantiate the learning system under investigation, this study will outline a neurobiological basis for conceptual learning in the literature review. To investigate changes to visual thinking and learning seven research questions are considered:

1. What does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition?

2. What changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fourteen of an academic success course?
3. What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?
    a. What do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course?
    b. What do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course?
    c. What do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course.
    d. What meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students' visual thinking and learning?

Answering the Research Questions

There are several stages of analysis, outlined in this section, that must be addressed to carry out a successful investigation of the research questions. The first stage involves examining whether first year, first-generation college students think with a visual or auditory cognition. The second stage of the analysis is focused on investigating, a) students previous experiences with learning, b) what students know about their own thinking and learning, and c) what strategies students utilize to support thinking and learning. At this stage the researcher will explore:

1. participants' explanations of their previous learning experiences.
2. participants' understanding of the ways they learn new concepts.
3. how participants use strategies to learn concepts, e.g., how participants use mental images as a source of thinking and learning.

The third stage of analysis involves investigating language samples from a reflective journal entry and class assignment at the mid-point of an academic success course to identify prominent meta-learning themes. The fourth stage of analysis is focused on comparisons between themes that emerge in the pre-assessment and class activities and themes that *emerge* or *accumulate* by the post-assessment to identify changes to participants' visual thinking and/or learning (see Chapter 3).

Significance

Understanding the dynamics of how first-generation students think and learn, can help educators support their needs early in college, particularly in courses geared toward their academic success and immersion. Building on current literature that links metacognition to development (Kuhn, 2000), the researcher will frame metacognition as a language-based function (see Chapter 2), allowing conceptual thought to come under conscious control of the learner (Arwood, 2011). Teachers who assign meaning to one's learning and thinking, in the context of an academic success course, may help students develop metacognition for their visual thinking and learning. Furthermore, the application of metacognitive strategies for visual thinking and learning, (e.g., conceptual drawing or writing ideas in one's natural language) may help students improve their academic learning and/or performance. Therefore, investigating how first year, first-generation students come to understand their visual thinking and learning in a meta-learning context may support the theoretical underpinnings and effectiveness of accessing *metacognition for visual thinking*. If most first-generation students use a visual system for learning but need metacognitive access to their visual thinking to use this system well, educators are better informed as to the pedagogical practices needed in higher education to provide equitable opportunities (i.e., learning supports) for these students' learning and development.

Theoretical Framework

This section will provide the theoretical framework that is interpreted in the review of literature to support the use of a neurobiological model of conceptual thinking and learning. The neuroeducation theoretical framework considered includes 1) research that focuses on language acquisition and function as well as socio-cognitive theories of human development; 2) cognitive research on metacognition, mental imagery, and conceptual representations; and 3) neuroscience findings that outline a neurobiological model of conceptual learning, including the functionality of the visual system. This framework will help construct working theories for visual thinking, learning, meta-learning, and metacognition.

The Arwood Neuroeducation Model (ANM) (2011) is an interpretation of neuroscience that illustrates how people learn language and concepts simultaneously by processing sensory inputs into overlapping sensorimotor patterns which layer to become concepts (circuits) in the brain. When students assign meaning through language to their visual cognition (i.e., mental pictures) they are engaged in a process of language and conceptual learning embodied by the brain's neural circuitry and disposition to wire together (Arwood & Meredith, 2017). Therefore, Arwood's Neuroeducation Model represents thinking and learning as a neurobiological set of processes (Arwood et al. 2009), which can theoretically be learned by students to better understand strategies for making meaning in relation to subject matter. In assigning language to our thinking through introspection, students engage in a metacognitive process of learning the subject matter as well as learning their own ways for thinking and learning based on their neurobiological learning system (Arwood, 2011). When students can use their neurobiological learning system well, they can access their own knowledge and refine higher order meaning between complex conceptual relationships (Arwood, 2011).

Conceptual Framework

This section will provide an overview of the conceptual framework used in this study to frame constructs such as visual thinking, learning, meta-learning, and metacognition. The author proposes an alignment between research reported in the literature on language (acquisition and function), conceptual learning and development, the visual system, mental imagery, visualization, embodied semantic circuitry, and metacognition to support a conceptual framework for students' *visual thinking and learning*, the properties of which have been explained in Arwood's (2011) Neurosemantic Language Learning Theory (NsLLT) (see Chapter 2). This study utilizes the term *visual learning system* to describe how the brain functions with language for learning, thinking, reaching higher levels of thinking, and thinking about thinking.

Neuroeducation researchers have outlined the need for a paradigm shift, utilizing a conceptual framework of 'visual metacognition' (visual cognition integrated with metacognition from a neuroeducation lens), to explain how many students 'see' their thinking and need language assigned to what they mentally see to encode what they are learning (Arwood & Merideth, 2017; Robb, 2016; Debreczeny, 2019). Visual metacognition therefore indicates the "naming" (assignment of meaning) to one's visual cognition (i.e., forms of visual imagery) with language (Arwood, 2011). Because language is both interdependent and representational of cognition (Vygotsky, 1986), language used to think about one's thinking is metacognitive in nature. Consequently, students who use metacognition to visually represent language-based concepts need visual learning strategies rather than auditory strategies (i.e., lecture) to acquire and think with concepts and language. These students are said to have a visual learning system; meaning, their neurobiological system uses a visual cognition, which causes students to think in a language of pictures, rather than the phonetic sounds that make-up words (Arwood, 1991, Robb, 2016). Visual thinking, in the context of this study, therefore, refers to the act of using a visual cognition for learning.

Conceptualizing student learning as a process embodied in neural circuitry helps frame important constructs such as learning, thinking, cognition, metacognition, and visual cognition (see Chapter 2). A conceptual framework for students' visual thinking and learning that is supported with a strong interdisciplinary review of literature is needed to validate theories on how metacognition functions to support visual cognition. This includes where and how both constructs originate, develop, are accessed, integrated, and utilized in education. The researcher will build the conceptual framework for students' visual thinking and learning by integrating literature from the fields of neuroscience, cognitive psychology, and language acquisition to explain how they think, learn, and access their own thinking.

Definitions

The author will take great strides to operationalize the terms of this study. Most terms will be defined as they are introduced but there are key terms worth mentioning in this section as they are constructs that support the conceptual and theoretical frameworks of this study. The interdisciplinary field of neuroeducation requires different conceptualizations of some specialized terms because it may view those terms as serving different or expanded functions than the field in which it has been constructed or primarily researched. In these instances, the original term and meaning will be mentioned and briefly expostulated.

All subsequent terms, as they relate to this study, are informed by, 1) cognitivist theories of information processing, 2) neuroscience research in correlation learning and embodied cognition theories 3) and language acquisition research pertaining to the interdependence of language and cognition. These theoretical perspectives will be explored in further detail in the review of literature (see Chapter 2).

Thinking is defined as the integration of bottom-up sensori-motor perceptual processes, and top-down (feedback) processes that create modal simulations allowing for object recognition, representation, productivity, abstraction, and/or introspection (Palmiero et al., 2019). Cognition is defined as: activation and/or reactivation of mental representations that form through correlation learning, emphasizing (embodied) linkage between concepts (represented as categorical words) and circuits, underlying past internal (i.e., sensori-motor) experience (Barsalou, 1999, 2008; Pulvermüller, 2013). Visual mental imagery (or just "mental imagery") is defined as: simulations that are characterized by spatial/schematic configurations of perceptual, motor, and semantic components (stored in sensori-motor areas), which function as symbols (multi-modal representations) aiding in conceptual processing and introspection (Arwood, 2011; Barsalou 1999, 2008; Palmiero et. al, 2019; Kosslyn et al., 2005). Visual cognition is defined as: bottom-up and top-down visual processing that combines prior knowledge with retinal input to generate mental representations in the form of visual (mental) images (Arwood, 1991; Cavanagh, 2011). People who use visual cognition to learn language-based concepts, i.e., people who use mental pictures to learn, are what's termed *visual thinkers*. Therefore, based on extant literature, visual thinking in this study refers to the act of (consciously or unconsciously) using visual cognition (i.e., visual mental imagery) for learning (Arwood, 2009; 2011). Learning then, is recognized as a permanent change in neuronal circuitry as a result of semantic processing and internal experience (Hebb, 1949; Debreczeny, 2019). Learning, in the context of this study is defined as the act of learning based on the ways humans neurobiologically process, recognize, understand, and learn concepts that language represents (Arwood, 2011). All conceptual learning in this study is considered a process of learning with language.

Metacognition is defined as: language that functions to reflect on thoughts and behavior, also known as introspection; also, language that functions to assign meaning to cognition (including thinking and learning); as well as language used to think about thinking (Arwood, 2011; Weil et al., 2013). Learning system is defined as “how a human neurobiologically learns concepts that language represents” (Arwood, 2011, p.111). Finally, meta-learning is defined as: learning about one’s thinking and learning processes (e.g., through perception, inquiry, reflection), which gives way to awareness and control for one’s thinking and learning, including behaviors and attitudes that support learning (Colthorpe et al., 2018; Maudsley, 1979; Jackson, 2004).

Summary

Allowing FYFG students opportunities to develop metacognition based on how they think and learn may help them manage the complexities of university academics and life (Tao, 2021). The academic success course (ASC) employed in this study will focus on developing first year first-generation (FYFG) students’ understanding of their thinking and learning processes. This objective aligns with literature that supports first-generation students as academic learners, not only in the traditional sense of getting good grades, but helping first-generation students integrate their sociocultural experiences to support more developed and ‘multidirectional’ ways of understanding (Castillo-Montoya, 2018; Ives & & Castillo-Montoya, 2020; Freire, 2005). The researcher co-designed the curriculum for the ASC, so that first year, first-generation students would be encouraged to integrate their cultural identities into higher education through language, rather than feeling the need to shed their culture to succeed academically.

The researcher considers it possible (in the context of this study) that students who develop metacognitive knowledge for their thinking and learning processes report changes to metacognitive strategies that support visual thinking and learning. Maxine Greene (1995) states that learning how to learn requires "imagination on the part of teachers and on the part of those they teach (p.14)." Greene is referring to teachers being able to develop meaningful activities that cultivate *habits of the mind*, allowing students to critically consider diverse perspectives, and adapt in a rapidly changing world. The question Chapter 5 will address is how should educators facilitate the habits of the mind of which Greene speaks on behalf of first-generation and underrepresented students? The present study seeks to explore metacognition as a point of access to first year, first-generation students' visual thinking and learning. By helping first year, first-generation students develop metacognitive knowledge for their own visual thinking and learning processes, particularly through self-reflection, the researcher seeks to help students learn about themselves as learners and develop strategies and skills that support the ways they learn best.

Chapter 2: Literature Review

The purpose of this mixed-methods study was to investigate how first-year, first-generation college students assessed the way they visually thought and learned when entering college, and what changes occurred to their visual thinking and learning in the context of a course that facilitated meta-learning. In other words, the researcher sought to understand what meta-learning contributed to FYFG students' visual thinking and learning. This chapter was broken into four parts – 1) exploring first-generation college students and their academic learning, 2) the relationship between, metacognition, meta-learning, and first-generation students, 3) exploring the connection between language, cognition, and metacognition, and 4) constructing the framework for visual thinking and learning. To measure whether FYFG students made changes to their visual thinking/learning, this case study focused primarily on FYFG students' language as a source of their a) thinking, b) learning, c) meta-learning, and d) metacognitive thinking. The first part provides literature that, a) addresses the characteristics of first generation students, b) contextualizes the challenges they face, and c) details the interventions and personal/interpersonal factors that impact their persistence, academic success, and well-being. Two bodies of literature will be discussed, one that contextualizes FGCS by addressing their deficits and another that focuses on integrating their strengths into academic learning.

In the second part, meta-learning will be discussed as a way for college students to develop metacognition as well knowledge, strategies, and positive dispositions that support learning (e.g., motivations, attitudes, confidence-based factors). Literature on metacognition will show, 1) how metacognition is measured and operationalized in the literature (including sub-constructs), 2) how metacognition positively impacts thinking/learning, particularly among first-generation college students, 3) how implementing metacognitive strategies in educational and college environments impacts students, and 4) how meta-learning affects students' learning and development. Metacognition (e.g., metacognitive knowledge and skills) will be discussed as a developmental ability that college practitioners facilitate to help first-year and first-generation students academically succeed.

In the third and fourth parts, language and brain research related to thinking and learning will be explored. To operationalize and explain the construct of meta-learning (i.e., learning about one's learning) in this study, the researcher chose a neuroeducation theoretical framework, which integrates literature on cognitive psychology, language acquisition, and neuroscience, to illustrate how students visually think, learn, and reach higher levels of thought. The following literature review will build on current neuroeducation research that suggests students in the 21st century predominantly think and learn with a visual system; meaning they, 1) use overlapping visual and motor patterns to process language-based concepts, 2) use visual mental imagery to semantically encode and represent concepts, and 3) use language to layer/scaffold visual concepts to reach higher level thought processes. Thus, the author utilizes the term visual learning system to describe how the brain functions with language for learning, thinking, reaching higher-levels of thinking, and thinking about thinking within the visual and motor systems. Findings will be presented that show an interdependence between language and cognition, which supports the neuroeducation hypothesis that language represents and layers a persons' visual way of thinking and learning. A conceptual framework for *visual thinking and learning* will be outlined, through alignment of research in language (acquisition and function), conceptual learning and development, the visual system, mental imagery, visualization, embodied semantic circuitry, and metacognition.

Neuroscience literature, particularly in embodied cognition and semantic word learning, will comprehensively show how people's conceptual learning is embodied by their neurobiological system and how learning is supported by distributed neural language networks. A strong interdisciplinary review of literature outlining the human visual system will validate the constructs of visual cognition and visual thinking and explain how metacognition functions to support visual thinking and learning. To support the conceptual framework the review of literature will also explain how the mind functions with language and how the brain develops neurobiologically in the context of learning. This framework is intended to legitimate how FYFG students' language supports their visual or auditory way of thinking - as will be assessed by the TEMPro analysis (see Chapter 3). Therefore, this chapter will frame the constructs of visual thinking, learning, meta-learning, visual learning system, and metacognition as well as summarize the literature that leads to the primary research question, *What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first-year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?*

Exploring First-Generation College Students and Their Learning

The subjects in this study were first year, first-generation college (FYFG) students who enrolled in an academic success class (ASC) intended to support their academic performance, academic learning, and integration into college. A 5-week section of the ASC focused on students' meta-learning within a neuroeducation framework. The changes to FYFG students' visual thinking and learning during this 5-week section were the focus of this study. Thus, the researcher sought to understand what meta-learning contributed to FYFG students' visual thinking and learning.

This section will introduce and explain various aspects of being a first-generation college student (FGCS) that have been captured in the research examining this group of students. The following section will also discuss findings that highlight how educators can support FGCS within a college environment. To help the reader understand ways in which first-generation students' academic learning is supported the follow subsections will, 1) operationalize and discuss criteria for the term, "first-generation college students," 2) detail the demographics, characteristics and challenges of first generation students, 3) address the frameworks for studying first generation college students as learners in the American education system, 4) detail the interventions that have impacted their persistence and academic success, and 5) address various factors that have contributed to improved outcomes for first-generation students such as self-efficacy, agency, and sense of belonging. In general, this section focuses on the studies that helped the researcher co-design the ASC curriculum. Therefore, studies that explain how to integrate first-generation students' strengths in college academia will be discussed, while research that contextualizes the various challenges FYFG students face as students and learners will also be covered. Lastly, the first-generation population in America constitutes a cross-section of demographics that can increase the risk for being unsuccessful in college. Therefore, the following section will discuss research on racial minority, underrepresented, and low income students as these are some of the first-generation demographics that are important to consider when studying first-generation students' college success.

How We Define First Generation College Students Has Implications

First-generation college students (FGCS) can be defined as those students whose biological parents or guardian(s) did not receive a 4-year degree (Ishitani, 2006; Spiegler & Bednarek, 2013; Saenz et al., 2007). This operational definition of FGCS aligns with the

University and program in which this study was conducted and adheres to the language in the U.S. Department of Education's Higher Education Act of 1965 and 1998. However, definitions of first-generation vary depending on the research, institution, or program supporting first generation students (Whitley et al., 2018). Classifications of FGCS vary based on, a) number of parents counted, b) criteria of being a 'parent', c) whether parent(s) had college experience or completed a degree, and d) whether parents attended a 2-year or 4-year college (Peralta & Klonowski, 2017; Toutkoushian et al., 2018).

Many researchers who examined FGCS persistence and degree completion defined first generation as *neither parent having experienced college culture* (Choy, 2001; DeAngelo & Franke, 2016; Dumais & Ward, 2010; Lohfink & Paulsen, 2005; Redford & Hover, 2017). Those who support this stricter criterion for first generation argue that it focuses on those students who are most disadvantaged (Ward et al., 2012). The rationale being that any amount of experience parents receive in college is conferred to their children over time resulting in knowledge that better prepares progeny for college life (Choy, 2001; Ward et al. 2012).

Studies that compared various levels of parental experience to children's' degree attainment found there were significant differences between parents who, a) had no experiences in college, b) had some college experience, c) had earned a 4-year degree, and differences between one and two parents having received a 4-year degree (Chen & Carroll, 2005; Ishitani, 2003, 2006; Redford & Hover, 2017; Toutkoushian et al., 2021). This suggests that the number of parents who earned a degree and the level of parents' college experience significantly impacts children's' 4-year degree completion. Toutkoushian et al., (2021) for example, composed eight definitions of FGCS and examined their relationships between 2-year and 4-year degree completion. Definitions pertained to zero or (at most) one parent attending college across four levels of experience: a) some college, b) completed associate degree or more, as well as c) some college at a 4-year institution, and d) received a bachelor's degree or more. The researchers found that, 1) FGCS overall were less likely to graduate from a 4-year college than non-FGCS and, 2) the magnitude of effect varied based on the parents' level of college experience. This means the more experience parents received college, the more likely their children were to graduate from college.

Educators could thus argue that the broader definition of first generation (i.e., neither parent receiving a 4-year degree) overrepresents the first-generation population by inflating the number of students who qualify, and therefore diluting the challenges of those students with parents who have no college experiences to draw from (Ward et al., 2012). On the other hand, not including those students whose parents have had some college experience, or that have one parent that graduated from college, can overlook students who occupy a middle ground and who still face challenges in college (Ishitani, 2006; Toutkoushian et al., 2021). For example, Redford & Hoyer (2017) analyzed a national dataset of first-generation students and found that students whose parents had some college experience graduated at lower rates than students who had one parent that graduated with a 4-year degree. This suggests that students whose parent(s) have college experience but at least one of whom did not earn a degree, benefit differently based on the level of both parent's experience in college.

While most programs utilize the broader definition of first generation (Whitley et al., 2018) to date, there is little consensus in how much parental education is necessary to give students an advantage in their college education (Toutkoushian et al., 2021). As a result, both in the research and in practice numerous definitions of 'first generation' proliferate (Kilgo et al., 2018; Whitley et al., 2018). The lack of consensus in the literature, makes it challenging to generalize findings across studies, particularly when researchers do not operationalize "first generation" in their published articles (Peralta & Klonowski, 2017). New literature bears out the importance of defining first generation and detailing the implications of such definitions in their researched works (Toutkoushian et al., 2018; 2021; Whitley et al., 2018).

In operationalizing FGCS as *those students whose parents have not received a 4-year degree*, the researcher contends that more students are included under the umbrella of "first generation," since more students fall under the criteria of, a) having parents who did not attend college or b) attended some college. This means, more students were offered the services/programs offered by the University. This practice aligns with the majority of U.S. programs who use the broader definition to offer services to the most students possible (Whitley et al., 2018). The broader definition alternatively means that the cultural and social capital (i.e., cognitive resources and support networks) of students vary because of the broader population of students with parents who have varying levels of college experience. Another implication of the broader definition of FGCS, is that students who've had only one parent graduate from college, are excluded from inclusion as 'first generation,' though these students may still need access to college resources. Neither the broader nor stricter definition explicitly accounts for students who lack the types of parental relationships which would afford them resources to prepare them in college (Peralta & Klonowski, 2017). The demographics of first-generation students and the challenges FGCS face are discussed next.

Demographics, Characteristics, and Challenges of First-Generation Students

First-generation college students' (FGCS) make-up around one-third of the national college student body (Cataldi, et al., 2018; Harackiewicz et al., 2016; Staklis & Chen 2010; Skomsvold, 2014). The majority of educational research on FGCS has concentrated on their demographic make-up and how these factors negatively correspond with academic success and subsequent earnings leading to socioeconomic disparities (Cahalan et al., 2018; Cahalan et al., 2021; Chen, 2005). Longitudinal survey data, spanning the last 50 years, suggests over half of FGCS identify as racial minorities (Lauff & Ingels, 2013; Saenz et al., 2007), with Hispanics making up between 38 - 48% of all FGCS (Saenz et al., 2007; Skomsvold, 2014). Although, the rate of FGCS overall and FGCS among minorities has declined slightly over the last two decades, the proportion of Hispanic first-generation students has remained highest (Cataldi et al., 2018; Saenz et al., 2007; Skomsvold, 2014; Staklis & Chen 2010). Hispanic FGCS have the lowest odds of attaining a bachelor's degree among ethnic demographics, at just 18.8% (McCarron & Inkelas, 2006) and are the most likely to drop out after the first two years of college (Lohfink & Paulsen, 2005). For instance, Latino et. al, (2020) examined the composition of Hispanic FGCS and non-Hispanic FGCS (*N* = 2,499) and compared their academic performance (GPA) and retention rates. In their study, Hispanic FGCS were more likely to come from lower income families than Hispanic non-FGCS and Hispanic FGCS had significantly lower first-year GPAs (2.53 vs. 2.85) and significantly lower persistence rates (i.e., first-to-second year retention rates) than Hispanic non-FGCS (75% vs 79%).

FGCS are also more likely to come from lower-income households than non-FGCS (Choy, 2001; Ward et al., 2012), which among other demographics is correlated with increased risk of poor academic performance and college attrition - (e.g., 28% - 35%) (Ishitani, 2006; Jenkins et al., 2009, Lohfink & Paulsen, 2005; Pascarella et al., 2004; Sirin, 2005; Stephens et al., 2012a; Woosley & Shepler, 2011). Using national datasets from the U.S. Department of Education, Engle & Tinto (2008) reported that low-income, first-generation students were nearly four times more likely (26 to 7%) to depart college after their first year (i.e., persist) than students who did not belong to these demographics. Lower FGCS graduation and persistence rates have been attributed to personal challenges including, financial difficulties, working long hours, having children and/or family to look after, and commuting longer distances to attend college (Chen & Carroll 2005; Horn & Premo 1995; Lohfink & Paulsen, 2005; Mangan, 2015; Terenzini et al. 1996).

FGCS can also experience mental health challenges in college, such as feelings of not belonging, and greater levels of depression and/or stress than non-FGCS (Stebleton et al., 2014). FGCS often find it difficult to fit in early in college and are likely to have negative social experiences (Housel & Harvey, 2009; Johnson et al., 2011; Ostrove & Long, 2007). Minority FGCS may be forced to negotiate cultural values and obligations with family against obligations and values in a university setting (Leu et al., 2011; Jenkins et al., 2013). The pressures on minority FGCS to be self-reliant, assertive, and acculturate to White, middle-class culture, has been shown to create undue physiological stress which can lead to burn out and fatigue (Housel & Harvey, 2009; Ostrove & Long, 2007; Burt et al., 2017). Thus, FGCS face background specific challenges which can impact their academic performance and degree completion (Stephens et al., 2012a).

FGCS are also more likely to, a) identify as female, b) have a disability, b) be born outside of the U.S., c) be nonnative English speakers, d) be raised in single-parent households, and e) support themselves financially (Bui, 2002; Choy, 2001; Lohfink & Paulsen, 2005). Academic challenges that have been attributed to ‘first generation’ status when compared with continuing generation peers, include, a) being less academically prepared, b) lack of knowledge about institutional processes, c) poorer performance on tests, c) lower persistence/retention rates, and, d) lower degree completion rates (Atherton, 2014; Choy, 2001; Coffman, 2011; D’Amico &

Dika, 2013; Engle & Tinto, 2008; Nguyen & Nguyen, 2018; Sirin, 2005, Ward et al., 2012; Pascarella et al., 2004; Redford et al., 2017). It's been argued that such challenges create an achievement gap between FGCS and non-FGCS which can negatively impact first-generation students' ability to achieve higher earnings over time (Stephens et al., 2014a; 2014b). Despite these known challenges many college policies and educational practices still advantage continuing generation or 'traditional' students over first-generation students (Collier & Morgan, 2008; Nguyen & Nguyen, 2018; Person et al., 2006). Several researchers have showed that FGCS need help developing internal resources (e.g., self-efficacy) to overcome the academic challenges they face and to cultivate the capabilities that will help them thrive after college (Garriott et al., 2015; Majer, 2009; Stephens et al., 2012a, Stephens et al., 2014a). Social and cultural capital are discussed next.

Providing Social and Cultural Capital to First Generation College Students

Pierre Bourdieu (1973; 1986) theorized social and cultural capital as resources transmitted among the dominant class, that systematically advantage specific groups of students in educational institutions. Bourdieu and Passeron (1977) were concerned with the educational system in France and how it contributed to the reproduction of class power structures by redistributing 'capital' among these classes. They used multiple survey questions with university students to examine the relationship between cultural differences (e.g., attitudes, tastes, competencies, views) and social origin differences (e.g., financial status, affiliations) (Robbins, 2005). Their research and theories provided a framework of how middle and upper-class families structurally redistribute social and cultural resources which advantage their children in educational institutions (Bourdieu & Passeron, 1979 via Robbins, 2005). Their rationale was that schools reflect the experiences of the *dominant class* in society. Children raised among the dominant class, learn social and cultural cues during their lifetimes, but must learn to leverage the knowledge and skills they've acquired upon entering school to be successful. Knowledge acquired in school is later transferred to their children thereby redistributing normative educational culture and reinforcing normative academic standards. Although children from lower-class families can access social and cultural capital by developing resources that comprise the dominant class, they are at a disadvantage because their experiences are at odds with the preferences of educational systems. Therefore, these students must acculturate the normative culture embedded in academic practices, procedures, and structures to succeed. In other words, these students must negotiate or exchange their own natural (i.e., indigenous) culture with the dominant culture or risk continual social exclusion (Robbins, 2005).

Social capital is theorized as the sum of resources that exists among a network of relationships (e.g., friends, family, acquaintances) that can be used as a tool for the dominant class to reinforce and redistribute power (Bourdieu, 1986) . Cultural capital correspondingly, refers to valued knowledge and resources (e.g., competencies, attitudes, tastes) of the dominant class that are transferred via actions and language among families. Bourdieu and Passeron's theoretical frameworks have become foundational, particularly in America for research that a) examines non-schooling factors related to students' educational achievement and experiences (DiMaggio, 1982; DiMaggio & Mohr, 1985; Lareau, 1987), and research that b) critically examines educational systems by assessing the ways they reinforce social stratification and/or inequality by advantaging and disadvantaging specific groups of students (Apple 1995; 2012; Cookson & Persell 1985*;* Giroux 1983; Stephens et al. 2014b).

Coleman (1988) for example, applied a social capital framework to examine high school students' relationships within and outside the family. He used a weighted logistic model of a random sample of 4,000 students from public schools to measure factors of social capital within the family and in the community, e.g., number of school changes due to family residential moves, and frequency of discussions with parents on personal matters. He found that social capital can be amassed by staying in school through high school graduation and reciprocally that students' social capital was related to lower dropout rates in high school. More recently, research on social capital in public schools has shown it to be a predicting factor of graduation rates and academic success (e.g., GPA and test scores) (Israel et al., 2001; Israel & Beaulieu, 2004). Dufur et al., 2013 for instance, using data from the National Longitudinal Education Study found that capital exchanged in family contexts and capital exchanged within schools were strong predictors of academic achievement. Social capital within children's families, friend groups, and the community has been shown to additionally impact school participation (Sun, 1999) and lead to higher college enrollment (Yan, 1999).

Growing up with parents that attended college affords children *cultural capital*, valued as the 'knowledge, attitudes, skills, and tools necessary to represent oneself to the dominant culture to succeed, as well as *social capital*, valued as social networks that offer academic, administrative, and psychological support and resources (Bourdieu, 1986; Lamont & Lareau, 1988; Lin, 2017). First generation and underrepresented college students are said to have differences in social and cultural capital when enrolling in college compared to continuing generation students (Holland, 2010; Stephens et al., 2014a; Ward et al., 2012), which leads to greater challenges associated with academic achievement and well-being (Collier & Morgan; 2008; Israel & Beaulieu, 2004b; Jenkins et al., 2013; Mehta et al., 2011). Students who do not benefit from their parents' experiences may lack an understanding of administrative and academic policies, practices, and expectations making it difficult for them to fulfill the role of a college student and integrate successfully into college (Collier & Morgan, 2008; Ward et al., 2012). Differences in capital among FGCS and non-FGCS have been said to lead to disparities or 'gaps' in academic preparedness and achievement, as well as upward social mobility (i.e., higher earnings) after graduation (Atherton; 2014; Choy, 2001; Coffman, 2011; Duncan & Murnane, 2011; Pascarella et al., 2004; Schmid et al., 2016; Stephens et al., 2014a). However, research examining the effects of social and cultural capital on educational outcomes are not conclusive, which may be an indication that factors which add value or 'capital' vary for specific groups and individuals (Dika & D'Amico, 2016; Padgett et al., 2012).

Educational research on underrepresented high school and college students (e.g., first generation) suggests they rely on school resources (e.g., staff and faculty relationships and extracurricular activities) to assist them with administrative and learning tasks (Venezia & Kirst, 2005; Wimberly, 2002), but frequently do not seek help in resolving challenges because of negative feelings associated with perceived lack of abilities (Collier and Morgan, 2008). FGCS regularly expect to have positive relationships with faculty (Trammell & Aldrich, 2016; Wang, 2014) yet they interact with professors less than continuing generation students (Soria & Stebleton, 2012; Yee, 2016). FGCS and underrepresented students who build supportive networks early in college are better able to adjust to college practices (Hurd et al., 2018), perform well academically (Parnes et al., 2020a; 2020b), and develop *belonging* within the campus community (Means & Pyne, 2017; Museus & Chang, 2021; Nuñez, 2009). Sense of belonging refers to the feeling that one is connected to a group, community, or institution, similar to the connectedness one might feel towards 'home' (Hurtado & Carter, 1997; Smith, 2020).

Atherton (2014) argues that FGCS need targeted programs that help them prepare for college academia and set them up for success. First-year programs/interventions designed for

FGCS can assist the transition to college by providing academic resources (e.g., strategies, skills, dispositions) as well as access to social capital through peer-to-peer or mentoring connections, that mitigate achievement/preparedness gaps and support well-being (Atherton, 2014; Becker et al., 2017; Dennis et al., 2005; Stebleton et al., 2014; Thayer, 2000). However, some research suggests precollege outreach programs lack core components that predict successful college enrollment (Perna, 2002). Ives & Castillo-Montoya (2020) suggest more research is needed to understand FGCS strengths in terms of the capital or 'wealth' they bring into college academics and how that capital can be leveraged to support academic learning. The next section focuses on approaches and interventions that support FGCS academic learning in college.

Frameworks for Studying First Generation College Students as Learners

Ives and Castillo-Montoya (2020) screened 473 articles, conducting systematic reviews of 59 research articles which focused on supporting first generation students in higher education through academic learning contexts (i.e., interventions). They found that the majority (42%) of studies utilized social and cultural frameworks to examine how students were impacted. These studies were categorized by, a) how first-generation students' culture interacts and often conflicts with the culture of higher education, b) how providing FGCS access to social and cultural capital supports their integration into college, and c) how first-generation students prior knowledge (e.g., previous experiences) provides valuable ways of knowing and skills that can be useful in supporting disciplinary learning (González et al., 2005; Rios-Aguillar & Kiyama, 2018). Much of this research captures the *dissonance* first generation students experience between their culture and the normalized white, upper, and middle-class cultures of college institutions (Stephens et al., 2014a).

FGCS commonly struggle with pressures to prioritize institutional or workplace identities over their family identities (DerSarkissian et al., 2022). They may alternatively experience resentment from family members who disagree with them leaving home to attend college or harbor resentment toward family members for their perceived lack of support (Longwell-Grice et al., 2016). Because of such challenges, minority FGCS often experience social isolation early in college (Cushman, 2007; Dennis et al., 2005; DeSousa & Kuh, 1996) which is strongly related to symptoms of depression (Arbona & Jimenez, 2014; Suwinyattichaiporn & Johnson, 2022). Research suggests that those who successfully integrate to college life, *acculturate* the university's cultural characteristics (Collier & Morgan, 2008; Hertel, 2002; Lohfink & Paulsen, 2005; Pascarella et al., 2004). Acculturation refers to the process by which a person raised in an immigrant or minority family, adopts characteristics of the destination culture while negotiating aspects of their own identity and heritage (Schwartz et al., 2020). Acculturation, however, can prove challenging (Aspelmeier et al., 2012; Koo et al., 2012) and conflict with students' cultural/ethnic identities (Jenkins et al., 2013). Compounding their academic challenges, FGCS report less social support experience greater financial hardship, and have prior family and employment commitments (Jenkins et al., 2013; Lohfink & Paulsen, 2005). The pressures on minority FGCS to be self-reliant, assertive, and acculturate to White culture, can create undue stress physiology (Jenkins et al., 2013) which can lead to fatigue and burnout (Kundu, 2019; McCullough, 2022).

Some research focuses on alleviating dissonance by altering how FGCS experience and integrate into college culture. For example, Parnes et al. (2020b) utilizes the Connected Scholars program, which employs a model of mentoring for underrepresented college students, whereby students recruit mentors from their current social network. Connected Scholars is designed to help students develop skills and dispositions (e.g., self-efficacy) necessary to foster mentoring relationships associated with social capital (Schwartz et al., 2016). The researchers found that underrepresented FGCS experienced positive changes to help-seeking attitudes, and orientation related to help-seeking usefulness, which accounted for improved GPA and faculty relationships. These findings correlate with previous studies which emphasize the importance of facilitating faculty mentorships and peer connections to close differences in social capital among first year and first-generation students (Perna, 2002; Schwartz et al., 2016; Thayer, 2000). Other studies that have focused on ameliorating first-generation experiences have proven beneficial to students' sense of belonging, well-being, and academic performance (Harackiewicz et al, 2014; Stephens et al., 2014a; Becker et al., 2017).

FGCS also experience racism, discrimination, and micro-aggressions in college which can negatively impact their academic learning and chances of persistence (Terenzini et al., 1996). Comparative racial studies indicate minority students who have negative diversity interactions on college campuses have lower cognitive gains than White students (Nelson Laird 2005; Roksa et al., 2017a; 2017b). Higher-order cognitive gains (e.g., critical thinking) have correspondingly been shown to be greater among White students in college than minority students (Black and Hispanic), indicating cognitive learning disparities at some college institutions (Flowers & Pascarella, 2003; Kugelmass & Ready, 2010; Roksa et. al, 2017a; 2017b). Many researchers seeking to support first-generation students suggest that they be provided academic preparation and opportunities to build strong social support systems when entering college (Coffman, 2011). However, some studies suggest that learning to 'transition' or 'integrate' to college, may be less important for minority students than getting involved on campus (e.g., through ethnic programs, service opportunities, student groups, mentorships, etc.) to facilitate multi-cultural awareness, and aid the development of internal resources (e.g., strategies, skills, self-confidence, self-authorship, sense of community) (Jehangir, 2009; Nuñez, 2011; Throgmorton, 1999; Tracey & Sedlacek, 1987), For example, Attinasi (1989) conducted life-history interviews with eighteen Latino/a students, 13 of which persisted, and five who did not persist in college. Attinasi interpreted that college experiences consist of three geographies: 1) the physical geography, (2) the social geography, and (3) the academic/cognitive geography. He posited that collective affiliation (i.e., total involvement) for Latino/a students was critical because it provided opportunities for them to develop knowledge, strategies, and skills “for negotiating (these) physical, social, and cognitive/academic geographies" (p. 267).

When factoring for academic success, involvement in college co-curricular activities has shown to mediate other demographic factors such as family income (Attinasi, 1989; Kuh, 1995; Pascarella, 1984; Pascarella & Terenzini, 1983). This means, the more involved a student is in campus activities the more likely they are to perform well academically. Hoffman (2002) examined 188 full-time university students’ transcripts using exploratory factor analysis to identify patterns of involvement. Using structural equation modeling Hoffman found that cocurricular involvement among minority students, had a significant, but slight, positive relationship with academic achievement. This finding aligns with other research showing that cocurricular involvement is positively related to academic achievement for minority and first-generation students (Flores, 1992; Nuñez, 2009; Hoffman, 2002; Terenzini & Pascarella, 1978).

Social and Cultural Capital as Deficit-Based Frameworks. Among the articles cited by Ives and Castillo-Montoya (2020) that used social and cultural frameworks to examine first-generation students’ academic experiences, six articles employed social and cultural capital theories and eleven articles employed Bourdieu’s broader framework. Among these articles, most (80%) focused on helping FGCS learn the hidden curriculum (non-verbalized expectations) to better navigate academic landscapes (Yee, 2016). In continuance of their 2020 study, Castillo-Montoya and Ives (2021a) synthesized the recommendations from 53 research articles and found that over one-third (38%) included recommendations to provide supports to first-generation students as academic learners. In their review, offering support through curricular strategies (to improve psychological and affective factors related to 'self') and increasing FGCS social and cultural capital were most often mentioned. Accessing cultural capital (in terms of valued knowledge, skills, and strategies), as well as social capital, has been shown to positively impact factors related to academic achievement (e.g., GPA, persistence, and/or years of education) (DiMaggio, 1982; Dumais, 2002; Dumais & Ward, 2010; Wells; 2008).

Some authors argue however, that this body of research too often frames 'capital' as 'deficiencies in resources' and disregards the power dynamics engrained in educational institutions that make it difficult for FGCS to acquire said 'capital' (Dika & Singh; Ives & Castillo-Montoya, 2020); Sablan & Tierney, 2014; Yee, 2016). In reviewing Bourdieu and Passeron's work Robbins (2005) suggested the authors sought to account for social differences and how those differences proliferated through cultural exchanges over generations. Ives & Castillo-Montoya (2020) argue that research which utilizes their framework often portray FGCS as 'lesser than' or 'in need of' the assets their peers have to succeed. Thus, the issue of inequity is framed as the students' lack of preparation, literacy, skills or otherwise. In practice, such justification may lead educators to, a) engage in practices that fashion first-generation students as traditional students, b) use language that frames students poorly and does harm, and c) miss opportunities to leverage first-generation students' strengths to improve learning or develop psychological resources (e.g., self-efficacy, interdependence, identity) (Ives & Castillo-Montoya, 2020). Alternatively, deficit framing may deflect responsibility from college institutions for perpetuating inequitable academic outcomes for minority, underrepresented, and first-generation students (Bensimon, 2012; Ives & Montoya, 2020; Castillo-Montoya & Ives 2021). Yee (2016) argues that researchers who use Bourdieu's theory must shift their focus from specific groups of individuals to "interactions between individuals and institutions within a social context" and call attention to the role that colleges and pedagogies play in "imbuing value to some cultural resources and not others, (p.852)."

First-Generation Students' Persistence/Retention Framework. In Ives & Castillo-Montoya's (2020) previously cited research, the next most frequently used framing category among first-generation students as academic learners focuses on persistence/retention theories (22%), which predominantly use Tinto's (1975; 1993) model to examine factors related to students' academic and social integration into college. Tinto's (1993) persistence model is based on longitudinal interactions between a) precollege student characteristics (e.g., goal orientation, parental background, skills and abilities), b) student's institutional and external commitments, and c) academic and social experiences on campus. Tinto (1993; 1997) argued that persistence, was based on students' integration into both formal and informal academic systems (e.g., academic expectations and interactions with faculty/staff) as well as formal and informal social systems (e.g., extracurricular activities and interactions between peer groups). Student backgrounds, initial commitments, and interactions interact cumulatively over time to produce varying degrees of academic and social integration, which causes commitments to shift, ultimately determining whether students will finish college or depart prematurely. In order to help first-year students persist, institutions must establish clear expectations as well as opportunities to acquire social and academic integration skills (Tinto, 1993).

Many studies involving FGCS use Tinto's (1975; 1987; 1988) theories or adaptations to his theories to explain the challenges FGCS experience transitioning to college life that cause them to depart in the first year (Cabrera et al., 1993; Longwell-Grice & Longwell-Grice, 2008). Influenced by such research, several interventions (e.g., retention programs) have been developed to help first generation students transition to college life (Tucker, 1999). These interventions often involve summer bridge programs that provide opportunities for students to a) take core college courses under academic supervision, b) develop study skills (e.g., reading or writing), c) facilitate interactions with peers through learning communities or mentoring, and d) engage in tutoring or other support services (Cabrera et al., 2013; Wibrowski et al., 2017). Minority students who participate in such programs, have been shown to graduate from college at higher rates, stay in school longer, and have higher GPAs (Cabrera et al., 2013; Douglas & Attewell, 2014; Murphy et al., 2010), though there is conflicting evidence for first-generation students (Odeleye & Santiago, 2019).

Self-Efficacy and Developmental Frameworks. The last three most frequently used framing categories in Ives & Castillo-Montoya (2020) previously cited study, are 1) critical pedagogy-based studies (12%) that examine how systems in higher education disadvantage students and how teachers can change those systems, 2) self-efficacy based studies, using Bandura's (1997) framework to examine first-generation students' self-efficacy and its impact on academic success, and 3) developmental theories (7%) that examine how first-generation students learn and develop (cognitively, affectively, and behaviorally) within academic contexts. Literature pertaining to critical pedagogy shows how academic curriculum/structures can connect first-generation students' lives and identities to disciplinary concepts, to facilitate deeper understanding and develop students' academic self-concept (Castillo-Montoya, 2018; Castillo-

Montoya & Ives, 2021a; 2021b; Freire, 2005). More on this, will be discussed in subsequent sections.

Literature on self-efficacy suggests that students who believe in their abilities to execute specific behaviors (Bandura, 1986, 1997) are more likely to perform well academically (DeFreitas & Rinn, 2013; Elliott, 2014; Majer, 2009). Self-efficacy is closely related to the construct of an internal locus of control, which personifies academically *resilient* students, i.e., those students who expend more effort on academic learning tasks and can persevere through failure. In a study of fifty, academically resilient, minority first-generation students, Morales (2014) found that first-year students who succeeded academically developed an initial belief they could succeed in college. Students needed faculty support to develop and reinforce self-efficacy, as confidence waivered when encountering students who had more experience in rigorous academic contexts (also DeFreitas & Rinn, 2013). Morales (2014) asserts that faculty can support minority FGCS by facilitating, a) development of help-seeking attitudes, b) understanding of what it takes to succeed, c) understanding of how to work through failures, and d) reflection of learning strengths and weaknesses to identify what works best.

Finally, developmental literature considers college environments (e.g., learning contexts) and their impact on students' social and cognitive development. These studies may also consider how university cultures incorporate minority students' and other marginalized voices in the learning process (Ives & Castillo-Montoya, 2020; Throgmorton, 1999). *Development* in this sense predominantly refers to progressive stages by which humans acquire knowledge, organize mental processes, and learn to think based on experiences (Piaget & Cook, 1952; Vygotsky, 1978). Developmental studies of FGCS have focused on types of academic and social engagement that foster agency, sense of belonging, self-authorship, and multi-cultural awareness

(Carpenter & Peña, 2017; Markle and Stelzriede, 2020; Jehangir et al. 2012; Padgett et al., 2012).

Co-curricular and peer involvement play a significant role in the intellectual, academic, and interpersonal development of college students (Astin; 1993; Colbeck et al., 2000; Demetriou et al., 2017; Engberg & Hurtado, 2011; Jayakumar, 2008; Padgett et al., 2012; Pascarella et al., 2004; Pascarella et al., 2014; Whitt et al., 2001). Interventions designed to support first-generation students' reflection and discourse with peers, such as *learning communities*, have proven valuable to students' learning, well-being, development, and academic success (Jehangir, 2009; Jehangir et al. 2012; Markle & Stelzriede, 2020). Engagement with multi-cultural viewpoints during the learning process is designed to facilitate academic success, foster students' sense of belonging, and ease students' transition to college life (Gurin et al. 2013). When students are given opportunities to examine challenging multicultural issues with peers, and reflect on their own experiences, they are engaged in critical thinking about multiple perspectives, which can empower them to develop multiple ways of knowing (Jehangir, 2009). Such, strength-based approaches were considered when designing the academic success curriculum for this study, which is discussed next.

Supporting First Generation Students' Academic Success Through Early Interventions

Research suggests that first-year, first-generation students are less academically and socially involved than continuing generation students, e.g., contribute less to class discussions, involved in fewer co-curricular activities, interact less with peers than continuing generation students (Filkins and Doyle, 2002; Pascarella and Terenzini, 2005; Pascarella et al., 2004; Pike & Kuh, 2005; Soria & Stebleton, 2012; Tinto, 2006).

FGCS regularly experience difficulties managing the task-oriented nature of college academics and describe feeling disconnected from university life (Collier & Morgan, 2008; Mehta, et al., 2011). This may be because first-generation students have fewer encounters, particularly in high school, that facilitate familiarization of college expectations, norms, and standards (Atherton, 2014; Jenkins et al., 2013; Mehta et al., 2011). Conversely, Stephens et al. (2012a; 2012b) suggests FGCS experience a cultural mismatch between their own interdependent (communal) values and the autonomous norms of college. For FGCS, the mismatch between interdependent and independent norms, can contribute to a number of unfavorable outcomes, such as lower academic performance, help-seeking avoidance, heightened perceived difficulty of learning tasks, and greater academic stress (Stephens et al., 2012a; 2012b; Stephens et al., 2014a; 2014b).

Conceptualizing First-generation Students Learning Upon Entry to College. Literature indicates that discrepancies exist between first-generation and continuing-generation students in critical thinking, literacy, and development (Padgett et al., 2012; Strayhorn, 2007; Pascarella et al., 2004). For example first-generation students have scored lower on measures of cognitive and moral development, as well as attitudes toward literacy than non-first-generation students (Padgett et al., 2012). FGCS have also reported lower gains in learning and intellectual development during college as compared to continuing generation students (Pike & Kuh, 2005). Many first-generation students attend high schools that emphasize preparation for high-stakes assessments rather than the development of academic and literacy skills (Ruecker, 2013; Wahleithner, 2020). This is because high schools that serve students from low-income and immigrant households typically adopt preparatory guidelines for high-stakes assessments rather than focusing on the types of literacy tasks students can expect in higher education McCarthey, 2008; Wills & Sandholtz, 2009). Additionally, first-generation students particularly in rural and urban areas may attend low performing schools that lack resources, including qualified teachers (Engle et al., 2006).

Wahleithner (2020) found that first-generation students reported a lack of rigor (i.e., high standards) at their high school institutions, which allowed them to skim readings, and study minimally. Curriculum in secondary education often calls for memorization and comprehension tasks which does little to prepare students for more rigorous literacy tasks (i.e., reading and writing), such as examining texts for context and credibility (Rainey et al., 2018; Wahleithner, 2020). The lack of rigor in high school can create an *academic mismatch* when minority and first-generation students enter college (Wahleithner, 2020). Because of this misalignment first generation students have reported not feeling prepared for the demands of college academics, particularly in science-based disciplines which require strong academic skills (Athanases et al., 2016; Reid, 2007; Reid & Moore, 2008). For instance, Reid & Moore (2008) interviewed 13 first-generation graduates of the same urban high school and found that 10 believed they had not been challenged enough to develop sufficient study skills in high school, which made college more challenging. Correspondingly, Penrose (2002) found that FGCS had lower perceptions of their academic literacy skills and academic preparedness compared to non-FGCS.

Reconceptualizing FGCS Academic Learning. A substantial body of literature, previously cited, conceptualizes the ‘gaps’ that exist between first-generation students and continuing generation students as deficiencies in cultural capital. Those ***students*** who lack ‘capital’ associated with academic preparation, are said to face greater challenges to their academic identities, have more trouble understanding faculty expectations for student achievement, and be more inclined to avoid interactions with instructors (Collier and Morgan, 2008). While examining/understanding these challenges is important, Chang ***et al.*** (2019) state the social-class achievement gap is too often framed as a “resource deficiency” of financial or academic resources or skills. They add that researchers often “overlook the importance of a cultural mismatch between the norms of independence ingrained in American higher education and interdependent norms that characterize working-class contexts (in Stephens et al., 2012a; 2012b).”

In place of cultural capital, Yosso (2005) utilizes the Community Cultural Wealth (CCW) framework to recognize the cultural knowledge, skills, motivations, abilities and relationships that racial minorities have upon entry to college. When nurtured these cultural resources can result in *forms of capital* (e.g., aspirational, navigational, social, linguistic, familial and resistant) that foster educational success. Yosso’s cultural framework simultaneously acknowledges the institutional changes that must be made to frame minority students relative to their experiences while leveraging their knowledge and abilities. Ives & Castillo-Montoya (2020) similarly conceptualize first-generation students as learners whose “lived experiences, when connected to academic content, can contribute to their academic learning, advancement of disciplines, self-growth, and community development (p.139).” The authors borrow from Vygotsky’s sociocultural theory (SCT) to conceptualize “academic learning” as a process of content or disciplinary-based knowledge acquisition and application whereby, sociocultural contexts affect and shape cognition (Esmonde & Booker, 2016; Holland et al., 2001; Ives and Castillo-Montoya, 2020; Vygotsky, 1978). The researcher of this study adopted the same view of academic learning when co-designing the academic success course for first year, first-generation students (though “conceptual learning” is framed with a neuroeducation framework).

Facilitating Learning Communities. One of the primary sources of first-year student departure is the lack of involvement in academic and social systems (Tinto, 1993; 1997). Involvement is critical not only for persistence, but because of its positive relationship with learning and development (Astin, 1993; Ory & Braskamp,1988; Pascarella & Terenzini, 1991). Participation in *learning communities*, has shown to have positive relationships with students' academic and social involvement, as well as their disciplinary learning (Tinto, 1997). Learning communities refer to small student cohorts that learn collaboratively through discussion and study within supportive environments (Inkelas & Weisman, 2003). Learning community programs are offered to first-year and sophomore FGCS and non-FGCS at many 4-year universities. These programs have a variety of formats including, a) residential learning communities which focus on the social benefits of living and studying in the same residential hall, b) course clustering initiatives that enroll student cohorts into interdisciplinary programs, and c) first-year courses that facilitate disciplinary learning, development, and social connection (Inkelas & Weisman 2003). Courses that facilitate learning communities typically employ active learning, reflection, and assessment techniques while emphasizing themes such as community, diversity, and awareness (Jehangir, 2009; 2010; Smith et al., 2009.

Learning community programs have shown to positively impact FGCS academic and social integration at institutions with culturally different makeups (Gonzales et al., 2015; Inkelas et al., 2007) and institutions that are predominantly White (Jehangir, 2010). When peers of different ethnicities engage in intellectual dialogue and interact with faculty, they are more likely to have higher GPAs and persist into their second year (DeAngelo, 2014; Nosaka & Novak, 2014; Pascarella & Terenzini, 2005). Gonzales et al. (2015) for example, followed 320 Latino/a student's college paths (from 2004 to 2012) after participation in a first and second year learning community which was receptive to their cultural and linguistic strengths/needs. In order for the students to develop a strong sense of community the program required student cohorts to enroll in first-year English and math courses together and participate in block scheduling (Tinto, 1998). Students also participated in an introductory ethnic studies course and seminars focused on student success strategies. By the second year of the program students were expected to have the academic and psychological skills necessary to be successful. Per Tinto's (1998) recommendation, the second year of the program involved students choosing and enrolling in various ethnic studies courses together, thereby extending the learning community and the time and effort students spent together. Gonzales and colleagues noted that students built lasting bonds with their peers and faculty, which was the primary contributor to their success. The authors also discovered that first- to second-year retention rates for Latino/a students increased and a sense of family was fostered between students and faculty/staff.

Latino/a and first-generation students who develop strong community and familial ties often discover a sense of belonging in college (Hurtado & Carter, 1997; Nuñez, 2009) which can aid their performance and persistence (Saunders & Serna, 2004). Connections with peers can support minority and first generation students through transitionary stages which weigh into decisions of whether they stay in college (Cerezo & McWhirter, 2012; Gonzales et al., 2015). Jehangir et al. (2012) for example, used a developmental framework to examine the impact of a multicultural learning community (MLC) on first-generation students 3-4 years after their initial participation. The MLC was designed to help first generation and low-income students overcome isolation and marginalization, which they often experience at predominantly White colleges (Jehangir, 2009, 2010). The MLC curriculum consisted of two disciplinary courses and one first-year writing course, with the themes of identity, community, and social agency linking each course. The learning community met several times a semester to reflect and discuss complex multicultural issues. The researchers conducted interviews with 24 participants and analyzed their transcripts using narrative and case study analysis. Discussion of multicultural issues and written reflections were found to positively impact FGCS development – specifically the intrapersonal dimension of self-authorship.

Self-authorship refers to Kegan's (1994) three-dimensional framework that captures people's cognitive, intrapersonal, and interpersonal development. The intrapersonal dimension specifies development of a person's identity and beliefs independent of others. Pizzolato et al. (2007) states that people who are self-authored "employ complex cognitive processes of meaning-making in ways that recognize the socially constructed nature of knowledge (cognitive) while also keeping in mind their own beliefs, values, and goals (intrapersonal) in balance with maintaining healthy relationships (interpersonal) (p.196)." First-generation students who develop self-authorship are better able to overcome the marginalization and/or isolation they experience in college (Jehangir et al., 2011). Jehangir et al. (2012) found that first-generation students who participated in the MLC, "demonstrated a growing awareness of their strengths and weakness as learners and individuals and the recognition of voice as a powerful tool for self and others (p.279)." These findings correspond with other research that shows peer involvement to be a strong predictor of openness to different cultures and viewpoints (Engberg & Hurtado, 2011; Hu & Kuh, 2003; Jayakumar, 2008).

Facilitating the formation of 'community' within a culturally reflective curriculum that supports students' voice and/or experiences has shown to be an effective way for first-generation students to develop internal resources (e.g., empowerment, sense of belonging, self-authorship) (Bass & Halverson, 2012; Jehangir, 2009). Such 'constructivist' pedagogical approaches shift from traditional (didactic) teaching methods and can help students form new ways of thinking, knowing, and learning. For instance, Jehangir (2009) followed seven cohorts of 128 total students who participated in a Multicultural Learning Voices Community (MLVC). The MLVC facilitated discussion of multicultural concepts through students' stories and first person experiences. Students were invited to share their lived experiences with each other and integrate disciplinary concepts through reflection. The author found the MLVC fostered a) *a sense of place* where students felt they belonged, b) *figurative bridges* between the curriculum, students' home worlds, and their peers which supported learning, c) students' *voice* for self-expression and knowledge-construction, and d) students' identity (and multiple identities) within the academic environment. Jehangir (2009, p. 40) stated, that giving voice to one's identity "is to lay claim to a stronger sense of self and in doing so to gain confidence to express ideas, engage in dialogue, and develop a capacity for self-authorship (from Baxter Magolda, 2003)." Facilitating connection and understanding between one's own cultural identity and the identity of others, can help students feel their culture is being incorporated into the institutions' culture (Throgmorton, 1999). This is important because students' perceptions of the inclusivity of campus culture is one of the main predictors of whether they persist or depart college during their first year (Terenzini & Pascarella, 1998).

Facilitating Sense of Belonging and Social Involvement. Seven criteria were cited by Tinto (1996) as reasons why students choose not to return to college for their second year: 1) academic challenges (e.g., GPA), 2) adjustment challenges, 3) financial worries, 4) external obligations (e.g., family), 5) changing or unclear goals, 6) lack of academic fit (e.g., motives), and 7) social isolation. Continuing generation students customarily, rely on family and friends for support or assistance, while first-generation students often have limited social support to draw from (Jenkins et al., 2013; Soria & Stebleton, 2012). Because FGCS departure is relatively high in the first year, setting up early experiences that make students feel welcome and cared for, is important to their academic success (Mireless Rios & Garcia, 2019; Tinto 1993; 2012). Ostrove & Long (2007) found that college students' socioeconomic status (i.e., family income, parents' education, parents' occupation) significantly predicted their *sense of belonging* which influenced their academic and social adjustment to college. This suggests that students from lower socioeconomic backgrounds are more likely to feel marginalized in college (Ostrove, 2003) and sense of belonging can mediate their adjustment. Indeed, research on belonging suggests the psychosocial construct has strong effects on cognitive processes, emotional patters, behavioral responses, well-being (Baumeister & Leary, 1995), and predicts peoples' perceptions of how meaningful life is (Lambert et al., 2013). Because first-generation students come from predominantly low socioeconomic backgrounds facilitating places of belonging for them on campus is important to their college transitions (Jehangir, 2009).

In Phinney & Haas' (2003) research, students who felt unsuccessful academically, reported they could not stay focused on coursework because they didn't feel supported by others. Research shows that first-generation and racial minority students who participate in *mentorships* (or have role models) are more likely to a) develop better grades, b) have reduced stress/anxiety, d) be more academically/socially engaged, e) cultivate a positive outlook or connection to the university environment, and f) heighten their academic identity or self-concept, and g) stay in school while completing courses (Baker, 2013; Bordes & Arredondo, 2005; Brooms et al., 2015; Campbell & Campbell, 1997; Deil-Amen, 2011; Phinney et al., 2011; Santos & Reigadas, 2005). Demetriou et al. (2017) interviewed successful first generation students and found that every participant fostered at least one developmental relationship with a more experienced person, with the most cited relationships being academic, peer, and employment mentorships. However, the composition of the mentor-mentee pairing is important because students who share similar life experiences and have similar demographics may be better able to develop trust and bonds, which can lead to beneficial academic outcomes (Brooms et al., 2017; Lee, 1999; Santos & Reigadas, 2005;*)*. Mireles-Rios and Garcia's (2019) asked 25 Latino/a undergraduate students their insights in developing the ideal graduate mentorship program for first-year students. Students recommended that mentors have similar cultural backgrounds as their mentees, so they can connect through shared experiences. Successful pairings can help promote high academic and career aspirations as well as goal-setting (Santos & Reigadas, 2002). Mentors can also facilitate faculty and staff interactions, since minority students may feel shy or nervous about reaching out to faculty (Mireles-Rios and Garcia, 2019). While mentoring does not always have efficacious results (Grossman & Rhodes, 2002), social support may be particularly helpful to students who have few family members to rely on for help (Phinney & Haas, 2003).

Receiving social support and having positive interactions with administrators, faculty, and/or peers, has been shown to help students develop successful relationships which positively impact belonging and self-efficacy (Braxton et al., 2000; Phinney & Haas, 2003; Torres & Solberg, 2001; Strayhorn, 2008). Both self-efficacy and social support have been found to positively impact college students' academic success (e.g., persistence and adjustment) (Chemers et al., 2001; Cutrona et al., 1994; Newby-Fraser & Schlebusch, 1997) and well-being (Wang & Castañeda-Sound, 2008). Social support may mediate the relationship between students with low self-efficacy and their academic performance by providing vitality (i.e., high interest and energy) in learning tasks (Carmeli et al., 2020). Access to supportive people (e.g., faculty) is critical for students' academic engagement/involvement (Gándara & Contreras, 2009, Gibson et al. 2004;

Umbach & Wawrzynski, 2005). Students who believe they are part of an environment that is supportive of their learning processes and are more engaged/involved academically are more likely to experience cognitive and affective developmental gains (Astin, 1984; Kuh et al., 2008; Filkins and Doyle, 2002; Montelongo, 2002).

Facilitating First Year, First-Generation Students' Academic Learning and Development. Supporting first year, first-generation college students' academic learning and confidence is important because academic performance in the first year can increase chances of persistence, as well as graduation from disciplinary fields (Crisp et al., 2009; Dika & D'Amico, 2016; Hanson & Swann, 1993; Whalen & Shelley, 2010). Developing cognitive resources associated with cultural capital such as strategies, skills, attitudes, and values, as well as opportunities to develop relationships with faculty and peers, have been discussed as important factors in students' development into adulthood (Zarrett & Eccles, 2006). Many colleges try to help FGCS transition to college by offering programs that supplement social and cultural capital, thereby closing social and achievement gaps. For example, academic skills (e.g., linguistic, reading, writing, metacognitive and regulation skills) have been cited as important resources in first generation students' disciplinary learning and educational success (Crook 1997; De Graaf, et al., 2000; Horowitz, 2019). Students who effectively utilize and/or master specific strategies and cognitive skills that are preferred in higher education, can be said to have access to cultural capital.

Successful first-gen programs offer systematic and thorough academic support services, such as learning laboratories, tutorial services, progress monitoring, and mentoring and advising (Richardson and Skinner, 1992). Pre-college, federally funded TRiO programs such as Upward Bound seek to support underrepresented FGCS by providing guided instruction and counseling to help facilitate their entry into a college program/discipline. Additionally, MESA a state-funded program, empowers teachers to support underrepresented middle and high school students to excel in STEM (science, technology, engineering, and math) by equipping them with the abilities to solve problems and work with others. Other outreach programs include nonprofits such as *UStrive*, online communities such *rise first*, district partnerships such as *AVID*, and university partnership programs such as GEAR UP, which seek to prepare students for college academics while supporting their cultural transition (Contreras, 2011). Programs that assist underrepresented minority students in making the transition to higher education can be essential in identifying student abilities and nurturing those abilities to prepare them for the academic rigor of college (Contreras, 2011).

Smoothing first-generation students' transitions from their home worlds (e.g., high school) to the college world has been stated in the literature as an important educational goal, as is providing focused support for the duration of their first year of college (Cerezo & McWhirter, 2012; Garriott et al., 2015; Terenzini et al., 1996). First-generation students have shown to benefit more than continuing-generation students from engagement in non-traditional academic pedagogies, such as collaborative and active learning environments which facilitate peer interaction and reflection (Filkins & Doyle, 2002; Tinto, 1997). First-year interventions that integrate students’ voices, knowledge, and experiences can foster a sense of belonging and support students’ academic transitions (Rendon, 1994; Tinto, 1987; Jehangir, 2009). Learning communities which facilitate disciplinary learning by connecting (rather than separating) students’ lived experiences offer students opportunities to, a) more meaningfully discuss and learn academic concepts, b) reflect on how they learn, c) use dialogue to teach others, and d) connect cognitive and affective ways of knowing, e.g., connecting ways of feeling and thinking (Gonzales et al., 2015; Jehangir, 2009; 2010; Markle and Stelzriede, 2020).

Facilitating underrepresented students' reflections on their personal experiences and connecting those experiences to academic subject matter, can heighten how they see themselves and their identities (Castillo-Montoya and Reyes, 2018; Ives and Castillo-Montoya, 2020). Such opportunities for learning fosters critical thinking and consideration of multiple perspectives which aids development. First-year, learning community programs that increase reflection and academic learning outside of the classroom, have shown to improve persistence and retention rates (Gilbert-Thomas, 2018: Pike et al., 1997), intellectual and interpersonal development, as well as academic performance (DeAngelo, 2014; Pasque & Murphy, 2005; Markle & Stelzriede, 2020). However, there is still much to learn about how participating in these academic experiences affects students (DeAngelo, 2014). Learning communities have a positive relationship with student engagement (Pike et al., 2011; Rocconi, 2011) but because they are often facilitated on the margins of the dominant curriculum (i.e., not incorporated into academic learning across disciplines) their effects on student development and learning may be mitigated (Tinto, 1997).

Classroom Teaching and Student Involvement in College

The college classroom is where academic and social worlds converge. The majority of students' academic involvement with peers occurs inside the classroom, which makes this environment an important factor in students' academic success (Demaris & Kritsonis, 2008). Research indicates that students' academic and social engagement/involvement, learning, and persistence are all intimately related via the classroom experience (Astin, 1993; Demaris & Kritsonis, 2008; Dwyer, 2017; Tinto, 1993; 2020; Umbach et al., 2005). Tinto (1997) contends that academic and social involvement must occur in the classroom if students are to be supported effectively.

Though, the value of collaborative, competency-based learning environments are well documented (Cabrera et al., 2002), transmission methods are in ubiquitous practice. The didactic model or ‘lecture’ in higher education is the predominant form of teaching (Stains et al., 2018), which has limited impact on student participation, motivation, and learning (Gorham & Millette, 1997; Nunn, 1996; Schmidt et al., 2015). Lecture-based courses are associated with traditional, teacher-centered pedagogy, in which knowledge flows from teacher to student. There are various types of lecture formats, with varying degrees of student involvement, but in general, lecture implies that teachers spend the majority of class time speaking about subject matter of which they are knowledgeable (Pintrich, 1994). Lecture is an efficacious and cost-effective way to ‘transmit’ large amounts of information to large classrooms of students. Students are then expected to comprehend and recite this information for quizzes and tests.

Referred to as the “recitation script” by Tharp & Gallimore (1991), the transmission model of learning, limits participation, casting students into passive, response-oriented roles (Haertel, 2009; Tharp & Gallimore; 1991; White-Clark et al., 2008). Engeström (1987) posited that traditional classrooms reverse the *object* and the *instrument* making the act of ‘schooling-going’ counterintuitive. Instead of utilizing a textbook as a mediating tool to explore and discuss meaningful concepts, traditional classrooms aim to recreate the very text or lesson that is assigned to students. In this way, all lesson activities and tests revolve around the recreation of the text; it becomes the object as well as the instrument of schooling. In this paradigm, learning is often perceived by students as not something they do, but something that happens to them

(Ramsden, 2003). Students may seek to fulfill the required coursework with minimal effort and little reflection on what and how they learn (Biggs and Tang 2011; Prosser & Trigwell 1999).

Power Dynamics of Traditional and Constructivist Classrooms. Some scholars suggest that teachers in traditional classrooms act through ‘authoritarian’ (the one who knows) roles (Alt & Itzkovich, 2018; Hammerness et al. 2005). Students are expected to be attentive listeners, adhering to the sociocultural realities and formulations of knowledge that the dominant culture disseminates. Delpit (1988) contends that educational institutions codify ‘cultures of power’ in their practices through unchallenged linguistic forms (i.e., ways of talking, ways of writing, and ways of interacting) often silencing minority students dialogue, forcing them to acquire or assimilate the dominant literary culture (p.283). Traditional methods ask students to accept the teachers’ conceptions of truth, morality, and the ways in which knowledge is formulated in class, which may *disempower* them by disallowing their development of expert knowledge (Delpit, 1988; Weimer, 2002). Tinto (1997) argues that classroom experiences that fail to integrate student voices are tantamount to them having “no voice at all (p.616).”

In contrast, teaching as a facilitative practice is associated with helping students learn independently (Kember and Kwan, 2000). The objective of this approach is to change students’ roles and conceptions of learning from passive listeners to active learners who construct knowledge through forms of literacy (listening, speaking, reading, writing, viewing, thinking, and calculating) (Arwood, 2011). Research consequently suggests that learning is enhanced, when students actively engage in their learning processes and communicate what they’re thinking and learning (Astin, 1987; Ahn & Class, 2011). Santos et al. (2019) for example, conducted an integrative literature review of student-centered pedagogical practices in higher education, and the results from such studies. The authors identified several strategic practices that promoted students' active involvement in their learning processes, such as, a) peer and formative evaluation, b) active/collaborative learning (e.g., flipped classrooms), and c) mixed approaches (with lecture and/or technology) that integrate discussion, reflection, and problem-solving (e.g., problem-based learning and research based learning). The articles they examined on student-centered approaches in college, cumulatively showed that students learned more deeply, developed higher-order cognitive skills, and developed critical and reflective thinking. Collaborative practices/strategies also increased students' motivation for learning and improved their ability to communicate with peers/faculty. Challenges to student-centered approaches were associated with class participation and difficulties thinking creatively and critically. Teachers in turn, reported greater levels of satisfaction and involvement (e.g., feedback). The authors surmised that diversification of pedagogical practices, should be considered to support all students' needs.

What is agency? Student-centered pedagogies, which give students a voice and a choice in their learning have been shown to be empowering, helping students become agents in their learning and academic success (Ahn & Class, 2011; Bovill et al., 2011; Freire, 2005; Reyes, 2009). An agent is a person who intentionally acts into the world to shape their functioning, experiences, and circumstances (Bandura, 2006). However, agency is not finite, and is mediated (influenced) by a person's sociocultural environment and experiences (Bruner, 1996; Case, 2015; Rappa & Tang, 2017). Agency is important in academic settings because students who develop agency are better able to direct (or regulate) their thinking/learning inside and outside the classroom to achieve specific goals (Vaughn, 2014; Vaughn et al., 2020). Student agency is related to a) better academic learning and literacy achievement, b) increased learning satisfaction, and c) improved cognitive development, including critical reflection/engagement, problem-solving, and self-regulation (Blair, 2009; Crick et al., 2015; Luo et al., 2019; Lindgren & McDaniel, 2012; Rappa & Tang, 2017; Rutenberg et al., 2022; Reeve & Tseng, 2011; Vaughn et al., 2020).

Vaughn (2020) systematically assessed literature examining the construct of *agency* in education and found that agency constitutes, a) positional factors related to the social structure in learning contexts, b) motivational factors linked to students' abilities to regulate their behaviors, (see Bandura, 1986; 1997; 2001), and c) dispositional factors, such as being determined to achieve a goal or being resistant to challenges. Conversely, Rutenberg et al., (2021) identified three different (but similar) factors constituting agency in a flipped classroom: action, metacognition, and self-efficacy. Research examining student agency is relatively consistent in describing agency through behavioral, cognitive, and motivational characteristics (Vaughn et al., 2020). These characteristics are socially constructed in learning environments where students contribute their voices, cultural backgrounds, lived experiences, identities, languages, and goals alongside teachers (Vaughn, 2020).

Equitable Learning Practices for First-Year and First-Generation Students. Minority students from disadvantaged backgrounds experience a range of factors that negatively impact their academic achievement such as early experiences (within families/schools) that affect cognitive and non-cognitive development, changes in parental makeup, microaggressions, and discrimination in educational contexts (Barton & Coley, 2010; Perry & Morris, 2014; Valencia, 2012). Early US government research on minority students (Mexican-American students) schooling showed that many were not engaged in meaningful classroom interactions and even ignored when compared to White students (US Commission on Civil Rights, 1973, p.43). More recent research from the US Commission on Civil Rights (2019) shows that black students are disciplined more severely (e.g., expulsion), for longer durations than their white peers, though they commit no more infractions (US Commission on Civil Rights, 2019, p.24). The report adds, that “excessive exclusionary discipline negatively impacts classroom engagement and cohesion and increases the likelihood excluded students will be retained in grade, drop out of school, or be placed in the juvenile justice system (p.24).” This finding is consistent with previous educational research that shows disciplinary actions in K-12 public schools are administered unequally against minority students and adversely impact academic outcomes (Lewis et al., 2010; Monroe, 2005; Perry & Morris, 2014; Skiba et al., 2002). Racial minorities regularly experience structural inequalities in the form of negative stereotypes within schools, which can lead to their departure (Lee, 2003).

Supporting first-generation students’ learning is conceived by many as a matter of equity because the population is interlaced with demographics (e.g., racial minorities, females, lower-income families) that regularly experience oppression, marginalization, and inequity in educational environments (Choy, 2001; Ives & Castillo-Montoya, 2020; Lohfink & Paulsen, 2005; Rondini et al., 2018). Minority students in predominantly White colleges may correspondingly encounter educational cultures that are unsupportive or aloof to their intellectual and cognitive development (Allen, 1992; Fleming, 1984; Nettles & Theony, 1988; Olivas, 1986; Fleming et al., 1995). Such educational inequities (i.e., lack of opportunity) are largely defined by what occurs in the classroom (Reyes, 2009). Many teachers have not been adequately prepared to implement equity-based pedagogical practices and strategies for minority and disadvantaged students (Gillian-Daniel & Kraemer, 2015). Research shows that instructor quality and instructional practices impact minority students’ learning and academic performance

(Bensimon, 2007; Darling-Hammond, 2000; Ehrenberg & Brewer, 1994; Ferguson, 1991; Nettles, 1991).

Tinto (1997) contends that most college classrooms are likely "not involving and therefore not a factor in student persistence (p.616)." Learning is only 'involving,' when it is meaningful for students, i.e., when the subject matter and activities are meaningful (Tinto, 1997). To properly promote first-generation college students' integration into the academic community, faculty can be more proactive in early outreach efforts (McKay & Estrella, 2008). For instance, Pascarella et al. (1996) found that teachers practices in the classroom impacted first-year students' beliefs that classroom success stemmed from their internal abilities. Three teaching practices which related to students' internal attribution of success were those in which teachers' effectively a) organized and prepared class material, b) helped students understand academic material, and c) offered support (e.g., made themselves available outside class). In other words, students believed they had more agency over their academic success because of effective teaching practices and support.

Practitioners can consider the nature of students' interactions with agents (e.g., peers and faculty), as a contributing factor in their socialization and success (McCallen, & Johnson, 2020; Pascarella et al., 1996). For instance, Wang (2014) interviewed 30 first-generation students to understand turning points that led to their successful transition to college. Using qualitative thematic analysis to identify themes in participants' transcripts, the author identified 105 different turning points - one of the most prevalent being teachers who empowered students to believe they could take "ownership or control for their learning" and "overcome challenges" associated with being a first-generation student (p.77). Similarly, Reyes (2009) analyzed interactions that supported marginalized, Mexican-descent students in their first-year in college through the College Assistance Migrant Program (CAMP). The researcher found that key interactions occurred between faculty and members of the academic community that contributed to their agency, learning (e.g., knowledge of self/community), and/or empowerment. Reyes (2009) argues that “schools and classrooms today must contend with sociohistorical, cultural, and socioeconomic aspects of schooling that affect the learning and development of marginalized students (p.116).”

FGCS need help seeing that they can flourish in academic environments by understanding how their own social and cultural differences matter (Stephens et al., 2014a). Studies demonstrate that the achievement gap for disadvantaged and FGCS decrease when faculty engage in development programs that support the deployment of more inclusive teaching strategies/practices (Schmid et al., 2016). Preparing faculty to teach more inclusively to a diverse student population, has been stated as a critical strategy for boosting the success rates of minority students (Gillian-Daniel Kraemer, 2015; Castillo-Montoya & Ives, 2021b). For example, Schademan & Thompson (2016) found that faculty were better able to support FGCS when they changed their conceptions of FGCS from students with ‘fixed abilities’ to students with ‘cultural wealth’ who ‘develop’ in their classrooms.

Instructors can help first-generation college students by integrating their lived experiences, identities, and backgrounds as positive learning resources (Bass & Halverson, 2012; Jehangir, 2009). Students who perceive a learning activity is consistent with their own identity are often better able to engage with subject matter and tend to perform better (Oyserman & Destin, 2010). One method to do this, is to help students understand the value of their diverse cultural backgrounds (Denson, 2009; Gurin et al., 2013; Milem et al., 2005). Interventions that support FGCS through identity-congruent activities (i.e., alignment between student backgrounds and academic activities) can help students develop psychological resources (e.g., self-authorship) that influence desired learning behaviors, while altering the structural conditions of the academic environment (Oyserman & Destin, 2010; Reyes; 2009, Stephens et al., 2012a). When instructors acknowledge first-generation students' prior experiences, in terms of what they've been through, what they've learned, what they believe, and are capable of doing, they can help students build a foundation of learning (Jehangir, 2009).

Grier-Reed et al., (2009) for example, offered a constructivist career development curriculum to 75 college students at a large Midwestern university, 45% of which were racial minorities and 55% were White. Students were administered two separate assessments before and after the intervention. One assessment measured career self-efficacy and another measured students' confidence to complete career-related tasks. Differences between pre- and post-test scores were measured using multivariate analysis of variance. The authors found that at-risk culturally diverse college students had increased career self-efficacy and less self-defeating thoughts. The authors posited that constructivist activities, such as problem-solving and self-reflection can help students uncover strengths that empower at risk college students. Constructivist strategies for learning, such as "narrating one's own story, exploring one's values, beliefs, and culture, constructing identity in context, and interpreting experience in personally meaningful ways" provides effective tools for facilitating empowerment and decision making processes (Grier-Reed et al., 2009, p.301).

Teachers who foster agency, cultivate classroom environments for group discussion where students share their stories, ideas, and viewpoints and students are empowered to make choices about how they convey ideas (through assignments) (Vaughn, 2020). Students are also encouraged to consider other people's perspectives and work collaboratively. Jehangir et al.

(2012) contends that the classroom itself can function as a ‘learning community’ by incorporating activities and opportunities that honor first-generation students' narratives in a manner that enables them to “gain voice and empowerment.” Learning communities have been shown to simultaneously foster academic self-concept, knowledge construction, and factors related to confidence (Jehangir, 2009; Morales, 2014). As first-generation students negotiate their perceptions, beliefs, and identities across communities that learn in concert, they can develop schooling identities (literacy-based identities of themselves as readers, writers, learners with motivations that compel learning) (Jehangir et al., 2012; Vaughn, 2020; Verdín, 2020). College learning environments are therefore critical in first-generation students’ academic success, and the ways they think about and control their academic learning (Franklin et al., 2018; Wibrowski et al., 2017. Teachers specifically, can bend the power dynamics inside the classroom to empower students to shape the cultures in which they learn and grow (Jehangir, 2009; Kirk et al., 2016; Lewis et al., 2008; Vaughn, 2000). The next section discusses this study’s conceptualization of metacognition and metacognitive regulation before discussing literature that shows how metacognition supports first-generation students’ learning and success.

Relationships between Metacognition, Meta-learning, and First-generation Students

Many universities have expectations for students to develop critical thinking and metacognitive skills (Davies, 2011; Villalon & Calvo, 2011). Despite substantial research showing the impact metacognition has on college students’ critical thinking (Magno, 2010), academic success, and learning (Coutinho, 2007; Veenman & Elshout, 1999), there has been few systematic efforts to support metacognition among FGCS, and sparse research to draw conclusions from. This study conceives of metacognition through a) developmental literature which explains how children acquire language, b) neuroscience literature that outlines the brain’s thinking and learning processes, and c) psychology literature that delineates the various metacognitive components and their impacts on students' thinking and learning (Barsalou, 1999; Brown, 1978; Jacobs & Paris, 1987; Flavell, 1979; Efklides, 2006; 2008; 2009; 2011; Pulvermüller, 2012; 2013a; 2013b). In this section, the construct of metacognition will be operationalized and its various psychological components outlined. The concept of *meta-learning* will be discussed as an avenue to support underrepresented students' metacognition, regulation, conceptual learning, and life-long learning. Five recent studies have been conducted with first-generation students that focus on their metacognition as a means to support their academic success, and each will be discussed in a subsequent section.

Metacognition in the Research

Metacognition has been conceptualized broadly in the literature as *thinking about one's thinking or learning,* and is recognized in this study, as a language-based function that allows conceptual thoughts and mental representations to come under a person's conscious control (Arwood, 2011; Flavell, 1979). Flavell (1979), a developmental psychologist, first introduced metacognitive functionality to explain how children monitor cognitive tasks, and ultimately develop in educational contexts. He operationalized monitoring into four classes of cognitive phenomenon 1) metacognitive knowledge, 2) metacognitive experience, 3) tasks and goals, and 4) actions and strategies. Metacognitive knowledge consisted of three categories which impacts whether students act on a cognitive enterprise: a) Person factors, b) task factors, and c) strategy factors.

The "Person" category encompasses students' knowledge and ideas about themselves as thinkers and learners (e.g., mental strengths and weaknesses), as well as beliefs about the thinking/learning processes of others (Baten et al., 2017). This personal knowledge, as well as the knowledge of the strategy and task guides the learner in how they manage the task and track their success. Thus, students may evaluate, engage in, or withdraw from a learning task based on their own interests, their beliefs of the difficulty of the task, and whether their abilities/strategies allow them to complete the task successfully. This leads to a wide range of metacognitive experiences, which attune the mind to interactions with oneself, tasks, goals, and strategies, enabling an individual to interpret the behavioral implications of such experiences.

An emphasis on strategic control processes was later expanded to encompass what some refer to as “metacognitive control” (Nelson et al., 1994). Nelson (1996) for example, described metacognition, as a higher-level cognitive process, which plays a role in forming conscious representations of cognition through monitoring processes and in exercising control over cognition using those representations (Nelson 1996). In other words, information flows between lower-level cognitive processes and higher-level metacognitive process in a reciprocal bottom-up and top-down exchange, which allows a person to become aware of their mental representations (i.e., ideas generated from interactions with the external world) and exert control over their thinking based on those representations. As one becomes aware of and can control their cognitions they enter a critical step of being able to learn new and positive behaviors.

Research in cognitive psychology from the latter half of the twentieth century has differentiated metacognition into various domains that involve 1) knowledge 2) affectual experiences and 3) self-regulation and control skills (e.g., planning, monitoring, revision, evaluation) (Baker & Brown, 1984; Efklides; 2006; Nelson & Narens, 1990; Weil et al., 2013). This latter domain involves the process by which students come to *regulate their learning* (i.e., enact successful behaviors or strategies that lead to learning) (Winne & Perry, 2000). Also termed *regulation of cognition* by Scraw & Dennison (1994) and *metacognitive regulation*

(Brown, 1978), this process involves a dynamic information exchange between monitoring processes, judgments of cognition, and control processes using judgements to direct specific goal-oriented activities or behaviors (Dunlosky & Ariel, 2011; Jacobs & Paris, 1987). The researcher of this study conceptualizes metacognition as Frazier et al. (2021) in their metacognitive intervention with FGCS, as allowing for self-regulation through the processes of metacognitive control (see Efklides 2011; Hertzog, 2015). This study thus, distinguishes between the terms, metacognitive control, metacognitive regulation, and self-regulation as separate but connected processes. Metacognitive regulation (MR) or just, 'regulating learning' refers to internal mental processes governed by metacognitive control that support thinking and learning (e.g., mental strategies); whereas self-regulation refers to learning strategies, actions, and behaviors students engage in to direct their learning. The ability of a learner to think metacognitively is denoted by their abilities to "to reflect upon, understand, and control (their) learning (Schraw & Dennison, 1994, p.460)." This includes questions and assessments of one's learning and thinking.

Though, metacognition has been researched in depth, in various fields for over four decades (amounting to a canon of literary work), new phenomena/behaviors are still being explored (Tarricone, 2011). As mind and brain research has become more prevalent over the last two decades, researchers have begun to investigate the neural basis for metacognition to provide an interdisciplinary theoretical framework (bridging cognitive behavior and neurobiology) that can support educational applications of strategic thinking (Sodian & Frith, 2008; Valk, et al., 2016). These studies investigate metacognition as an extension of executive functioning (EF), utilizing conscious judgments (e.g., confidence ratings) of task performance as indications of metacognitive ability. Several of these studies suggest that metacognition is a dynamic neural ability in which specific metacognitive modalities (i.e., domains) may be dependent on divisible, introspective networks in the brain (Baird et al., 2013). These networks are responsible for semantic processing, social-cognition, and language comprehension (Frith, 2012; Valk, et al., 2016). For instance, some research has suggested that the medial and lateral anterior prefrontal cortex (aPFC) are uniquely situated to mediate metacognitive abilities given its connection to supramodal cortical architecture, allowing for the integration of lower-level operations with higher-level metacognitive evaluations (Baird et al., 2013; Christoff et al. 2003). As a result, metacognition is linked to neural feedback (linking cellular fibers), associated with top-down modulation, making it possible to conceptualize sensory input (e.g., visual stimuli) from the environment and retrieve semantic knowledge (Baars & Gage, 2010; Nelson & Narens, 1990; 1994).

Relevant Components of Metacognition

Researchers, such as Kluwe (1982) helped contextualize how procedural knowledge of metacognition can be acquired from the assessment of one's own mental processes in learning contexts and be applied to self-regulatory behaviors to reach a target goal. Consequently, metacognition denotes the intricate connection an individual has to internal mental representations of their external environment (Hacker et. al, 1998; Kluwe, 1982; Nelson, 1996). This connection includes the knowledge one has gained about their thought processes, how those thought processes function, and affective states resulting from previous experiences (Borkowski et al., 1990; Efklides, 2011; Flavell, 1979; Hacker et. al, 1998). Efklides (2009) noted that metacognition is not a 'mirror' of cognition, but rather a model or representation of cognition based on the brain's monitoring function. Monitoring and control functions during task representations (i.e., learning new ideas in tasks) can occur unconsciously or they can "take the form of inner subjective experiences…that constitute the contents of conscious awareness (Efklides, 2011, p.14).” Consequently, the development of metacognitive knowledge and strategies/skills is an effortful cognitive process that is crucial to one’s control of cognition and regulation of learning.

Paris and Winograd (1990) succinctly differentiated metacognition into a *self-appraisal* component, which denotes reflections of one’s knowledge, abilities, and affective states, including agency, and a *self-management* component which captures the active mental processes (e.g., monitoring and control) that helps learners *regulate* their cognition to solve a problem or complete a task. Correspondingly, Baker and Brown (1984) categorized metacognition as *monitoring* and *self-regulative mechanisms* that control the monitoring process. Monitoring denotes the ability to identify and evaluate one’s internal mental representations, while *control* signifies the regulation of cognitive behavior to achieve a goal (Grainger et al, 2016). Literature on self-regulation is more all-encompassing of metacognitive phenomenon, referring to the self-regulatory process as “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals (Zimmerman, 2002, p.85).” Those who self-regulate their learning are posited to metacognitively monitor and control their thinking and learning processes (Schunk & Zimmerman, 2007). Metacognitive skill, which is the control center for the student's cognitive effort to achieve their learning objectives, is a necessary component of self-regulation (Gourgey, 2000; Hacker, 1998; Händel et al., 2013)The interaction of metacognition and self-regulation can positively impact one’s learning and the development of academic/cognitive skills (Schunk & Zimmerman, 2007).

Whether metacognition is conceived of as a superior mechanism which guides self-regulation (Brown & DeLoache, 1978; Kluwe, 1987) or as subordinate but interdependent with self-regulation (Efklides, 2014; Schunk & Zimmerman, 2007; Zimmerman, 1995), affective (emotional-motivational) states, agency beliefs, and self-efficacy beliefs also play a crucial role in a students' ability to self-regulate their learning (Bandura, 1986; Efklides et al., 2006; 2019; Hacker et al., 2009). Self-efficacy in this instance, refers to students' perceptions of their ability to learn and perform learning tasks successfully (Zimmerman, 2000b) whereas, agency refers to the learners' perceptions they can exert control over their environment.

Efklides (2006; 2011) prioritized the affective component of metacognition to broaden Flavell's conception of *metacognitive experiences*. Efklides (2001) describes metacognitive experiences as various affective states which occur in learning tasks (the Task x Person Level), such as 'feelings of familiarity', 'feelings of confidence', 'feelings of satisfaction' that function to drive data to the "Person" level in a bottom-up self-regulatory fashion. This data interacts with attributes at the "Person" (or top-down level), such as one's self-concept, perceptions of control (e.g., agency beliefs), affect (i.e., social-emotional feelings), and perceptions of ability, which drives goal-directed, 'top-down' regulatory behaviors. For instance, a student's agency beliefs (i.e., perceptions of control) can be based on memory from previous metacognitive experiences, in which the student was involved in learning tasks and had control of their learning, comparative to learning tasks in which they did not have control (Metcalfe & Greene, 2007).

Efklides (2011) contends that self-efficacy is part of a person's self-concept (at the Person level) and "intricately connected to both metacognitive experiences (ME) and metacognitive knowledge (MK) in a bottom-up and top-down exchange (p.8)." Continual engagement with similar learning tasks and awareness of the demands in said learning tasks provides a flow of information about the self and self-efficacy beliefs which updates one's self-concept in specific domains or disciplinary fields (e.g., science) (Efklides, 2011). This could explain how students who regulate their learning successfully develop literacy-based identities with agentic or efficacy characteristics. One’s self-concept thus, has motivational, affective, and metacognitive characteristics (Efklides, 2011) and can involve one’s beliefs about the positioning in a classroom as compared to others, as well as one’s perceptions of what others think about their abilities (Dermitzaki & Efklides, 2000; Vaughn, 2000).

The relationship between self-efficacy and self-regulation is bidirectional, meaning the greater one’s self-efficacy, the greater their capacity to self-regulate learning and vice versa when self-efficacy is low (Schunk, 1990; Trautner & Schwinger, 2020). Zimmerman (2000b) contends that a student's self-efficacy promotes self-regulated learning in a given educational context by influencing the extent to which the student feels motivated to regulate their learning. In Bandura’s (1986) social-cognitive theory, the learning environment plays a critical factor in fostering self-efficacy to support students’ self-regulation or control processes and illustrates why students’ self-regulation can vary based on their academic involvement. Students’ experiences with agency in classrooms, in terms of being the “I” in control of ‘my’ learning processes and/or the agent who implements strategies on behalf of ‘my’ learning, are important motivational components of students who enact metacognition and control their learning successfully (Efklides 2008; 2011; Metcalfe & Greene, 2007).

Teaching and Facilitating Metacognition

Metacognition has been studied in depth over the last five decades, as educators have realized its potential in supporting students’ thinking and learning processes. Young children, in preschool and kindergarten have relatively little knowledge about their own cognition and therefore engage in limited monitoring of their own learning (Brown 1978; Flavell, 1978; Flavell & Wellman, 1975; Kreutzer et al., 1975). Educational research has corroborated that metacognition can be explicitly trained and/or embedded in educational curriculum over prolonged periods and is learnable in children (Schneider & Artelt, 2010; Veenman, 2013) as well as adolescents (Veenman et al, 2005). Metacognition has correspondingly been shown to be important in the academic success of late adolescents, including college students (Ley & Young, 1998; Ward & Butler, 2019; Wolters, 1998).

Metacognition is posited to play a role in exerting influence on the phases of forethought, performance control, and self-reflection involved in self-regulated learning (Efklides, 2011; Ohtani & Hisasaka, 2018). Metacognition has thus, been assessed in terms of *cognitive ability*, denoting self-regulatory or introspective skills by which learners govern their own thinking and behaviors (Efklides; 2011; Flavell; 1979; 2000 Fleming & Dolan, 2012; Frith, 2012; Schneider, 2008; Joseph, 2009; Weil et al., 2013). Findings suggest that students with insufficient metacognitive skills are more likely to be poor performers who tend to overestimate their academic performance (Kruger & Dunning, 1999; 2002). Educators play a critical role in the development of metacognitive knowledge and skills, by facilitating reflective experiences and offering feedback on learning tasks (De Jager et al. 2005; Sandi-Urena et al., 2012). Metacognitive skills have consequently been shown to be a powerful predictor of learning performance, including deeper conceptual understandings (Azevedo et al. 2010; Marulis et al. 2016; Sodian & Frith, 2008).

Recently, high school and university educators have begun to facilitate metacognition within collaborative learning environments. Findings from this literature suggest that group learning is dependent on students' metacognitive regulation (Volet et al., 2013). Khosa & Volet (2014) for example, examined the role metacognitive regulation played in controlling the flow of cognitive activity among groups in an undergraduate physiology course. The researchers found that metacognitive regulation was shared among group members which led to collaborative discussion, (e.g., reflection, elaboration, and justification of academic content). High levels of metacognitive regulation explained differences between groups collective understanding. This finding is commensurate with Lajoie and Lu (2011), suggesting scientific decision-making within groups is associated with high-levels of metacognitive regulation which is associated with high-levels of cognitive activity and conceptual understanding. Metacognitive thinking and regulation can, therefore, be shared or co-regulated among group members in the pursuit of disciplinary knowledge. Students who consciously monitor, reflect on, and exert influence over their learning and/or the learning of others can be said to exercise ‘agency’ and ‘regulation’ simultaneously.

Metacognitive Strategies

Students who self-regulate their learning are active in the use of learning strategies, including metacognitive strategies, to support their thinking during learning tasks (De Backer et al., 2011; Paris & Paris, 2001; Pintrich et al. 2000; Winne, 1996; Zimmerman & Pons, 1989). Metacognitive strategies, consist of the methods that students employ to gain and/or develop metacognitive control of their learning processes (Rahimi & Katal, 2012). Therefore, metacognitive strategies involve students’ knowledge of their thinking and learning processes, including planning, monitoring, and regulation strategies that support these processes (Pintrich et al., 1993; Pintrich, 2002). Several studies have found a connection between metacognitive knowledge and monitoring accuracy (Schraw, 1994; Schraw & Dennison, 1994), suggesting that monitoring improves with practice and understanding (Delclos & Harrington, 1991). Additionally, Moè et al. (2001) illustrated how students’ strategy comprehension - that is the knowledge they had of strategies, and their ability to utilize and evaluate strategies - was a critical component in their academic achievement. Students who develop metacognitive skills (i.e., skilled use of metacognitive strategies for learning) are better able to grasp the difference between shallow learning (involving memorization and recall) and deep learning (constructing meaning through the acquisition and development of language-based concepts) (Arwood, 2011; Lindblom-Ylänne & Lonka, 1998). A student may thus, implement a metacognitive strategy, such as writing in their own voice (i.e., words), to avoid the surface level approach of copying notes the teacher provided because they believe the deeper approach is more beneficial to their development and/or success. Knowledge and application of metacognitive strategies, initiates metacognitive experiences, which are learnable moments constituting affective components, providing the road map to metacognitive skills and self-regulation (Efklides, 2006; 2011).

Besides supporting control processes, the implementation of metacognitive strategies (including visual-mental strategies) supports students' engagement in higher-level thought processes beneficial to problem-solving, critical thinking, and conceptual learning (Arwood, 2011; Magno, 2010; Swanson, 1990). Students who effectively apply metacognitive strategies have been shown to a) consciously integrate new information with existing information (Baten et al., 2017) b) scaffold their learning, and c) evaluate their performance (Zhang & Goh, 2006). When explicitly trained and/or embedded in the curriculum, metacognitive strategies have helped learners develop literacy skills in reading (Dabarera et al, 2014; Artelt et al., 2001), math (Baten et al., 2017; Schneider & Artelt, 2010; Desoete et al. 2003; Veenman, 2013) and academic writing (Negretti, 2012). Metacognitive strategies and/or skills have also been linked to improved academic performance in fields such as mathematics (Özsoy, 2011), chemistry (Mutambuki et al., 2020) medical science (Colthorpe et al., 2018), and English (Pintrich & De Groot 1990), among other fields.

Muteti et al., (2021) for example, found that most first-year chemistry students used rote memorization techniques (e.g., reading/re-reading, memorizing, flashcards) for STEM classes rather than higher-order strategies (e.g., practicing problems, reflective learning, collaborative learning, self-assessment) commensurate with scientific disciplines. The researchers applied a metacognitive intervention that taught first-year students about higher-order study strategies (HOSSs), such as a) reflecting on their learning experiences, b) writing down important ideas they learned in class (without consulting notes), c) identifying patterns in various concepts, and d) drawing diagrams (e.g., flowcharts) to help students see the relationships between concepts. Students who participated in the metacognitive intervention reported more use of HOSSs, which corresponded to improved academic achievement. The researchers argue that first-year students need access to metacognitive strategies because many have not been taught effective learning strategies consistent with college-level STEM disciplines.

First-generation Students and Metacognition in the Literature

This subsection focuses on research that examines first generation students and the construct of metacognition as a means to support learning and academic success. Underrepresented and first-generation students in general enter college with varying degrees of academic preparation, but often find support programs helpful for strengthening college planning and academic skills (Santos & Reigadas, 2002; Throgmorton, 1999; Wibrowski et al., 2017). Antonelli et al. (2020) showed that both first-generation students and non-first-generation students lacked self-regulatory skills conceived of as being necessary to succeed in college. First-generation students scored lower on most scales that measured self-regulated learning (SRL) than traditional students, showing a pattern of strengths (e.g., motivation) and weaknesses (time management and self-testing). Additionally, the authors analyzed whether coursework at a 4-year university would impact any gains between the two groups, but the researchers found the differences were negligible. This means that coursework did not significantly impact strategy learning or study skills between first-generation and non-first-generation students. The authors suggested that first-year programs be designed to support the development of SRL skills rather than hoping students develop these skills on their own.

Aspelmeier et al. (2012) conducted an online survey with 322 undergraduate students and found that FGCS status significantly moderated the relationship between psychological factors (e.g., self-esteem and locus of control), and academic outcomes (GPA and adjustment). Meaning, first-generation students who felt more in control and believed in themselves were more likely to report better academic and personal adjustment and have better grades than continuing generation students. The authors suggest that interventions be designed for FGCS to help them develop academic self-efficacy and personal control of learning (or self-regulation skills) to improve academic outcomes. Morales (2014) similarly recommended that programs seeking to retain at-risk students work toward developing students' self-efficacy and their ability to appraise personal strengths and weaknesses (akin to emotional intelligence). From the body of research, it's evident that cognitive and affective aspects of first-generation students' development are important for their academic success. Therefore, the development or changes to those internal resources are important to consider. Consequently, there is a need in higher education to understand how and why first-year FGCS take control of their learning, to inform educators of the support mechanisms needed to engage these students in their own thinking and learning processes.

Metacognitive interventions can promote conceptual change and understanding (Nickerson et al., 1985; White & Gunstone, 1989) and have been shown to improve students' academic involvement and cognitive development (Adey & Shayer, 1993; Georghiades, 2000). However, little research has been done on supporting first year, first-generation students transitions to college through metacognitive interventions. The five recent studies that have been conducted help explicate, a) how metacognition is conceptualized in terms of supporting first-generation students, b) the various constructs that align with metacognition, c) the ways metacognition can be facilitated in a classroom, d) the benefits of metacognitive interventions on first generation students' learning and success, e) previous experiences with learning and f) the challenges that FGCS face in their first few years of college. Those studies are discussed next.

Tao (2021) Metacognition Study. Tao (2021) conducted semi-structured interviews with seven first-generation students who had just completed their first year at a predominantly White liberal arts college. Six students identified as racial minorities, and one student identified as White. The researcher asked about their experiences and challenges in introductory biology and/or chemistry courses. Tao (2021) utilized Flavell's (1979) *metacognition* theoretical framework to examine how students overcame academic challenges. Using Interpretative Phenomenological Analysis on participants transcripts, the author identified four prominent themes in the language samples: 1) all participants stated their high school coursework was easy, but spoke highly of previous teachers who helped them graduate and pursue science disciplines in college; 2) participants felt bias against them in their introductory science courses because of their identification as first generation and/or their ethnic and cultural makeup; 3) participants had trouble adjusting to the events surrounding the COVID-19 pandemic which forced in-person classes to move to an online format; three of the seven participants subsequently dropped their science courses; 4) participants' responses to setbacks and challenges were framed as emotional, which caused "frustration, fear, and helplessness" and/or behavioral, resulting in "avoidance, denial, self-blame, and self-doubt (p.115).” Among the six students who identified as minority, four faced micro-aggressions and/or feelings of isolation, which made it difficult to reach out for help and continue with their studies. Metacognition was discussed as a psychological trait that many participants were not able to utilize, but when applied to their studies helped bolster self-efficacy and self-advocacy of their learning needs. The researcher recommended that FYFG students be provided interventions that offer a) mentoring support, b) affirmational practices that show they are valued and belong in college, and c) metacognitive strategies to facilitate development of metacognitive thinking and effective learning approaches.

Wibrowski et al. (2017) SLSP study. Wibrowski et al. (2017) conducted a study with 876 first-year college students. The intervention group (*N* = 137) consisted primarily of first-generation students from disadvantaged backgrounds who did not meet normal academic admission standards. Participants in the intervention group enrolled in a Skills Learning Support Program (SLSP), which sought to prepare them for the academic and social demands of college. The SLSP provided, a) a counselor to guide students through their first-year, b) a systematic review of the program, c) teaching assistants who directed workshops and offered tutoring as needed, d) study skills instruction, and e) prepatory coursework. Students also enrolled in an academic success course (ASC) which facilitated reflection, awareness, and support for students’, 1) self-perception, 2) personal and academic relationships, 3) study skills and metacognitive strategies (e.g., goal-setting strategies, self-monitoring, and self-evaluation), 4) problem solving, and 5) health and well-being. The SLSP began in the summer and continued through participants’ first two semesters focusing on effective practices such as journal writing, academic dialogue between peers, and development of regulatory strategies for academic success. The researchers used pre-test/post-test quantitative measures, (e.g., The Motivated

Strategies for Learning Questionnaire and the Patterns of Adaptive Learning Scale), to assess gains in students' self-regulation skills and motivational beliefs from the beginning to the end of the SLSP. The researchers found that students who participated in the SLSP had significantly higher gains in self-regulatory skills than students who did not participate. SLSP participants particularly saw significant gains in their learning strategies, such as elaborating on ideas, repeated practice of information, help-seeking, and metacognition (though the authors did not elaborate on the metacognitive strategies participants engaged in). Participants also increased significantly in measures of self-efficacy, intrinsic motivation, and orientations toward goal-setting.

Sermon (2018) MRT Study. Sermon (2021) co-facilitated a metacognitive regulation training (MRT) program with low performing, first year, first-generation (FYFG) students. Participants were described as underrepresented minorities who attended a predominantly White public college in the southeastern US. The MRT prioritized collaboration with peers to support active learning, social support, and familiarity, as well as reflective workbooks which could be used for listing strategies, monitoring progress, and exploring current beliefs related to learning. Additionally, the researcher presented motivational concepts such as *efficacy* so students could examine threats to achieving their own self-efficacy. The researcher explored the impacts of the MRT on participants' metacognitive knowledge, strategies, skills, as well as agentic actions. Because metacognition and self-regulation can be driven by motivational factors, the researcher utilized motivational content (related to research on agency), in the MRT to support the students' development of "positive underlying beliefs about their learning (p.6)."

Sermon (2018) administered the metacognitive awareness inventory (MAI) and self-regulation skills inventory self-report (SRSI-SR) at the beginning and end of the MRT program.

These quantitative assessments measured gains in participants' metacognitive regulation (MR) (knowledge and skills) between the beginning and end of the MRT program. The researcher also conducted interviews with 11 FYFG students six months after the MRT program concluded to identify ways students applied MRT skills for agency in academic situations. The researcher found that FYFG students made significant gains in their metacognitive awareness (i.e., awareness of metacognitive knowledge and skills), and MR skills including, a) awareness for when to apply learning strategies, b) advanced planning skills (e.g., asking metacognitive questions before an assignment), and c) help-seeking behaviors, e.g. asking a professor for help to better understand material (p.96). Participants also reported continual application of the MR strategies six months after the MRT program concluded.

The researcher then identified four qualitative themes related to application of MR strategies and development of skills. These themes are as follows: a) new awareness of self or awareness of wrong paths in academic life, b) seeking and using feedback to adjust strategies, c) time-related strategies, and d) adapting the academic environment. Lastly, the researcher concluded that FYFG students practiced agentic tenets noted by Bandura (2001; 2006): intention, forethought, self-reactiveness, and self-reflectiveness. FYFG students developed plans and strategies (intention), set goals to guide and direct their efforts (forethought), employed metacognitive strategies (self-reactiveness), and evaluated learning outcomes and adjusted accordingly (self-reflectiveness). Sermon (2018) concluded that *agency* and *communality* interacted in the MRT which provided students with increased satisfaction, sense of belonging, and motivation for academic activities which supported their learning. As FYFG students gained awareness for their own efficacies and identified where they felt less efficacious, they were redirected to applicable strategies they could use in learning situations. In other words, participants' experiences in the program fostered affective-motivational factors, which likely compelled participants' metacognitive thinking toward their learning abilities and aptitudes, and to strategies they could utilize to support areas they felt less efficacious.

Franklin et al. (2018) IMPRESS study. Franklin et al., 2018 conducted a study with two groups of college students; deaf/hard-of-hearing and FGCS, both of whom chose STEM majors. Students participated in Project IMPRESS (Integrating Metacognitive Practice and Research to Ensure Student Success), which consisted of, 1) a two week summer experience, 2) metacognitive coursework throughout the following fall and spring semester, 3) a faculty mentorship, 4) situations in a STEM classroom that placed students in roles of leadership, and lastly, 5) student leadership roles in next year's Project IMPRESS. Participants engaged in metacognitive practices in authentic scientific learning scenarios (e.g., scientific experimentation and conceptual model-building around the theme of climate change). Throughout IMPRESS, faculty drew on self-questioning strategies and peer-collaboration to facilitate discussions that prompted socially-mediated metacognition (i.e., socially-constructed metacognitive talk-thinking) (Goos et al., 2002; Larkin, 2009).

In the metacognitive curriculum, students observed the daily topic, which related to climate change and worked in small groups to build conceptual models of the causes of atmospheric degradation. The (atmospheric) model was represented in a dynamic concept map with additions and revisions highlighted in different colors to emphasize the evolutionary process of their model. Students utilized introspective writing to reflect on their learning and update previous conceptual frameworks. The reflections were made personal because the conceptual models included assessments of their own scientific thinking and determinations. The metacognitive curriculum sought to spark a passion/interest in science and to help students develop scientific identities which would support their matriculation in STEM.

In addition to concept maps, which helped students develop conceptual coherence (i.e., a coherent mental structure of various ideas), students drew *lateral transfer maps* which showed the information they learned and transferred across different courses/experiences. The drawing of 'maps' in general was designed to help students make connections between ideas and skills, within and across the IMPRESS courses. In this article, however, the researchers did not consider the role that visual mental-representations (i.e., mental pictures) played in supporting participants metacognition and learning. It's possible that students who see the learning process unfold, learn more about their own learning, which reinforces metacognitive awareness and knowledge. Franklin et al., (2018) found that IMPRESS had a significant impact on the first four cohorts enrolled, in terms of increasing 2-, 3-, and 4-year retention rates (88% retention for 2nd year, and over 80% retention for 3rd and 4th years).

Conefrey's (2021) HIP study. Conefrey (2021) conducted a qualitative case study of 25 first-year, first generation (FYFG) students (14 identifying as men and 11 identifying as women) at a private 4-year institution. Students engaged in *high-impact practices* (HIPs), including learning communities, writing-intensive English courses (e.g., Critical Thinking and Writing), and ePortfolios to help develop college-level studying and literacy (reading and writing) skills. The HIPs engaged FYFG students in, a) reflective thinking and writing for their literacy abilities and study habits, b) utilization of new study strategies, c) goal-setting behaviors, and d) collaboration with peers. As a result of the HIPs, FYFG students reported increased self-efficacy, particularly a boost of confidence in literacy and study skills. Students mentioned that they were previously stuck using strategies (e.g., excessive notetaking and highlighting) that they had used in high school, which did not support them adequately in college level learning tasks. Thus, students devised new ways to be successful in academia.

As students reflected and assessed their abilities, they became more metacognitively aware of what they were learning, how they were learning, and why learning was valuable to attain their future goals. Students who strengthened their metacognitive awareness (for learning) had increased confidence in their literacy and study skills, which positively impacted the implementation of more effective learning strategies and goal-setting behaviors. FYFG students specifically, began to regulate their learning by engaging in study strategies and habits more commensurate with college-level reading and writing skills. Students noted these *changes* were beneficial to their learning in the overall college curriculum. One student stated, “I now use what I learned about myself in all my classes. The different insights allow me to have better study habits and be more successful.” As FYFG students’ perceptions changed, the expectations they set for themselves also changed, which improved their motivation. Thus, cognition, self-efficacy, and metacognition positively influenced each other, which supported beneficial changes in understanding and behaviors (for learning/literacy). Additionally, FYFG students were able to develop friendships with their classmates which enhanced their sense of belonging.

Conefrey (2021) used Bandura’s (1986) social cognitive theory to frame the study, which explains human functioning and development through reciprocal interactions between individual influences (e.g., thinking, perceptions), social (or environmental) factors, and behaviors. According to social cognitive theory students who believe in their abilities and have knowledge that their abilities can lead to success are more likely to overcome academic and social challenges. Social cognitive theory has some overlap with Vygotsky’s (1962; 1978) sociocultural theory, which is utilized in this study as a framework for developmental change. The two theories overlap in that they recognize the role that cognition and metacognitive mediation play in learning and development. In both theories, socially-mediated activities influence the internalization of thoughts and affective states, which can lead to intelligent (regulatory) behaviors (Zimmerman & Schunk, 2011).

What Studies on First-generation and Metacognition Reveal. First-generation students face learning challenges including bias against them in classrooms, microaggressions, and approaches that are consistent with rote learning, which can yield lower-order (i.e., shallow) learning strategies (e.g., memorization, re-reading). The previous studies highlight the relationship between metacognition and first-generation students' academic adjustment (or transition) to college. Findings support links between, agency, self-efficacy, metacognition, and regulation in the literature (DiDonato 2012; Bandura, 1986; Frazier et al., 2021; Marulis et al., 2020; Zimmerman & Schunk, 2011). The more a student believes in their abilities to think and learn (self-efficacy), the more they have the ability to support their thinking and learning through effective practices (agency), the more knowledge a student has about their own learning, and the more aware a student is about their own learning (metacognitive awareness/knowledge), the greater capacity they have to regulate their learning (e.g., set goals, implement strategies) successfully. Antonelli et al., (2020) suggests however, that engaging in regular college coursework is not sufficient to improve first-generation students' strategic learning and study skills. College coursework does not consistently provide metacognitive instruction to improve students' conceptual learning and self-regulation. Effective interventions early in college can foster positive *changes* to first-generation students' metacognition, regulation, and affective aspects of learning. Table 1 lists some of the practices shown to be effective for first-generation and underrepresented students early in their college careers.

Table 1

Effective Early Practices for Underrepresented and/or First-Generation College Students

Effective Practice	Curricular goal	Student Changes	Research
Metacognitive instruction (fostering cognitive/ affective resources & learning/literacy strategies in tandem)	Facilitate development of academic, metacognitive, and regulatory knowledge/skills and motivational dispositions (e.g., agency, beliefs, attitudes, confidence, efficacy)	1) metacognitive and regulatory gains (e.g., self-monitoring) measured qualitatively and quantitatively 2) positive affective states 3) developing literacy and leadership knowledge and identities	Conefrey, 2021; El-Hindi, 1997; Franklin et al., 2018; Sermon, 2018
Learning communities	Foster a sense of belonging and community	1) sense of belonging 2) deeper conceptual understandings, 3) greater agency and/or self-efficacy 4) cognitive and affective developmental gains	Conefrey, 2021; Jehangir 2009; Jehangir et al. 2012; Markle & Stelzriede, 2020; Wibrowski et al., 2017
Reflective (Journal) writing for learning	Engage students in reflective writing for their own study strategies, skills, and learning processes	1) metacognitive gains 2) conceptual gains 3) literacy development	Conefrey, 2021; Franklin et al., 2018; Sermon, 2018; Wibrowski et al., 2017
Multicultural learning and reflection	Engage students in thinking about others' perspectives. Show students value in their own cultural backgrounds.	Cognitive and affective developmental gains (e.g., multiple ways of knowing)	Jehangir 2009; Jehangir et al. 2012
Collaborative assignments and active learning projects	Involve students in student-centered activities within small groups, such as problem-solving, concepts maps, research projects, etc. where students have agency.	1) conceptual learning 2) agency and/or efficacy 3) metacognitive skills 4) interpersonal skills 5) cognitive and affective developmental gains	Acevedo & Lazar, 2022; Franklin et al., 2017; Jehangir et al., 2012; Rendon, 1995; Sermon, 2018

Note. Practices in Table 1 align with the ASC curriculum in this study. Additional note. Other effective practices not mentioned in Table 1: a) community/service learning, b) ePortfolios, c) integration of students' previous knowledge (i.e., funds of knowledge) and d) fostering safe spaces. Last note. The term “changes” is meant in a broad sense as anything that changed from the beginning of the intervention to the end.

The previous studies integrated metacognitive instruction into other effective practices (e.g., learning communities, reflective writing) to facilitate a number of positive changes to FGCS including development of academic identities and skills (e.g., metacognitive and regulation skills). Students who engage in learning strategies while becoming metacognitively aware of how strategies impact their thinking/learning, engage in a process of learning about their own learning (meta-learning), which may reinforce self-efficacy (and other motivational beliefs), and support the development of critical thinking capacities (Ahn & Class, 2011; Bamber, 2005; Conefrey, 2021; Sermon, 2018). As students develop metacognitive skills (e.g., planning, monitoring, self-questioning, evaluation) they become better able to self-regulate (i.e., self-direct) their learning toward specific goals (Eggen & Kauchak, 1996; Siegesmund, 2016; 2017). Given that metacognition is not domain-specific - meaning it impacts affective, cognitive, and behavioral elements of human psychology (Schraw, 1998) - it can be extremely useful to introduce to new, especially underrepresented college students to help them overcome a range of academic and social challenges (Cummings, 2015; Mytkowicz et al., 2014, Tao, 2021; De Villiers, 1990).

Metacognition as a Matter of Equity. As a matter of equity, Horrell and colleagues (2019) help underrepresented students at a historically black public university develop metacognitive skills to succeed in STEM related fields. They argue underrepresented students need opportunities to develop the academic skills denied to them in public education which can help them overcome discriminatory practices. Ferguson (2008) similarly contends that educational inequalities proliferate in public education because schools fail to prioritize practices that help racial minorities develop intellectual and academic skills. Ferguson used survey data of black and white students' involvement in 7th to 11th grades, as well as SAT scores to highlight differences in behaviors and achievement. He surmises that "skills and learning techniques…should be the focus of efforts to close the achievement gap" (p. 278). McGuire (2021),who has written extensively about metacognitive strategies and helps students apply metacognitive strategies in college, similarly argues that K-12 education does not involve students in metacognitive strategies that engage them in higher-level learning processes. The author contends that closing the gap for students with different backgrounds, is a matter of "metacognitive equity," in that all students need opportunities to access the types of thinking and skills that support their academic success (also, Lawson et al., 2021).

Implementing Meta-learning

Reading and writing tasks in high school often comprise basic comprehension skills (Armstrong et al., 2015; Addison & McGee, 2010; Cook et al., 2013; Karpicke et al., 2009; Conefrey, 2021; Shanahan & Shanahan, 2008; Zhao et al., 2014) however, college students are asked to engage in more demanding literacy tasks, such as synthesizing ideas, making and supporting arguments, and evaluating credibility of sources (Armstrong et al., 2015; Blau, 2010; Holschuh, 2019; Yancey, 2009). Consequently, first-year students, may mistake current surface-level approaches associated with basic comprehension (e.g., memorizing key terms) with 'deep' approaches associated with literacy, e.g., connecting ideas to form logical arguments (Biggs, 1985). This brings up educational concerns of whether first-year students are ready to think and learn in rigorous disciplines and have the competencies to succeed in constructivist classrooms which require students to be active learners.

Facilitating metacognition for learning is one of the most effective ways to engage college students in a process of deeper learning (Gijbels et al., 2005; Rickey & Stacy, 2000;

Cooper & Sandi-Urena, 2009; Delvecchio, 2011) and higher order thinking (Cook et al., 2013; Flavell, 1979, Rickey and Stacy, 2000; Sandi-Urena et al., 2012). Meta-learning was conceptualized by Biggs (1985) as a subprocess of metacognition comprised of a developing awareness of one's motives in relation to learning, and control over strategy selection and application. The researcher suggested linkages between personal, situational, process, and outcome factors in the learning process which roll up to a metacognitive process when students align their motives with applied strategies. Biggs, (1988) later stated, "Metalearning is evident when the student matches strategy with motive and task to produce a desired outcome." Biggs (1985) found that meta-learning occurs in three successive stages between the approximate ages of 14 and 16: 1) a meta-motivational state in which students become aware of what they want out of a specific learning task/situation. 2) a developing awareness and increased control of learning approaches, and 3) the subsequent deployment of appropriate strategies. Biggs (1985) theorized that learning is motivated intrinsically based on personal factors and/or extrinsically based on outcome-based factors (e.g. grades), which impacts the learning approach taken (e.g., surface, deep, or achieving), in turn affecting meta-learning processes. The researcher found that many students in secondary school were not able to control their learning accordingly and surmised that metalearning is most likely only involved with deep learning strategies (as opposed to surface learning strategies) where in the search for self and task-knowledge, the mind is attuned to one's understandings and misunderstandings (Biggs 1985; 1988).

In conceptualizing the various components of meta-learning, Jackson (2004) explained that meta-learning is unique to everyone, because it's rooted in a) how people choose and incorporate new learning experiences and b) images of the future which motivate them to take control of their learning. *Possible selves* are students' current identities including fears, concerns, and aspirations, projected into the future in visual-mental images (Frazier and Hooker, 2006; Stokes, 2019). Oyserman et al. (2004) found that underrepresented minority youths with well-defined possible selves – visions of their future selves – were more likely to regulate learning, i.e., enact behaviors/strategies that led to their academic involvement. This is because students with well-developed conceptions of themselves tend to be more motivated to engage in behaviors to support their learning and goal-attainment (De Place & Brunot, 2020*;* Frazier & Hooker, 2006; Sampson, 2012). Frazier et al. (2021) contends that discrepancies between what students see in their future selves and their current abilities may prompt students to engage in metacognitive strategies to increase the prospect of their goal attainment. Such discrepancies, however, may also lead students to disengage from the learning process (Oyserman et al. 2004).

When students engage in monitoring and reflection for their thinking and learning processes they can come to develop knowledge which shapes the way they think about themselves and their abilities to monitor, assess, and control their own thinking and learning processes (De Villiers, 1990; Kunat et al., 2009). Meyer and Shanahan (2004) state that meta-learning is an "empowering concept" that resonates with other well-researched topics such as self-regulated learning and locus of control. Jackson (2004) similarly describes meta-learning as commensurate with the SRL process. Self-regulated learners are those that choose learning paths that allow them to achieve their goals, and these incentives motivate and guide their behaviors (Zimmerman, 2000a; Zimmerman, 2002). Meta-learning as a process of learning about oneself is therefore marked by an amalgamation of experiences, values, attitudes, motivations, and developing competencies (Jackson, 2004). Students' meta-learning competencies have been positively associated with creative abilities (Kunat et al., 2019), critical thinking (Bamber et al., 2005), developing awareness/knowledge for one's learning and learning strategies (Meyer &

Shanahan, 2004), and forethought and self-reflection (but not self-evaluation) in the SRL cycle (Colthorpe et al., 2018).

Facilitating Meta-learning Environments. Carnell (2007) asked eight, experienced teachers in UK higher education about effective teaching practices that support college students' learning and compiled their narratives. One of the primary themes that emerged was teachers who saw the importance of developing a dialogue about learning with students to encourage meta-learning competencies. Integrating metacognition into the classroom's everyday discourse helps students develop a language (or lexicon) for discussing their own thinking and learning (Pintrich, 2002). Meta-learning as a process is often facilitated in learning contexts where students engage in independent and/or collaborative learning experiences while reflecting and/or monitoring their thinking and learning approaches (Bamber et al., 2006; Colthorpe et al., 2018; Cook, 2022; De Villiers, 1990). Meta-learning, therefore, overlaps with pedagogies centered on constructivism – that is, students' own active construction of knowledge in student-centered environments (Meyer & Shanahan, 2004). Engaging in meta-learning occurs as students acquire knowledge for how to think and learn, which draws the mind's awareness to one's own cognitive processes and later, their learning approaches (Biggs, 1985). The awareness of our cognitive processes necessitates metacognitive functioning (i.e., thinking about how we understand new ideas), which is how students develop metacognitive knowledge for their thinking/learning processes (Flavell, 1979). Because meta-learning requires students to be actively involved in their thinking and learning, motivation becomes a critical factor to promote students' engagement in these processes.

White & Gunstone (1989) outlined the parallels between conceptual changes and students' adoption of meta-learning. The authors learned that secondary students must move from naïve beliefs about oneself to more fully realized conceptions of what it means to learn and make changes that coincide with that knowledge. However, they must be personally motivated to do so, which usually correlates with whether they find metalearning fruitful and intelligible, and that may only occur when students are dissatisfied with their current performance. Different experiences in education, such as working with teachers who implement shallow learning experiences can conflict with taking control of one's learning. Also, students must be interested in the material long enough, so it continues to provide meaning to them. When interventions carry on practices too long students may come to automatize the behavior, committing no more thought to it. Thus, teachers should focus on varying teaching methods and tapping into personal motivation factors, such as short-term goals (White & Gunstone, 1989).

Students' agency in terms of their abilities/capabilities to act on behalf of their learning and motivational factors which compel them to engage in deeper learning and higher-thinking approaches are factors to consider in meta-learning environments. Engaging students in deep learning is challenging but Cook (2022) shows how teachers can achieve this by helping students attain superior utility i.e., helping students understand how meta-learning competencies will be useful in academics and their careers. Cook (2022) states that students "are outcome-driven and will respond to opportunities offered in any learning environment, regardless of whether meta-learning strategy encompasses deep or surface approaches." Helping students perceive the usefulness of meta-learning competencies extrinsically and/or intrinsically can motivate them to engage in deeper learning approaches. Therefore, personalizing the process of meta-learning to each student is likely to be more meaningful and/or motivational, and yield better results (Cook, 2022; White & Gunstone, 1989). Other effective ways to implement meta-learning include content-specific meta-learning tasks (Colthorpe et al., 2018), offering interactive feedback about learning (Meyer & Shanahan, 2004), reflection and knowledge construction in learning communities (Carnell, 2007), experiential learning opportunities that offer utility (De Villiers, 1990; Cook, 2022), inquiry map exercises (Winters, 2011), and reflective coursework that aligns personal and professional development (Bamber et al., 2006). When facilitated correctly learning about one's learning should be a rewarding experience for students as they come to learn about themselves in ways that help them achieve their goals.

Potential Relationship Between Meta-learning and Self-efficacy. Conefrey (2021) illustrated how a first-year intervention helped first-generation students develop metacognitive knowledge for their own learning, which supported self-efficacy beliefs, and strengthened their abilities to control learning. Colthorpe et al., (2019) embedded meta-learning tasks in a physiology/pharmacology course, which prompted undergraduate pharmacy students to use more advanced learning strategies (e.g., forethought, self-reflection, self-evaluation). The researchers found that more quality learning strategies (from forethought and self-reflection phases) were significantly related to their academic achievement, which positively related to self-satisfaction and self-efficacy. Thus, students' satisfaction and perceptions of self-efficacy were significantly and positively related to the course and their academic achievement. These findings build on previous literature, particularly Robbins et al., 2004 who found study skills and academic self-efficacy were the best predictors of academic success for college students, stronger even than socioeconomic status and academic performance. Learners who develop self-regulatory skills for learning have been shown to have higher levels of self-efficacy and metacognition for their thinking/learning processes (Wibrowski et al., 2017; Sermon, 2018; Zimmerman, 2000b) which can positively impact factors related to their academic success (Altun & Erden, 2013; Cera et al., 2013; Lynch, 2006). Students' development of metacognitive knowledge for their learning processes through application of metacognitive strategies may be intimately related to perceptions of their self-efficacy (Frazier et al., 2021; Ridlo & Lutfiya, 2017).

Metacognitive Strategies in Relation to Meta-learning. De Villiers (1990) conducted an action research study examining 24 first-year students meta-learning skills (e.g., reflection, awareness, control, and facilitation of the learning process) after participating in an academic development program. The researcher found that students differ in their awareness of their own learning. Some participants monitored their learning progress and began to adapt their learning approaches/strategies to meet new task demands. Many of these students were consciously aware of task demands and their own intentions to meet said demands. Using qualitative methods, from interviews and written reflections, the author found that the turbulence students experienced by transitioning from secondary school to college learning environments made the possibility of meta-learning changes greater. The researcher argued that meta-learning skills, including increased awareness, are critical to student learning, particularly for first-year students who must adapt to meet new academic challenges.

Metacognitive strategy interventions similarly have been shown to support changes from lower-order learning strategies to higher-order learning strategies (Cook et al., 2013; Muteti et al. 2021), and support development of complex disciplinary skills (Volet, 1991), which correlate to academic achievement. Research suggests that learning is enhanced when students are shown how to understand their own learning processes (Wangerin, 1987). Allowing students opportunities to learn about how they think and learn may thereby help students manage the complexities of university academics and life (Arwood, 2011). The implementation of metacognitive strategies can help students become actively involved in their own learning processes (Pelton, 2019), thereby filling gaps in academic preparedness (Kane et al., 2014).

Meta-learning as Discourse. Bamber et al., (2006) conducted a study of three cohorts of undergraduate students pursuing a degree in community education over the period of ten years. The researchers conducted semi-structured individual and group interviews with only "working-class" students in the UK who were also considered "non-traditional." Interviews occurred successively in the program three months, 18 months, and 30 months after they started the program. First and second interviews were helpful in illuminating students' experiences and perceptions of their academic pursuits. The third study went deeper as students examined relationships between teaching and learning experiences. Students also engaged in coursework that sought to help them deal with the challenges of higher education by elucidating connections between the subject matter and their own professional development in community education. Students met regularly in learning clusters and discussed ideas and challenges. The coursework was broken into exercises that comprised professional and personal practices, and reflective and collaborative practices. Coursework exercises engaged students in a developing dialogue between themselves and peers which contributed to socially constructed forms of knowledge. The intention of the coursework was to develop an "open-ended talking space" (see also Lillis, 2001), between teachers and students.

Bamber and colleagues (2006) equated meta-learning to the development of valid knowledge for one's learning experiences, which "involves becoming aware of the fundamental attitudes, views and beliefs that we hold about ourselves and which influence and shape our engagement with the world, including our approaches to work and education (p.27)." Non-traditional students engaging in a meta-learning developed an "internally persuasive discourse," (see also Lillis, 2001) for themselves as active learners who received knowledge, communicated said knowledge with others, and 'authored" knowledge as they grappled with challenging and meaningful situations. The Bamber et al. (2006) study aligns with this study in that it conceives of learning and meta-learning as a developing dialogue between students' internal discourse and the discourse of others which supports social and cultural ways forms of learning. Students who come to construct an internal dialogue for themselves as learners, through reflective writing and dialogue with peers/teachers can be said to engage in meta-learning processes (i.e., acquiring valid knowledge for themselves as learners).

Conceptualizing Meta-learning in this Study. Meta-learning is not a subject broached often in HE research (Jackson, 2004), particularly in America. However, Meyer and Norton (2004) contend that acquiring knowledge for one's own learning (meta-learning) in college is as important as acquiring disciplinary knowledge and ways of thinking about knowledge. Engaging students in meta-learning within a college classroom has been conceived of as helping students a) develop metacognitive awareness for their thinking and learning processes, b) be more self-reflective in relation to their learning and learning strategies, c) be more active in directing their learning approaches toward specific goals, and d) develop positive dispositions (attitudes, mindsets, emotional-motivational factors) all of which enable lifelong learning capacities (Biggs, 1985; 1988; Crick et al., 2015; Colthorpe et al., 2018; Jackson, 2004).

Meyer (2003) draws from Torbert's work in conceptualizing meta-learning as the construction of valid knowledge from four territories of human experience comprising a) purposes, b) strategies, c) behavioral decisions that require awareness of self and skills, and d) knowledge of the outside word. As students engage in meta-learning to construct 'valid knowledge', their prior conceptions of these four territories are challenged through open dialogue with peers and faculty (*Torbert, 1994; Meyer, 2003*). People can construct valid knowledge for their learning by developing an awareness for seeing, embracing, and restructuring discrepancies among the territories which advise how they act into the world (*Torbert, 1994;* 2013). Thus, a key part of the meta-learning process is ongoing reflection and monitoring of one's thinking and learning processes, which fosters development of metacognitive knowledge and skills. Such development is conceptualized here as an internal/external discourse students engage in, when constructing 'valid knowledge' for their learning.

In this study, the researcher operationalized meta-learning as, *learning about one's thinking and learning processes, which gives way to awareness and control for one's thinking and learning* (Colthorpe et al., 2018; Maudsley, 1979; Jackson, 2004). This includes behaviors and dispositions (e.g., attitudes, mindsets, emotional-motivational factors) that factor into the regulatory process (see Crick et al., 2015). 'Awareness' in this sense denotes the metacognitive knowledge, strategies, skills, and attitudes students develop as they engage in meta-learning (Schraw & Denison, 1994; Veenman et al. 2006). The control aspect represents the metacognitive skills and regulatory activities students enact to support learning (Efklides, 2006; 2011). Thus, meta-learning hinges on becoming metacognitive and developing skills for one's learning.

It's important here to differentiate between meta-learning as a process, a competency, or a way of thinking or changing, among other things discussed in literature. Jackson (2004) outlines various conceptions of meta-learning in the research – "as a product (knowledge), a thought process (way of thinking to create routs to new learning), an attitude or habit (a way of engaging in learning and life more generally), a behavioural process (active regulation of behaviours in ways that will enhance learning," and "a way of growing knowledge about learning by imagining and thinking about the future, present, and the past." For the sake of clarity, meta-learning is conceived here as a developmental process one goes through in acquiring knowledge and control of one's thinking and learning. There are also developmental competencies or skills that are critical to regulatory processes. For instance, a student might engage in metacognitive or meta-learning strategies, quickly becoming competent in how to implement such strategies in specific disciplines. This competency is a developmental change occurring in the meta-learning process, just as metacognitive awareness and control are developmental changes that occur potentially when gaining knowledge for one's thinking and learning. As will be discussed later, these competencies are coordinated by students' language function, i.e., how they think with language to become metacognitive (Arwood, 2011). This study is focused on potential *developmental changes* or *changes in general* to students' visual thinking and learning when engaged in meta-learning as an individualized and social process. The researcher could find no studies to date that have studied first year, first-generation college students who've participated in meta-learning environments that approach thinking and learning within an interdisciplinary framework. Therefore, there is a gap in the literature that this study will begin to explore. Learning environments that provide 'knowledge of' and 'access to' visual-mental imagery (i.e., visual representations of ideas) can be said to promote meta-learning for one's thinking and learning processes (as will be discussed in a subsequent section).

Conceptualizing Metacognitive Phenomenon in the Context of this Study

Metacognitive findings are highly amenable to the methods and instruments that are implemented in the research (Desoete, 2008; Desoete & Roeyers 2002, 2006). In other words, 'what' is measured, and 'how' it is measured is sure to shape the findings (Baten et al., 2017). Metacognition is a difficult construct to qualitatively or quantitatively measure because its observability is dependent on protocols designed to guide thought to cognitive phenomena. In studying metacognition researchers must take care to operationalize the construct carefully and transparently so they can ensure they are assessing metacognition and not another other form of cognition. In the bounds of this case study, the researcher was interested in investigating the metacognitive knowledge and regulation of participants upon entering college and the internal discourse they develop as they actively construct valid knowledge (Bamber, 2008; Meyer, 2003; Reason & Torbert, 2001; Torbert 1999) for their learning in a class focused on meta-learning (i.e., learning about one's thinking and learning).

Students' meta-learning is generally measured by Meyer's (2004) Reflection on Learning Inventory, which engages students in a process of reflecting on their own disciplinary learning approaches (e.g., strategies) to develop meta-learning capacities (or competencies) (Jackson, 2004; Meyer, 2004; Winters, 2011). This inventory does not align well with the objectives of this study but specific items were used in constructing interview questions (see Chapter 3). Meta-learning and metacognitive phenomenon have been assessed amply using qualitive analysis on semi-structured interview transcripts and written reflections (for example, see Bamber et al., 2006; Tao, 2021).

Using semi-structured interviews and written reflections this study seeks to gather participants' discourses for their thinking and learning, which reflects the active assignment of meaning to their thinking and learning based on what the student has come to understand and found to be *valid* thus far (Efklides, 2006). Thus, semi-structured interviews and written reflections act as metacognitive assessments. Meyer (2004) states that instruments that assess meta-learning in students "should ideally possess the capacity to capture variation in contextualized student learning engagement...in a response domain that appeals for its validity in reflecting authenticity in everyday academic learning contexts as derived from students' experiences (p.491).” Qualitative data provides a rich contextualization of experience and knowledge as it pertains to meta-learning and is therefore a suitable means of developing understandings of metacognitive relationships among specific groups of students.

All metacognitive phenomena within the parameters of this study align with Arwood’s Neuroeducation Model that regards metacognition as a developmental language function accessed by concrete-to-formal-levels of thinking (Arwood, 2011). Language that *represents cognition* demonstrates metacognitive phenomena as framed in this chapter. Therefore, semi-structured interview questions provide an optimal source of data because they provide participants access to their internal (mental) states and a medium to communicate those states to the interviewer through language (Efklides, 2009). The same can be said for written reflections if written in the students’ natural language (i.e., own lexicon).

Table 2 illustrates the framework for metacognition that is conceived in this methodology to categorize/segment metacognition into observable and understandable phenomena. Table 1 is adapted from the Efklides (2006) model and does not consider all factors that make up self-regulation. The Efklides (2006, 2011) models, while valuable, do not consider concrete to formal-levels of thinking with language, which are embodied by language-based neural networks that develop in the human brain (Pulvermüller 1999; 2002; 2013b). All metacognitive facets/functions in this study are viewed within the context of language functioning. However, Efklides (2006, 2011) MASLR model is beneficial because it provides an encompassing model of metacognitive function, which helps to operationalize/categorize specific metacognitive phenomena, relevant to this research. When participants provide answers to questions based on what they know about their thinking and learning they are providing knowledge at the Person level (e.g., metacognitive knowledge), based on knowledge of *self*, as well as strategies and tasks, in relation to learning goals (Efklides; 2011; Flavell, 1979).

Table 2

Metacognitive Facets of Monitoring and Control Functions. Adapted from (Efklides, 2006; 2011).

Monitoring		Control
Metacognitive Knowledge (Person Level)	Metacognitive Experiences (Task x Person Level)	Metacognitive skills (Person Level)
Ideas, beliefs, 'theories' ○ Person/self (agent) ○ Task ○ Strategies ○ Goals ○ Cognitive functions ○ Validity of knowledge ○ Theory of mind	Feelings ○ Feelings of confidence (i.e., metacognitive confidence) ○ Feeling of knowing Judgments/estimates ○ Judgements of learning ○ Source memory info Online task-specific knowledge ○ Task features ○ Procedures employed	Conscious, deliberate activities and use of strategies for ○ Monitoring of task requirements/demands ○ Planning ○ Regulation of cognitive processes ○ Evaluation of the processing outcome

Note. Control functionality is based on the person's beliefs (i.e., knowledge) related to monitoring and control. Monitoring and control functions provide feedback between monitoring and control levels as the student learns (e.g., engages in learning tasks).

The framework for metacognitive knowledge (MK), metacognitive experiences (ME) and metacognitive skills (MetSkills) in Table 2 illustrates the metacognitive phenomenon that will be observed when interviewing FYFG students. Thus, Table 2 is helpful to see the various metacognitive phenomena (i.e., facets) that can be observed as it relates to monitoring and control functionality, and the phenomena the researcher will capture during qualitative analysis (e.g., metacognitive knowledge, metacognitive regulation, metacognitive strategies, metacognitive skills, metacognitive experiences, and metacognitive confidence) (Efklides, 2006; 2011).

Metacognitive skills overlap with metacognitive regulation in the literature as these phenomenon fall under the metacognitive control function (Brown, 1978, Hasselhorn & Labuhn, 2011). Metacognitive regulation (MR) (or "regulation of cognition") is knowledge about how students "plan, implement strategies, monitor, correct compression errors, and evaluate their learning (Saricoban, 2015, p.665)." Thus, MR involves how people control cognition to facilitate their learning or thinking about learning (Stanton et al., 2015). Metacognitive skills are then denoted by effective, deliberate and/or conscious learning and/or thinking strategies (Efklides, 2011, Versteeg et al., 2021). Therefore, this study interprets metacognitive regulation as separate from metacognitive skills, as not all controlled thinking is 'skilled,' (i.e., not all procedural knowledge is skilled), but all metacognitive skills are products of metacognitive control/regulation. The terms metacognitive control and self-regulation are intimately connected in the psychology literature and are sometimes used interchangeably to denote *thoughts that direct learning*.

Metacognitive skills (MetSkills) are critical in building a model of self-regulated learning (SRL) (Efklides, 2006). Students who have effective MR skills or metacognitive skills can select learning strategies that suit the learning task and themselves best (Sermon, 2018; Stanton et al., 2015). In theory, the more declarative and procedural knowledge a student attains for how to think and learn based on, a) the learning task, b) the subject matter, c) appropriate strategies, d) knowledge of self as a learner, and e) dispositions (i.e., affective states, mindsets, motivations, and attitudes) that support learning, the more capable they become in using metacognitive skills (to support self-regulated learning) (Efklides, 2019). Students who develop metacognitive awareness (i.e., knowledge and skills for learning) understand what they know and need to know and are able to choose appropriate strategies to suit the learning task. Without such awareness students may be unable to discern how to improve their academic performance (Balduf, 2009). Thus, meta-learning (i.e., learning about one's learning), may support the development of metacognitive awareness and skills to self-regulate learning.

Development of the PSL Framework

The person-student-learner (PSL) framework was devised through an in-depth analysis of the literature by the researcher, who has a background in learning design. The PSL framework is based on findings from 1) higher education research of FYFG students' identity development (Levya, 2011; Orbe, 2004; Stephens et al., 2014a); 2) constructivist-dialogic approaches to curriculum (Wells, 2007; 2009); and 3) holistic metacognitive models of self-regulation (Bandura, 1989, 2001, 2006; Biggs, 1985; 1987; Efklides, 2011; Flavell, 1979; Frazier et al., 2021). These fields were chosen as they provide a way to account for the socio-cognitive development and self-regulation of the whole person within a higher education context. The researcher designed the PSL framework to organize and make transparent the learning objectives of the academic success course. The PSL framework segments specific knowledge and competencies into three roles that students are implicitly expected to occupy while attending University (person, student, learner). The academic success course was structured to facilitate students' thinking about these roles, so they could occupy these roles in college successfully.

The PSL is a practical and transparent framework, modified from Efklides (2011) metacognitive and affective model of self-regulated learning (MASLR) model, which incorporates linkages between motivation/affect and metacognitive functioning to explain top-down regulation (p. 16). Efklides' (2011) conception of self-regulation is embodied by top-down (person-level) operations and bottom-up (person 'in task') operations. The 'Person level' operations are composed of the individuals' self-regulatory characteristics (e.g., motivation, cognition, volition, metacognition, affect) when confronted with a learning task. While the 'Task x Person level' operations are composed of what the learner does while engaged in the learning task based on what occurs at the Person level.

The PSL recontextualizes the 'Person' and 'Task x Person' as roles to be mindful of at university. The *Student* and *Learner* roles in the PSL framework are embodied by strategies and knowledge that are relevant to in task learning (i.e., top-down and bottom-up self-regulation). The *Person* role in the PSL framework, is embodied by the agency of the individual, which can be viewed as the 'marriage between self-awareness and the intention to act' (i.e., connection between metacognition and regulation). This 'marriage' explains how people gain control over their learning and come to view themselves as self-determining people (Bandura, 1989, 2001, 2006). Agency can provide the motivation to engage in challenging learning tasks and the self-assurance to overcome challenges when confronted with them (Frazier et al., 2021).

Person. The 'Person' is the agent, encompassing aspects of the whole person, including knowledge, cognition, experiences, motivation, emotions, belief, skills, and attitudes (Efklides, 2011; Biggs, 1985; Flavell, 1979). Students need help understanding that they are valued and have a support system based on *who they are*, not whether they are successful or not (Arwood, et al., 2015). This understanding empowers the 'Person' role, so all the other roles work synergistically. It's contingent upon the student to bring their own identity (e.g., culture, values) into their education, to help shape how they will grow in a university setting. Helping students to be conscious of the Person role through reflection, and share these understandings with peers, is intended to help cultivate positive experiences, in which FYFG students feel their intellectual capacities and sociocultural identities and beliefs are embraced.

Student. The ‘Student’ is the ‘person’ within an organized educational setting. The Student role is focused on tasks and situations that can help the student academically succeed and feel part of various communities. The instructor and guest instructors’ purpose in highlighting the student role is to reveal the embedded or implicit expectations in pedagogy, curriculum, assessment, and administration so students can understand ways of communicating and functioning to achieve their goals. The Student role embodies the activity inherent in the *Task x Person* level but from a Person-level (top-down) perspective. A student thinking of themselves as a student and knowing what expectations are placed on them in a given task can help shape what the person does when they are engaged in those situations.

Learner. The Learner is the ‘person’ in active meaning-making. The learner role is focused on thinking and learning tasks that help students create meaning, including collaborative experiences with others. Learning and thinking leads to development and will help shape the person’s knowledge, beliefs, and skills (Arwood, 2011). The Learner role embodies *Task x Person* but from a Person-level (top-down) perspective. Thinking of yourself as a learner, and knowing what to do (i.e., metacognitive knowledge) can shape what the person does when they are engaged in learning tasks/situations.

Exploring the Connection Between Language, Cognition, and Metacognition

In this study, learning, thinking, and metacognition, are viewed from an interdisciplinary neuroeducation framework that recognizes literature from 1) cognitive and educational psychology, 2) language acquisition and development, and 3) neuroscience literature. The previous sections discussed metacognition from primarily cognitive and educational psychology perspectives, though metacognition and meta-learning originated in developmental literature (see Biggs 1985; Flavell, 1979). The purpose of this was to explain the various aspects of metacognition that are relevant to higher education and first-generation students. This section outlines the findings primarily from developmental and neuroscience literature that show a) how children develop cognitively with language, b) how language represents cognition, c) how language functions to extend thinking to higher-level processes, including metacognition, and d) how people's development and learning is impacted by their social and cultural environment. Language research provides a developmental basis for cognition, helping to make thinking explicit through language function (Bruner, 1975; Clark, 2004; Halliday, 1977; Vygotsky, 1934/1987).

Language

There are multiple ways humans can express thought, but two central to human cognition and conceptual learning are language and mental imagery (Galaburda et al., 2002). This section focuses on how humans' function, learn, and develop with the English language, while the next section focuses on how humans' function with mental images and learn visually (through perceptual patterns, concepts, and metacognition). These functional processes are integrated at the neurobiological level, meaning that brain networks responsible for language and mental imagery work in tandem to process and represent semantic content (Barsalou et al. 2008; Mazoyer et al., 2002). They are also 'embodied' in so far as acquiring natural language allows one to acquire a system of symbols for representing and sharing thinking in various ways, in various social activities (Dove, 2014).

As caregivers (e.g., parents) assign meaning in social contexts, children acquire meaning and develop a hierarchical system of signs and symbols as a means of communicating and thinking (Jackendoff, 1999; Nöth, 2014; Perlovsky, 2007). Halliday (1993) suggests that language development is essentially "learning how to mean." Because humans are 'meaning-making beings' we engage in semiotic processes with signs and symbols to learn our environment (Halliday, 1975; Peirce, 2007). Semiotics refers to these sign processes (e.g., communicate acts), also known as *semiosis*, where people make meaning through the mediation and interpretation of signs (Tochon, 2013). Signs stand for verbal and non-verbal meanings that are interpreted and organized by humans based on their experiences (Arwood, 2011; Halliday, 1993). In other words, signs are the mediating representations of our external and internal (mental) experiences (Trevarthen, 1980). The symbols then, are the constructions or interpretations of meaning through regular use of signs (Halliday, 1993). Symbolizing can occur through gesture, spoken words, or sentences and always denotes usage (Peirce, 1905). Humans cannot learn language without semiotic exchanges with other humans because social interactions allow the shared construction of meaning that develops concepts and language (Arwood, 1983; 2011). Thus, learning language is the semiotic process by which experience emerges as knowledge (Halliday, 1993).

Importantly, language uses imitated surface structures (e.g., morphemes, phonics, and syntax) to represent the underlying meaning of cognitive functions (Arwood, 2011). Natural language denotes this cognitive functioning in so far as it represents the understanding of concepts through semantic acquisition. Thus, natural language is dependent on acquiring language structures and functions to represent semantic content (i.e., the meanings of things) (Arwood, 2011). The structures (or words) act as symbols to refer to objects which allow people to represent the functions – which are the underlying meanings of people's experiences and intentions, that they also acquire over time. Dove (2014) states that in acquiring natural language we acquire a "symbolic system that involves a systematic mapping between a virtually unbounded set of thoughts and a virtually unbounded set of sounds or manual gestures (p.373)." Word sounds and gestures cognitively map onto meanings (or referents) created in social contexts to create conceptual categories (Clark, 2004), which become the source of our socio-cognitive and neurobiological development (Arwood, 2011).

Language can thus be defined as "a set of arbitrary symbols that communicate conventional and shared meaning among two or more people (Arwood & Merideth, 2017)." Children increasingly develop meaning through discovery of semantic relationships between themselves and others, as well as actions, events, and objects (Clark, 2004). As children develop language-based concepts for thinking and behaving their language functions increase, which means their capacities for creating meaning with language increase (Arwood, 2011*;* Bruner, 1975*;* Halliday, 1975, 1976). Children can then begin to use language to extend and displace cognition (facilitating abstraction beyond the here and now), which supports higher order thinking and sharing of more complex meaning (Arwood, 2011; Clark and Chalmers, 1998; Dove, 2014). Humans may have correspondingly evolved to use language for such purposes - to not only communicate, but to develop reasoning and argumentation capacities (Reboul, 2017). The next section focuses on how children acquire language and the benefits it provides.

Early Language Acquisition. A baby comes into the world without language but with an ability to cognate – illustrated in their capacity to recognize gestures and talk in patterned formats with parents (Geertz, 2001). Gallagher (2006) suggests that infants are visually predisposed to follow and imitate the parents' facial expressions from birth. There is no early interaction between language and cognition in ontogenesis (development) - cognition is always the precursor (Langer, 2001). The longer period of immaturity - when infants are unable to use cognitive faculties and are therefore reliant on their caregivers - may allow the brain sufficient time to develop advantageous plastic (neural) networks for flexibility in the acquisition of culture and language (Bjorklund, 2006; Bruner, 1975; Montagu, 1983). Contrary to Chomsky's (1968) belief that language acquisition is an innate device in human development, acquisition is precisely how children come to understand linguistic and cultural norms (Geertz, 2001; Bruner, 1975; Vygotsky, 1986, Vygotsky, 1978) and how functional deficits can arise (Jaskowiak, 2018).

The structure of all language revolves around triadic interactions of *agent, action, object* or *agent, objection, location* – allowing children a coherent format to acquire and communicate the linguistic conventions in which the activity is contextualized (Arwood, 2011; Bruner, 1975; Vygotsky, 1986). An infant who is drawn into joint attention with a parent while playing a game of peek-a-boo, for instance, is able to learn the linguistic and cultural norms within the form of the game (e.g., the mother says "peek-a-boo" when making her face visible, before disappearing behind her hands) while language plays a secondary, but pivotal role of beginning to offer children new paths of thinking, and thus, new ways of acting into the game (Geertz, 2001).

Relatively soon after birth infants engage in 'protoconversations' (and protosongs) with their caregivers which involve interactions where they take turns gesturing, touching, and vocalizing (Bruner, 1985; Trevarthen, 1979). For example, a baby looks at her mother who is smiling and speaking to her. The mother rubs the baby's belly. The baby coos and gestures with her right hand. In response to the baby's sounds and gestures the mother says, "Come on. Again. Come on then. That's clever. Oh yes, is that right? Well then tell me some more then (adapted from Trevarthen et al., 2011)." These protoconversations are thought to provide the basis for emotional bonding (Blehar et al. 1977; Trevarthen, 1993; Schore, 2021), as well as communication and social/cultural learning (Bateson, 1975; Bråten, 1988; Trevarthen, 1998).

While Trevarthen (1998) and others theorize these interactions as being intersubjective, in terms of forming initial shared perceptions, Tomasello (1999) believes that these interactions do not become intersubjective until the infant understands others as agents, around nine months of age.

Gestures take on special significance in providing the infant ostensive cues of contextual meaning that guide memory and learning of object and event categories or relations (Csibra & Gergely, 2009; Perszyk & Waxman, 2018). For example, a parent might open a hand with a pacifier and say, “Do you want your binky?” Research suggests the child is more likely to understand the object category if there is ostensive demonstration (i.e., infant-directed speech and performance) even when there are conflicting (visual) surface structures (Kovács et al., 2017). McNeill (1992) suggests it’s important to understand and study gesture and accompanying speech as a combined system. For example, Yu and Smith (2012) showed that infants were more likely to learn an object label (i.e., word), when parents named the object and held/moved the object to a visually dominant location. These visually optimal moments for naming and learning correlated with the infants’ actions, including grasping and holding the object. These findings coincide with research that shows eye-gaze, pointing, and other movement gestures act as optimal visual cues to the referent (object of an idea), which can support word learning (Ahktar & Tomasello, 1997; 2000; Csibra & Gergely, 2006; Gergely et al., 1995; Gliga & Csibra, 2009). Research suggests that speech and hand movements are so pervasive in early childhood development that they set up an integrated or multimodal system of acquiring and communicating meaning during language production and comprehension tasks (Kelly et al., 2008). This will be discussed more in a subsequent section.

Relationships between agents, actions, and objects in social interaction facilitates children’s production of signs, which are the mental representations of meaning (Peirce, 2007).

Halliday (1993) states that symbols start to become established as "regular signs," generally between zero and six months. At this stage, the infant will imitate others' motor patterns such as hand gestures to indicate to an agent they want something or more of something in their environment (Arwood, 2011). These non-verbal hand signs or gestures are initial language functions that communicate intention. Infants' gestures show initial understanding of concepts before they are able to utter the words associated with the concept.

Representational gestures, that is gestures that represent the meaning of accompanying speech sounds (McNeill, 1985) (e.g., iconic gestures), help to develop spatial relationships between agent, action and objects (Kelly et al., 2008; McNeill, 1992). Gesture production develops spatial relationships by connecting aspects of speech to actions, locations, and objects, which layer to become spatial concepts that can be represented through mental imagery (Kelly et al., 2008; McNeill, 1997; 1998l Wesp et al., 2001). Additionally, the meaning of locative words (e.g., off, out, up, down, here, there, etc.) facilitates lexical acquisition when embedded in relational, motion, and goal-oriented roles (Stockman & Vaughn-Cooke, 1992), which helps the brain map spatial and semantic features onto language (Arwood, 2011). The spatial concepts of language, which the mind can 'see', are therefore relational to the space, time, movement, and goals of the individual.

Child Language Acquisition and Development. Starting at birth, humans proceed through developmental stages including sensorimotor (birth to 18 months), preoperational (18 months to 6 or 10 years), concrete (6 to 12 years), and formal operational stages (12 to 25 years) (Oesterdiekhoff, 2021; Piaget & Inhelder, 2014). Each of these stages coincides with children's' acquisition of language and concepts in social contexts. Children spend the first six months largely developing the sensorimotor patterns of their environment. Linguistic conventions are formed through affectual and communicative intentions that children share with adults (Tomasello, 2001). Thus, cognition precedes and allows for language acquisition (i.e., words and meanings) (Papafragou et al., 2007). By nine months to twelve months of age human infants have developed enough meaning that they begin to engage in several joint attention behaviors that suggests "emerging understanding of other persons as intentional agents…whose relations to outside entities may be followed into, directed, or shared (Tomasello, 1999, cited in previous work, 1995, p.104). Joint attention is crucial to facilitate interactions for children to be enculturated and will take different shapes in more complex social environments. Arwood (2011) correspondingly states "Early conceptual development expresses the meaning of the child's world to others and in turn the meaning of the world to the child (p.59)." Thus, one of the earliest language functions is the social reciprocation of meaning which helps develop the relationships that will become concepts, and later more complex language functions.

Children come to learn the social and cultural phenomena (e.g., beliefs, values) of their immediate environment through shared meanings (Takaya, 2008). Therefore, children acquire (or internalize) their culture as they develop. Children's language processing involves phonological representations (knowledge of word sounds), lexical representations (knowledge of whole words) and semantic representations (meaning of words). Studies have shown that some children, have difficulties processing the phonetic features (word sounds) that make up speech, which may lead to deficits in language learning (Bishop et al., 2004; Ziegler & Goswami, 2005). Nevertheless, many children are able to use different domains of perception – social, visual, and auditory to learn words (Cartmill et al., 2013; Medina et al., 2011; Smith & Yu, 2008).

Word learning is dependent on learning not only the lexical label of an object or action but also corresponding semantic features (Alt & Gutman, 2009). Children learn the surface structures of language but also the underlying meanings of social and cultural experiences, which maps words onto pre-established conceptual categories including actions, events, and properties (Clark, 2004). The interaction between agent-action-object thus, forms the basis for language formation and conceptualization of cultural meaning (Arwood & Brown, 2002; Tomasello, 2001) In the first 2 years of life, the child comes to develop a link between language and cognition, which fuels a cascade of learning and developmental opportunities by setting up the brain's representational capacities (Gentner & Christie, 2010; Perszyk and Waxman, 2018).

As children develop (e.g., after the ages of 30-36 months), the less they require joint attention to discover basic properties of the environment, and the more language becomes a tool of the mind (Arwood, 2011, Clark and Chalmers, 1998) to guide thinking (Perlovsky, 2013) and manage its own resources, particularly when processing new information (Brinck & Liljenfors, 2013; Kuhn, 2000). Vygotsky (1934/1987) unravels the role of language in ontogeny clearly:

> "It moves from the motive which gives birth to thought, to the formation of thought itself, first in inner speech, to its mediation in the inner word, to the meanings of external words, and finally, to words themselves … The relationship of thought to word is a vital process that involves the birth of thought in the word. Deprived of thought, the word is dead. …The connection between thought and word is not a primal connection that is given once and forever. It arises in development and itself develops (p. 283–284)."

Words are merely the invitations to create conceptual categories (Perszyk & Waxman, 2018). Children imitate the language structures but they also learn the meanings or semantic features of the acquired structures (words). When enough semantic features (i.e., underlying meanings) have been acquired from children's sensory system they begin to develop sematic relationships between words that represent concepts. In the process of acquiring semanticity children develop a system of signs and symbols to construct and share meaning (i.e., thinking) in social contexts. Acquiring signs is the neurological organization of external stimuli in such a way that they can be stored in long-term memory and represented in language production (i.e., thinking) (Arwood, 1983). When signs reach the symbolic level, which is an advanced level of meaning, it means they can be represented and shared as concepts (Arwood, 2011).

Once adolescents reach a heightened level of language ability, they are able to interact and share understandings of cultural artefacts in the environment and theorize about abstract concepts related to those artefacts (Arwood, 2011). Abstraction displaces thought, which is consequential for children's ability to think reflectively and construct concrete meaning in educational settings (Arwood, 2011). A child with good language development has acquired adult language structures by the ages of seven or eight years old, which means they can begin to read and write for literacy. Literacy is the child's ability to construct meaning for reading, writing, speaking, viewing, thinking, listening, and calculating through language structures and functions (Cooper & Kiger, 2006, in Arwood, 2011, p.30)." Thus, normal language development by the age of 7-8 coincides with the child's ability to refine their thinking and learning through forms of communication. Older students can develop their conceptual thinking into meaningful higher-order concepts using a variety of literacy forms, which adapts social behaviors (Arwood et al., 2015; Cooper & Kiger, 2006).

Language then "becomes the principal mode of meaning making," mediating communicative thinking in social contexts and through "inner speech" in which the individual's thinking is "brought under conscious control (Wells, 2007, p.244)." With greater development, language moves away from being "an adjunct of action" to becoming a profound tool to communicate (mental) representations in the environment (Bruner, 1972, 700-2). Such communication allows people to think abstractly by displacing themselves (beyond the here and now), giving shape to knowledge and belief (Bruner, 1972). Humans ultimately, derive meaning from the social interactions they have with others and modify those meanings by perceiving how others react to symbols (Blumer, 1969).

Thus, cognitive processes such as language, thought, and reasoning all develop through social interaction (Petrová, 2013). As a communicative function, language, likely evolved and is learned to provide humans the ability to share intentions of coordinated actions (in Geertz, 2001, p.33, via De Laguna, 1927). Intersubjectivity (i.e., shared perceptions), from the onset plays a role in the child's understanding of their parents' perspective taking. Later in life, when language is developed, intersubjectivity allows social activities to be internalized, helping adolescents separate themselves from the activity and develop semantic representations of the external environment (Petrová, 2013). Therefore, learning meaning, thinking of meaning, and communicating meaning is how the mind functions with language, based on semanticity (i.e., the neurobiological process of meaning-making with language), and this process will impact the child's literacy and conceptual learning during the lifespan (Arwood, 2011).

Inner Speech and Accessible Representations. Moving from the social plane to the internal plane of thought is what Vygotsky (1986) identified as higher forms of psychological functions. As the child develops greater language capacities, some time before middle-school, language that is egocentric in nature becomes gradually internalized to think about the social plane, while inner-thoughts become expressive language (Vygotsky, 1978). Thus, the child develops a "systemic unity" that allows "thought to become verbal" and speech to become intellectually internalized (Kozulin on behalf of Vygotsky, 1986). This process marks the beginning of *inner speech*, which will later become a psychological interchange between the symbolic systems of various cultures (i.e., like classrooms) and the inner-dialogue and imagery that makes sense of symbols within those cultures (Vygotsky, 1986).

Language paves the way for inner speech (Vygotsky, 1986) and visual imagery which makes forms of "consciously accessible" thinking possible (Carruthers, 2009, p.130). In this sense, visual imagery can act either as a mental representation of something perceivable in the environment or a mental picture that is constructed (mentally) without a matching external stimulus from the environment. Language functions for humans provide a way to represent these ideas of the external and internal world for thinking, learning, communicating, and developing. Language functions can thus be seen as a psychological tool that helps students to use their cognitive capacities to facilitate meaningful (mental) representations, and are a product of those capacities, developing in response to the child's personal relationships and learning (Arwood, 2011; Vygotsky, 1986). It's helpful to refer to Efklides (2009) position on language use for one's internal states.

> Observation and awareness of mental states along with language use allow the person to reflect on and analyze (their) inner states, behaviors and actions as well their outcomes. It also allows the person to communicate the content of his/her reflection to others, to draw inferences and to make attributions about the relations between inner states and observable behaviors and outcomes, and to compare (their) personal inner state and explanations with those of other people (p.77).

Languages "evoke ideas" in people that are encoded by the lexical and grammatical properties available to them (Clark, 2004, p.472). The conceptual knowledge available to the person will thus differ based upon their language function. As children are educated and undergo further enculturation they will ‘map’ different words onto various conceptual representations, thereby creating a unique “conceptual domain of experience,” that is represented by their lexicon (Clark, 2004, p.473).

Human lexicons become products of personal experience affecting how individuals interact with others, in turn deepening connections of who the individual is through those interactions (Arwood, 2011). Perlovsky (2013) states that as adolescents grow older and enter adulthood, language will guide their acquisition of “cognitive representations from experience (p.1).” Consequently, language funnels cognition through the minds’ cultural systems of knowing and the brains’ semantic memory, which in turn affects how the brain perceives new stimuli (Arwood & Merideth, 2017). By assessing how language is utilized semantically, a teacher can assess the efficiency of conceptual networks in the brain (E.L. Arwood, personal communication, May 30, 2022).

Interdependence of Language, Cognition, and Metacognition. Language research explains how infants and adolescents acquire language from their interactions and process meaning within their cultural associations (Bruner, 1985; Halliday, 1975; Vygotsky, 1986). The foundation of the present study relies on the interdependence of language and cognition (Halliday, 1993; Vygotsky, 1978; Vygotsky 1986). Language acquisition provides a semiotic means by which infants are enculturated (Halliday, 1993; Tomasello et al., 2005; Wells, 2007) and construct meaning both within and into their environment (Halliday, 1975; Vygotsky, 1986; Wells, 2007). It’s fair to say that not all cognition is dependent on language (Perlovsky, 2013) but all language is dependent on cognition (Vygotsky, 1986). Cognition precedes and structures language and language provides the source for social and cognitive development (Gentner & Christie 2010; Papafragou et al., 2007). Perlovsky (2011; 2013) has used a dual computational model for language and cognition to show that there are endless combinatorial possibilities to mentally represent and learn concepts. The researcher's findings suggest that language and cognition are separate but integrated processes that evolve jointly for thinking about information. Thus, language is a mediating factor in facilitating cognition from perception (Bruner & Austin, 1986).

Acquiring language for cognitive functioning arises from building meaning through combinations of words in relevant social contexts (Bruner, 1975; Corota et al., 2021; Pulvermüller, 2012; Searle, 1969; Vygotsky, 1986). When human participants process word meanings, a variety of cortical regions activate, indicating semantic comprehension (i.e., understanding of concepts) is linked to widespread brain systems (Carota et al., 2021; Pulvermüller 1999; Pulvermüller et al., 2021; Binder and Desai, 2011). Nip et al. (2011) for instance, studied twenty-four children between the ages of 9 and 21 months, and showed that faster speech movement speeds correlated with higher language and cognitive skills (on subtests), which suggests these variables rely on the same underlying developmental processes responsible for acquiring cognitive concepts.

Neuroscience evidence related to embodied cognition theory, shows that semantic learning is grounded in neuro-semantic cell assemblies in visual and motor association areas, along with perisylvian and extrasylvian areas associated with language (Barsalou, 1999; Borghi et al., 2004; Kaschak et al., 2009; Garagnani & Pulvermüller, 2016; Tomasello et al., 2017). These findings support evidence suggesting that conceptual processing and representation of word meanings involves two systems – a linguistic and simulation system, the latter of which generates mental images supporting situated actions (Barsalou et al. 2008; Louwerse & Jeuniaux, 2008; Zwaan, 2008). The two systems are believed to work together to support conceptual processing and learning (Barsalou et al., 2008). Humans are thus, likely to rely on language and simulated (i.e., imagery) capacities to process and construct conceptual meaning in various tasks (Louwerse & Jeuniaux, 2008).

Research has showed that language plays a role in restructuring cognition by realigning semantic categories (Majid et al., 2004); modifying or modulating cognition by influencing perception and categorization (Wolff & Malt, 2010); recoding cognition by remapping the relationships between our body, objects, and space (Borghi et al., 2013); and extending cognition by giving us access to an internal multimodal symbol system that augments and facilitates embodied representations (i.e., mental images of self in action) (Dove, 2014). As people acquire more concepts represented as language, they develop broad semantic memory networks that enable multimodal representations for conceptual thinking and learning, such as visual-mental images (Arwood, 2011; Binder & Desai, 2011). These networks allow people to recall a previously learned concept, develop semantic relationships for learning, expand/extend thinking, and scaffold learning. Thus, perception, cognition, and language are linked through cortical circuitry that processes the underlying meaning of specific words (Chatterjee, 2010) and allows for the extension of cognitive capacities into the social world (Borghi et al., 2013). Importantly, the brain requires functional language to process whole meaning, think conceptually, and reach higher levels of thought through expanded language functions (e.g., displacement, semanticity, flexibility, productivity and redundancy) (Arwood, 2011; Arwood & Merideth, 2017).

Language Functions. All language functions within social and cultural contexts, based on how those sociocultural contexts have historically functioned with language capacities (Reboul, 2017). In other words, specific words or combinations of words have specific meanings in specific societies and cultures based on what previous generations have decided are valid or meaningful about those ideas which influences the way we think and behave (Lenneberg, 1969; Whorf, 2012). Thus, language functions to not only help humans develop representations of the external world but also to communicate those representations which in turn lead us to affect our environment, providing stimuli that impacts the thought processes or representations of others (Galaburda et al., 2002).

Perszyk and Waxman (2018), eloquently discuss the role of language in human evolution and development.

> The power of language derives not from the exquisite detail of its signals or the precision of its grammatical rules but from its intricate and inextricable link to human cognition. This link, unparalleled elsewhere in the animal kingdom, serves as the conduit through which we share with others the contents of our minds. It enables us to move beyond the exigencies of the here and now, to represent the past and the future, to build upon one another's knowledge and beliefs, and to consider different perspectives on the same phenomena. Through human language, we can essentially hijack one another's minds, working collectively to invent history and time, to promote religious beliefs and scientific theories, and to create literature and art.

Importantly, language is greater than the sum of its word structures (Arwood, 1983). The acquisition of signs (i.e., meaningful content) through real-world contexts is crucial for changes to cortical circuitry and networks responsible for language functions (Pulvermüller, 1999; Pulvermüller et al. 2021). Inherent, in semantic language learning, is a need to have meaning assigned (or scaffolded) to behavior or language, usually from more knowledgeable others, for conceptual meaning to increase to a concrete level (Bühler & Eschbach, 2011; *Vygotsky, 1986*). As language acquisition and meaning increase, language functions develop and come to represent a person's underlying cognitive understanding and thinking. Once students reach a concrete level of thinking, they begin to 'see' themselves and others as agents and understand concepts and relationships between concepts (Arwood, 2011).

Language functions are expanded and extended in adolescence and adulthood into more complex and abstract thinking processes – what is often referred to in some literature as higher order thought processes, such as problem solving, critical thinking, and metacognition (Arwood, 2011). Expanded language function for *formal* thinking or 'linguistic function', is the ability to, a) use English grammatical structures (e.g., syntax, morphology, and semantics) flexibly and effectively, b) represent ideas of the past, present, and future, with a maximum level of displacement and semanticity, and c) assign meaning to one's own thinking and learning metacognitively. Therefore, language functions are the result of a developmental process of language acquisition and conceptual learning (occurring at the neuro-semantic level) (Halliday, 1975; Tomasello, 2005a; 2005b; Vygotsky, 1986).

Students develop expanded language functions for formal-level thinking from multiple cognitive and social applications of language, such as those in literacy-based formats, which allow the neurobiological development of semantic memory (i.e., networks of knowledge). The ability to develop metacognitive knowledge for oneself and one's learning or as Arwood (2011) calls it "development of the learning capacity known as the formal mind" requires substantial cerebral feedback (i.e., top-down regulation) and therefore, relies on developed neural networks of semantic memory. Thus, the brain functions synergistically to acquire language structures and use those structures to perceive experiences, think about experiences, communicate experiences, and develop thinking based on those experiences (Galaburda et al., 2002).

Metacognitive Functioning and Development. Neuroscience researchers often utilize (post-judgement) subjective confidence ratings correlated with decision accuracy as a strategy to measure metacognitive performance (Baird et al., 2013). In these studies, accuracy denotes decision-making and confidence denotes a sense of awareness (i.e., monitoring) related to performance. When measured by neuroimaging scans, such as fMRI, various structures have been found to be active (increased blood flow signaling neuronal firing), given the metacognitive skill under investigation. For instance, fMRI scans measuring the performance of metacognitive abilities (e.g., monitoring) during specific tasks have found in frontal lobes, specifically the rostrolateral prefrontal cortex (rlPFC), the posterior medial frontal cortex (pMFC), the anterior prefrontal cortex (aPFC), the precuneus, and the dorsal anterior cingulate cortex (dACC) to be active (Baird et al., 2013; Fleming et al., 2018; Fleming & Dolan, 2012; McCurdy et al., 2013). Metacognition is thus considered a top-down mental (or regulatory) process activated in cortical regions which carries out executive functions (Roebers & Feurer, 2015; Roebers, 2017), such as the pFMC which interacts with visual (i.e., perceptual) and motor regions driving attentional focus (Danielmeier et al., 2011; Fleming et al., 2018).

Weil et al. (2013) investigated whether metacognitive abilities improve through adolescence into adulthood. They defined metacognition as a participants' ability to judge performance on a task in comparison to how well they actually did on the task. Therefore, participants' confidence on task performance (i.e. monitoring) was linked to metacognition. The investigators studied 56 participants, separating them into adolescents and adults, depending on age. Each group was given a visual task and their confidence in judging performance on the task was later assessed. In this way, Weil and colleagues attempted to separate the act of knowing from monitoring one's own thoughts about performance.

The researchers found that metacognitive abilities improve through adolescence, peaking in late adolescence (around the time students normally enter college), and leveling-off in adulthood. Furthermore, adolescents performed better overall on metacognitive judgements of their own performance than did adults. The researchers speculated that their findings could be a result of key aspects in neurological development during adolescence which help children monitor their abilities and focus on aspects of learning that have yet to be understood. These findings shed light on students' metacognitive abilities when entering college. Previously cited literature on language development may fill gaps on the developmental aspects of metacognition mentioned in the study.

Cognitive psychology has several complementary, developmental perspectives of metacognition, including the psychological attribution of other peoples' mental states – a behavior known as theory of mind (ToM) (also termed mentalizing and mindreading) (Carruthers, 2009; Efklides, 2008; Kuhn, 2000; Schneider, 2008). Schneider (2008) discussed the longitudinal relationship between Theory of Mind (ToM) and metacognitive abilities (i.e. metamemory) in children's development starting from the age of three. Though these mental constructs are critical for mental development in adolescents, they had rarely been compared to one another. Schneider found that language abilities during development had a strong relationship with both ToM and metacognition competencies. Furthermore, the researcher found that the development of ToM competencies in young children had an effect on vocabulary linked to metacognitive understanding which then, had an effect on the development of metacognition in those children.

Therefore, it's becoming clearer that metacognition is not something that appears but rather something that develops in human beings very early on, perhaps in infancy (Brinck &

Liljenfors, 2013). Kuhn (2000) for instance, posited that metacognition begins developing before adolescence, illustrating that by the age of three, children show a capable awareness of themselves and others as thinkers and 'knowers.' Similarly, Balcomb and Gerken (2008) found that 3-year-old children demonstrated metacognitive monitoring skills when assessed on tasks in which they thought about their own knowledge. Therefore, metacognition may develop early in childhood and continue developing based on the development of language and cognitive functions.

Sodian & Firth (2008) point out that in the race to find which educational applications/strategies support which neural systems, researchers have lost site of the higher order cognitive processes that support student thinking. While mind-brain research has helped to illuminate the neural activity involved in various metacognitive skills, it has yet to integrate *language* as part of the higher-level cognitive processes involved in metacognitive development. Language is the most developed product of the feedback (top-down) system (in the cortex), allowing humans to think critically, reflect on their current understandings, represent their points of view, and act (with agency) into social contexts (Arwood, 2011). It follows then, that language also provides the ability for the brain to draw meaning from its own understandings (e.g., metacognition), particularly during/after socially-mediated activities (Fernyhough, 2008; Goos et al., 2002; Larkin, 2009). As Perlovsky, (2011) states, "cognition cannot be learned without language (p.7)."

The extensive, original literature on human development by Jean Piaget and Lev Vygotsky is intricately connected to metacognition as a cognitive process (Brown, 1987, McCaslin & Hicky, 2001; Fox & Riconscente, 2008) particularly with regards to conscious self-regulation and the roles private and inner speech play in development (Harris, 1990). For instance, Vygotsky based sociocultural theory (SCT) on observations of children acquiring language in social interactions with more knowledgeable adults (e.g., teachers). Vygotsky found that such interactions led children to learn culturally specific ways of thinking, speaking, and behaving (Berk, 1994). Vygotsky (1986) posited that reflective awareness, or “the consciousness of being conscious”, is a developmental path that late adolescents near, as they progress from using language, to extract meaning in social contexts, to using language to internalize systematic ways of thinking with scientific concepts (p. 170). It is the act of continued academic socialization - the exchange in signs between the external environment and internal ‘representations’ during pragmatic, goal-oriented activities - that the mind attunes to itself, allowing for the control of learning, thinking and behavior (e.g., self-regulation) (Fox & Riconscente, 2008).

Vygotsky’s (1934/87) research on childhood development and inner speech provides more evidence for a developmental metacognitive framework. In Vygotsky’s view language develops into an internalized representation of itself, first, in the form of private speech and then later as a more nuanced inner speech that verbally mediates cognition. Al-Namlah et al. (2006) for instance, gave children short-term memory tasks while recording their phonological recordings and discovered that children do indeed use private speech in the first years of school. Additionally, Winsler & Naglieri, (2003) found that the transition from private to inner speech likely takes place around middle school. These findings correlate with Arwood’s (2011) findings that children develop basic language functions (i.e., thinking that language represents) early in their cognitive development before being able to assign meaning to their own thinking and learning in adolescence. Children who have expanded language function are no longer restricted in language structure nor limited in cognitive development and can therefore use their language and cognition to create concepts about the world and their mental states (Arwood, 2011). Therefore, inner and/or private speech (which is shaped by the social environment) may have an important role in accessing or carrying out metacognitive functions, while metacognition (in itself) functions to shape cognition and behavior (Bermúdez, 2003; Castro, 2019; Clark; 1997; Dennett, 1993; Jackendoff, 1997; Morin, 2005).

If language and cognition are interdependent, as previous sections detailed, then language function entails metacognition because a person must use language to understand their own thinking. Thinking necessitates language acquisition because a persons' language (i.e., their lexicon) names their thinking (Arwood, 2011). In other words, language becomes the embodiment of the mental plane and the vehicle through which humans become consciously aware. Achievements in language acquisition then serve as a basis for metacognitive development (Brinck & Liljenfors, 2013). Metacognition can therefore be defined as *language used to think about thinking* (Arwood & Merideth, 2017).

Metacognition and Social Experience. There's an additional social element to metacognition that should be explicated to gain perspective on its developmental basis. Flavell (1979) states metacognitive functioning is not solely an inward-looking process but rather influenced by perceptions of others' cognitive states in social contexts. Brinck & Liljenfors (2013) maintain that metacognition arises in 2–4-month-old infants through dyadic interactions with parents, in response to intersubjective experience. Infants show a propensity to scan the facial expressions and gestures of parents and seem to understand their affectual states (Witherington, et al. 2004). These findings are consistent with Lev Vygotsky's (1934/1987) consideration of higher psychological functioning being in essence dialogic, and that origin of such inferential processes are a byproduct of the interpersonal social environment (see

Fernyhough, 2008). In this regard, meanings are always shared or constructed with others, certainly when reflecting on the experiences people share with other people. Hasson-Ohayon et al. (2020) argue that all thinking has a basis in the inherited meanings that are created through intersubjective experiences and thus, intersubjectivity is a condition “for the possibility of metacognition (p.2).” The sharing of understandings through social experience, what is called intersubjectivity, has been posited to be the developmental foundation for inferential thoughts which propel social and cognitive development (Hobson, 2002; Legerstee, 2005; Tomasello, et al. 2005). Therefore, metacognition is conceived of in this study, as an individual mental capacity that is socially-mediated in learning environments that facilitate meta-learning, literacy, and dialogue (Larkin, 2009).

Language and Metacognition in this Study. Language is used in this study to analyze how first year, first-generation students (of adolescent or emerging adulthood age) assign meaning to their visual thinking and learning and what changes occur based on these meanings over the course of an academic success class. Since language is interconnected with cognition, and names our thinking, then language used to think about one’s thinking and/or learning is metacognitive (Arwood, 2011). This is an assumption of research that assesses metacognition using qualitative data, though it’s rarely stated explicitly. This is also a reason why qualitative data provides a richer source of data for contextualizing an individual’s meta-learning (e.g., metacognitive knowledge).

Language in the Learning Environment. Dewey (1938) helped to reshape American education by shifting educational value away from traditional, transmission models that conceived of retention as the overall goal of learning, to problem-based, field experiences that sought human development through contextual language learning and reflective thinking.

Vygotsky (1934/1987) extrapolated the idea of experience in learning, theorizing that people develop intellectually through semiotic mediation, in which they appropriate signs or tools from their environment. Vygotsky (1981) asserted that 'tools' (or objects) help to mediate activities within a human's environment and can be either material in form, such as computers, smart phones or pens; or symbolic tools such as language, drawings, concept maps, or statistical diagrams. Thus, learning is essentially an act of enacting with tools in your environment (Tenenberg & Knobelsdorf, 2014).

Vygotsky's sociocultural theory (SCT) (1978), an extension of his findings on ontogenetic development, posits that knowledge moves to the mind through *representations* of the external - social and physical environment. In SCT, language is a higher cognitive function in which the brain accesses meaning through a mediation process with cultural tools (e.g., interpersonal dialogue, technology) (Theiner & Drain, 2016). If students are dependent on cultural tools to mediate activity in the world, then how those tools are utilized within a collaborative environment affects how symbols are represented invariably affecting how meaning is internalized (Tenenberg & Knobelsdorf, 2014, Vygotsky, 1978; Wertsch, 1988). Meaning is then *constructed* from symbolic (mental) representations through acts of experiencing culture with others (Innes, 2006; Xu & Clarke, 2012; Wells, 2002; Lee & Smagorinsky, 2000). Authentic problems supply a type of innate goal-oriented direction that motivates inquiry - giving power to dialogue in terms of intersubjectivity (shared understandings) (Innes, 2006; Xu & Clarke, 2012). Thus, the knowledge that learners should acquire from social interactions are "embedded in the structural form of the dialog" (Innes, 2006, p.756)."

SCT places importance on how a learner functions within their environment in a way that communicates their identity as well as their ideas. An ideal educational setting then, is one that provides a semiotic basis for people to collaborate and find solutions to practical (pragmatic) problems (Lee & Smagorinsky, 2000; Vygotsky, 1978). Language has a semiotic basis, which becomes a transactional artifact in social groups, utilized to mediate the individuals' relationship with their environment, and can be interpreted through reference to purposeful action (Xu & Clarke, 2012). Dialogue on the other hand, becomes an activity through which semiotic resources are proliferated, allowing individuals to structure conceptual understandings (Wells, 2002). Meanings emerge and are then refined, according to symbolic interactionism, through continual interactions with group or societal members (Carter & Fuller, 2015). Thus, knowledge construction in a developmental sense, is made possible by facilitating a dialogic culture through semiotic interactions and using the shared understandings cultivated in the classroom to feedback and facilitate the pragmatic needs of the learning environment (Bruner, 1996).

Dialogue in Constructivist Environments. Constructivist reforms over the last half century have begun a shift in education from transmission methods (teacher-centric) to self-directed and participatory pedagogies (student-centric) such as collaborative, student-centered environments where knowledge is co-constructed with peers (Cobb, 1994; Wells, 2009). Borrowing heavily from Vygotsky's sociocultural theory, collaborative environments utilize dialogue to orchestrate discourse between multiple agents (Innes, 2006). Sociocultural theories of learning detail how power, agency, and tools interact within educational environments to facilitate or limit knowledge acquisition and application (Esmonde & Booker, 2017; Holland et al., 2001; Vygotsky, 1978). Wells (1999) argued that higher-ed curriculum should place value in pragmatic activities that engage students in forms of "dialogic inquiry", allowing students to construct knowledge for the betterment of their own sociocultural reality. In this way, intellect is "accomplished rather than possessed (Pea, 2004, p.431)."

'Dialogue' from this perspective, is embodied as speech (language), gesture or bodily action and is necessary to achieve levels of intersubjectivity (shared understandings) which allow participants to conceptualize active inquiries (Wells, 2009). Such conversations engage students in comparisons of their own conceptual understandings and allow for refinement of their own thinking (Draskovis et al., 2004). Thus, humans, can essentially learn and connect to their development by engaging in sociocultural experiences where other people assign meaning to their language (i.e., thinking) and actions (Arwood, 2011). The process of intersubjectivity occurs as various learners work through divergent ideas or beliefs to come to mutual understandings by means of interaction (Wells, 2009). By layering symbolic representations into the structure of dialogue students may draw "communicative significance" from social activities (Tomasello, 2001, p.34)." These learning environments are, therefore, ripe for reflection and metacognitive development.

Literature suggests however, that the structure and efficacy of conversations are critical if learning is to be effective (Zwiers, J., & Crawford, 2011). Scaffolding for effective conversations can be difficult and teachers may not have the proper training to structure conversations between students properly. Thus, teachers are faced with a difficult challenge - to design the learning environment to be conducive with activities that will help students co-construct knowledge through the quality of dialogue between participants.

Constructing the Framework for Visual Thinking and Learning

In this study, FYFG students accessed and refined their visual thinking and learning through meta-learning (e.g., metacognitive) processes in an academic success class. The researcher then assessed changes to FYFG students visual thinking and learning. This section focuses on neuroscience, education, and developmental literature to capture how the researcher conceptualized visual thinking and learning and how language functions to support these processes neurobiologically. Therefore, this section closes the loop on the interdisciplinary research that encompasses the neuroeducation model which is used as the theoretical framework for this study.

Arwood's Neuro-Semantic Language Learning Theory (NsLLT) will be discussed as it provided a holistic framework for conceptualizing visual thinking, learning, and metacognition. The following subject matter will also be discussed to construct the theoretical and conceptual frameworks for visual thinking and learning - 1) neural plasticity, 2) the role of semantic memory in learning, 3) language as a referential/representational system, 4) the functionality of visual-mental images, 5) how mental imagery represents concepts, 6) the functionality of visualization and imagination, 7) how and why people use a visual learning system, 8) the connection between metacognition and mental imagery, 9) what metacognitive and visual strategies provide students, 10) the state of college academics in supporting students who think and learn visually, and 11) rationale for assessing how people use a visual or auditory cognition through natural language.

The Neuroscience of Learning & Development

This subsection will review cognitive neuroscience research to conceptualize what thinking, learning, and cognition entail in this study. Cognitive neuroscience emerged from the field of neuroscience over the last 30 years to explain humans' cognitive abilities and learning processes. This body of research appears to view language acquisition and cognition as interconnected processes that develop jointly as a result of semantic grounding mechanisms at the neurobiological level that bind information about words to their (physical and social) world meanings (Garagnani et al., 2021; Harris, 2006; Pulvermüller, 1999; 2013).

Discoveries in cognitive neuroscience contrasts with the dominant view held by Noam Chomsky and other linguists during the latter half of the twenty-century, that language is an inherent device (with grammatical knowledge) that children possess from birth. Cognitive neuroscientists alternatively, share general views held by cognitive linguists – that humans develop sociocognitively and neurobiologically based on the joint development of language acquisition and sensorimotor processes over the lifespan (Harris, 2006). The term *sensory* refers to areas of the brain that control the primary senses– i.e., primary and adjacent higher visual, auditory, somatosensory, olfactory, and gustatory cortex; while the term *motor* refers to the functionality of the motor areas including the motor cortex, i.e., neural processes that control motor acts or actions (i.e., walking) (Pulvermüller, 2013a). Therefore, 'sensorimotor' refers to the brain's sensory and motor functions or neural pathways.

Notable researchers Frederick Pulvermüller, Max Garagnani, and Rosario Tomasello among other neurobiologists have substantiated that neural tissue is plastic, meaning its malleable and develops in part from neuronal firing during episodes of language acquisition. Using neuroimaging techniques (e.g., fMRI), the researchers have discovered that learning semantic relationships between word forms and their referent objects and actions cause neurons to join together into distributed semantic neuronal circuits, invariably linking word structures to semantic information (Garagnani & Pulvermüller, 2016; Tomasello et al., 2017). Such findings largely support Vygotsky's research regarding the role social and cultural interaction plays in facilitating semantic learning of language-based concepts (Frith & Frith, 2012; Pulvermüller, 1999, 2013).

While humans generally have in-tact brain structures that perform specific cognitive operations, the brain also functions using semantic circuitry across cortical regions, including multimodal and modality preferential areas (e.g., visual or motor cortices), that mediate interactions between external and internal environments (Garagnani et al., 2021; Pulvermüller, 2018a; 2018b). The term *multimodal* refers to regions of the cortex that are equally dedicated to processing sensorimotor stimuli to create meaning, while modality ‘specific’ or ‘preferential’ means the brain is using some parts of the cortex (more than others) to process stimuli (Pulvermüller, 2013a).

Research indicates that language acquisition sets up, a) modality-specific ‘embodied’ mechanisms anchored in sensorimotor systems (e.g., visual or motor cortices) that ground language meanings in action, perception, and emotion, and b) ‘disembodied’ mechanisms in multimodal areas (e.g., perisylvian convergence area associated with language), that allow for processing of abstract meanings and thoughts (Pulvermüller, 2013a; 2013b; Pulvermüller & Garagnani, 2014). This means that people develop representational systems (i.e., ways of seeing and thinking) that interface with the external word as a result of learning language-based concepts, which invariably affects how they think, feel, learn, and act into the world.

The representational systems both embody the meaning of ourselves in action and allow us to process and think about ourselves (or other ideas) outside our immediate environments (i.e., thinking beyond actions). Thus, the brain functions synergistically through the joint activity of multiple areas which enables cognition (Galaburda et al., 2002). Concrete ideas or perceivable objects are linked to perception and action systems (Reboul, 2017), while abstract ideas are linked to language areas and multimodal convergence zones (Pulvermüller, 2013a; 2013b). Mental representations (i.e., thoughts) can thus, be described as being ‘embodied’ by our actions and ‘grounded’ in our neurobiology, allowing human cognition to be ‘disembodied’ from the physical form (Galaburda et al., 2002). Therefore, epigenetics (i.e., biological changes resulting from gene expression based on environmental forces), not merely genetic origins plays a role in humans’ biological development and cognitive functionality (Harris, 2006).

Semantic Memory and Neural Plasticity. By the time children reach school-age they have language networks that are developing at rapid rates (when healthy and interacting in pro-social environments) (Arwood, 2011). Neural networks are built on semantic circuits (i.e., neuronal assemblies) which develop from the layering of semantic patterns (i.e., overlapping sensorimotor patterns in the midbrain) that are processed (from stimuli) during interactions with the external world (Arwood & Merideth, 2017; Tomasello et al., 2017). Semantic circuits, which are often found in cerebral convergence zones, makeup a persons’ *semantic memory*, i.e., the system of meanings that have been interconnected over time (Binder & Desai, 2011; Pulvermüller, 2013b). Thus, semantic memory represents the *knowledge* one attains about oneself and the world during their lives (Binder & Desai, 2011).

Language acquisition stimulates semantic learning during authentic, inquiry-based scenarios, enabling the growth of semantic memory (Arwood & Merideth, 2017; Binder & Desai, 2011; Garagnani & Pulvermüller, 2018a; 2018b; Pulvermüller et al., 2021). If context is absent from the environment, neurons fail to receive the semanticity for sensorimotor patterns to cluster (wire together) into cell assemblies (circuits) that encode concepts for semantic access and memory (Pulvermüller et. al, 2009; Tomasello et al., 2017). On the other hand, increased semanticity in a child’s life helps innervate cerebral convergence zones (i.e., neural pathways made up supramodal processing streams) causing cell assemblies (i.e., circuits) to develop in associative areas of the cortex (Binder & Desai, 2011; Pulvermüller, 2013a; 2013b; Grisoni et al., 2016). Regions of the brain thought to mediate language and cognition (e.g., perisylvian and extrasylvian areas) have been found to be particularly excitatory and malleable to repeated semantic word learning instances (Harris, 2006; Tomasello et al., 2017).

Neural pathways develop via integration between cellular feedforward (sensory stimuli) and feedback (top-down) activation in the cortex which sends signals (or afferents) to lower-order cortices with contextual information pertaining to one's interpretations (e.g., task structure, goals, expectations, etc.) (Rindner et al., 2022). For instance, Matsumoto et al. (2004) used electrical stimuli in the language dominant hemisphere of epilepsy patients and found cortical connections exist in the perisylvian and extrasylvian language areas, via long and short association fibers that use feedforward and feedback projections. This indicates that functional connectivity and organization of language-based concepts is much broader than areas typically associated with language use. Arwood (2011) contends that the brain functions using a perceptual feedback system that allows for higher-order thinking. This system is composed of integration and inhibitory processes, which increases the potential (and efficiency) of neurons to continue firing together to form long-range connections from the peripheral nervous system (PNS) to the central nervous system (CNS) to the cortex. Neural feedback then, promotes *neuroplasticity* of pathways, which are changes to the functionality and architecture of the brain based on prior learning experiences (Arwood, 2011; Barron, 2021; Voss et al., 2017).

Semantic Circuitry. On a cellular level, semantic circuits represent an electrochemical response and adaptation to stimuli, which allows the person to comprehend what is being seen or heard in the environment (Baars & Gage, 2010). Each learning event changes a persons' semantic circuitry (via neuroplasticity), thereby changing the way they perceive new semantic input (Arwood & Merideth, 2017). No two people perceive semantic information the same way because each persons' neural circuitry is unique (Arwood, 2011). When a semantic input is received by a person, their prior experiences (i.e., conceptual circuits) will shape how they perceive that input. Continual feedback through language and other visual-auditory stimuli will grow circuits (i.e., concepts) into broad, distinct sensorimotor networks (Tomasello et al., 2017).

Thus, knowledge is developed neurobiologically through the processing of sensorimotor input, allowing for semantically grounded perceptions of real-world contexts (Tomasello et al., 2017). Semantic memory is critical for learning, because it allows information to be encoded in circuits that can be later accessed for thinking and metacognition (Binder & Desai, 2011). Humans could not envision the future, contemplate the present or reminisce on the past without the ability to activate and process concepts stored in semantic memory. Memory is thus, a neurological precursor to development and learning, because learners must store information to think about it and must think to gain deeper understandings which develops neural pathways.

To highlight this rationale, Garagnani & Pulvermüller (2016) tested a neurobiological model that explained semantic word learning in terms of general word-form processing and category-specific neural activity. The authors hypothesized that learning the meaning of language occurs through the processing of articulatory and phonological word forms (patterns) as they relate to the object and action of symbols being referenced. In this model, knowledge is developed neurobiologically through the processing of sensorimotor input that is semantically grounded based on perceptions of real-world events. The authors utilized a Hebbian associative learning approach, believing that various sets of nerve cells would activate, reactivate and interconnect as words came into continual contact with experiences. In other words, context in the real-world would be necessary for cells to fire and link.

As subjects underwent word training, their brains processed sensorimotor patterns whereby Hebbian associative learning strengthened synaptic circuitry, actuating cellular assemblies (CAs) to form over time. As this occurred, the CAs grounded action-related words in the motor system and object-related words in systems responsible for perception (e.g., visual to the occipital lobe, auditory to the temporal lobe). These CAs, thus experienced 1) category-specific effects across action or perception related tasks connecting to modality-preferential cortical regions and 2) functional word-processing effects in the form of pattern recognition that semantically bonded multimodal regions. Spontaneous lexico-semantic CAs formed as associate learning occurred, acting as cortical 'hubs' or convergence zones, which displayed more neural excitement, synaptic modification and density when interfacing with modality systems (than primary cortical regions).

Evidence from the study confirmed perisylvian areas of language activation (containing Broca's and Wernicke's area) with the ability to recognize word-form (as patterns), and more interestingly *extrasylvian* areas of circuitry growth, which were responsible for grounding semantic information that corresponded with modality-preferential regions. For instance, words that had visual-referents, such as animals, produced activity in extrasylvian CAs which 'lit up' the ventral temporo-occipital stream, which is responsible for cortically mapping (or encoding) the visual world allowing for perception. The researchers found that primary cortical areas like the occipital lobe, contain preferential modalities which are activated during the processing of sensorimotor patterns, and cellular hubs that form (over time) as associate (Hebbian) learning occurs, helping to ground action-related words in the motor system and object-related words in systems responsible for perception (i.e., visual, auditory). These findings suggest human perception, thinking, learning, and action are integrated processes that are embodied by cortical circuitry and are highly dependent on real-world experiences.

Neuro-Semantic Language Learning Theory

This subsection explores the framework utilized in this study to conceptualize visual thinking, learning, and a visual learning system. Dr. Ellyn Arwood's (2017) *neuroeducation* approach uses an interdisciplinary theoretical framework, incorporating findings from linguistics, cognitive psychology and neuroscience to outline how the brain processes language-based concepts from sensory input, and how those concepts are continually refined through higher-order and sociocognitive processes of learning. To solidify this framework, Arwood proposed the Neurosemantic Language Learning Theory (NsLLT), which is a four-level acquisition process, conceiving of how people learn and develop with language (Arwood & Merideth, 2017). In the NsLLT, the brain is physical (as in biological), while the mind is a separate neurobiological resultant of socio-cognitive learning, mediated by language (Arwood, 2011). Therefore, the NsLLT highlights the process of language acquisition through the neurobiological hierarchy of human conceptualization. Learning is therefore biological, social, and psychological.

In the first level the student receives semantic input (i.e., information) through auditory and visual stimuli (processed through hair cells in the ear and photo receptors in the eye), which increases the action potential of neurons in the peripheral nervous system (PNS) causing them to fire (Arwood & Kaakinen, 2009). In the second level, continual semantic input (i.e., stimuli) from the physical environment will stimulate rapid and repeated neuronal excitation and inhibition, precipitating cellular linkage that carries (electrochemical) signals from visual and auditory pathways through axons that reach into subcortical regions of the central nervous system (CNS) allowing for perception (Baars & Gage, 2010; Tomasello et al., 2017).

Importantly, the cells of the receptor organs convert sound and light waves into chemical changes that act as messages to the receptor cells. Chemical changes move along pathways in the central nervous system to the brain. The assembly of activated cells (i.e., cellular structures) allow for pattern recognition.

Under the right circumstances, signals will move through the corpus collosum into both hemispheres of the cerebrum, where they are interpreted (i.e., comprehended) by the formation of sensorimotor patterns in or adjacent to the somatosensory cortex (and perisylvian areas responsible for language comprehension) that connect with modal-preferential (i.e., category-specific) systems such as the motor cortex allowing the person to respond through movement or speech (Tomasello et al., 2017). Thus, perception, at a basic level, is a result of inputs overlapping into cellular layers that can be recognized by the existing cellular structures in the CNS.

At this point in the learning process, students can replicate the knowledge/skills that have already been modeled – either through imitation or recitation. Students have yet to gain thorough conceptual understandings and are thus, 'doing without the thinking' (Arwood & Kaakinen, 2009). Arwood (2011) asserts that acoustic patterns alone will not create enough meaningful connections that allow for conceptualization at the next level (of the NsLLT). This means that putting the sounds of words together (i.e., phonics) does not create concepts in the brain. The overlap of acoustic and visual patterns or multiple visual patterns, such as viewing someone's mouth movements and gestures as they speak can create enough meaning so the mind generates mental images which represent concepts at the next level. As similar stimuli enter the senses - through interactions with the external world "an idealized sensory or motor representation" of a concept is encoded in developing circuits, supporting integration (with other concepts) and reactivation (Binder & Desai, 2011).

Thus, at the third level of acquisition, the patterns overlap to form semantic circuits, which interconnect in the cerebrum to form concepts (represented as mental images psychologically) (Lam & Arwood, 2017). New semantic features in the form of patterns integrate with circuits to form scaffolded points of access invariably forming semantic relationships that broaden and/or deepen conceptual understandings. Neuronal processes of integration and inhibition (which make up the feedback system) filters new and old patterns during the learning process, so old patterns that have meaningful connections move on to integrate with previously learned concepts, while old patterns that are redundant or don't have meaningful connections are prevented (or inhibited) from progressing (Arwood, 2011). The integration and inhibition process allows for the development of semantic circuits (i.e., concepts), which enables higher order thinking. Language use represents and assigns meaning to these concepts which eventually allows one to develop more semantic relationships through one's language function. For instance, the emergence of cell assembly (CA) circuits and distributed circuits have been found to be associated with large-scale synchronous (neuronal) spiking in semantic learning scenarios where symbols for action and object are observed (Garagnani et al., 2017; Tomasello et al., 2018). This suggests the semantic grounding of symbols (binding language structure to word meaning) leads to the development of functional cortical architecture.

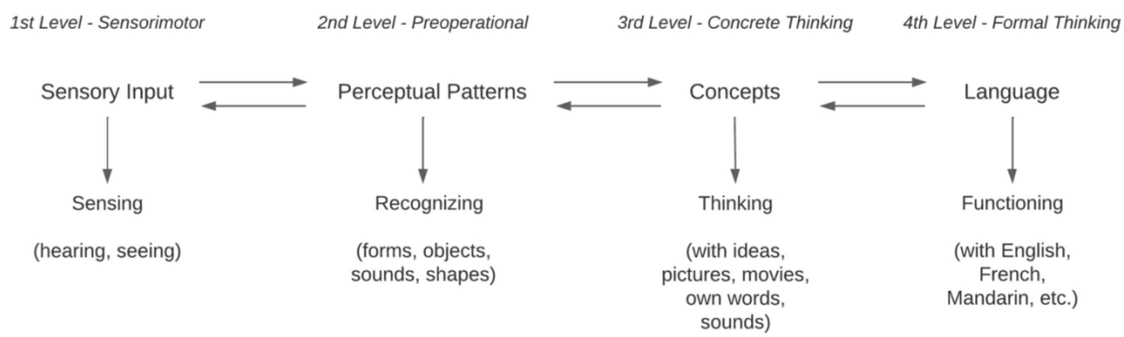
The connection between the third and fourth levels of the NsLLT are critical in education because this link outlines the process by which students move between using language to think about concepts and using language to think about thinking and learning. Continuous language learning, through phonological and articulatory word patterns, helps form lexico-semantic cell assemblies (CAs), which are convergence zones that facilitate formation of higher association neural connections (Damasio, 1989; Pulvermüller, 1999; 2012; 2013a). These CAs display more neural excitement, synaptic modification and density when interfacing with modal systems (than modular cortical regions), likely because they are integrating downstream feedback (i.e., conceptualization) from multiple sensory perceptions (Tomasello et al., 2017). CAs are likely to undergo growth in density and expansion into other regions, which is why it's believed these emerging networks are critical for learning new concepts, semantic memory, and processing semantic relationships inherent in language acquisition (Valk et al., 2016; Tomasello et al., 2018).

In the fourth level of acquisition, circuits form integrated language networks that connect through the corpus collosum to both hemispheres (Arwood, 2011). Within the NsLLT, learning is a spiral process, moving reciprocally - new information that fires a neuron begins a process of connecting to other neurons. As this occurs, circuits that represent the concept formation, begin to form. The integration and inhibition of new semantic patterns supports the layering of neurons until networks of circuits (and hubs) reach the frontal lobe, where formal thinking occurs. The spiraling formation (and reciprocal relationship) between *concepts* and *language* gets wider as concepts are learned more deeply. For language function to improve a student must have multiple representations of a concept presented so that the brain integrates/inhibits new semantic features, continuing the spiraling process towards higher levels of thinking. It should be noted that the spiraling process presupposes, one's *natural language* is being utilized in the learning environment (and meaning is being assigned by others) which drives the reciprocal relationship between the third and fourth levels. Figure 1 depicts the four levels of the NsLLT developed by

Dr. Arwood (2011). The arrows moving in both directions signify the feedforward and feedback processes.

Figure 1

Neurosemantic Language Learning Theory (NsLLT)



Note. Modified from Arwood, E. (2011). *Language Function: An Introduction to Pragmatic Assessment and Intervention for Higher Order Thinking and Better Literacy*, (p.56).

The four levels of the NsLLT depicted in Figure 1 encompass the following processes by which people learn language-based concepts: 1) sensory input is processed by receptors (i.e., eyes, ears, hands) in the peripheral nervous system (PNS); 2) sensory patterns overlap to form upstream pathways to sub-cortical regions of the central nervous system (CNS) where the stimuli is perceived; 3) repeated feedback creates semantic patterns that form circuits (i.e., cell assemblies) allowing for semantic memory, conceptual modulation and extension; 4) language patterns form in association areas that bond CAs to higher-order networks, semantically grounding word form and meaning. The various levels of acquisition also equate to different stages of thinking during childhood development: The sensorimotor stage (1st) where learners input semantic features; the pre-operational stage (2nd) where those inputs form semantic patterns; the concrete stage (3rd) where learners begin to understand concepts concretely; and the formal stage (4th) where concepts can be elaborated upon through language. At the third and fourth levels, new semantic inputs are integrated into existing networks or schemas, allowing concepts to be encoded into semantic memory and accessed for use in various subsequent contexts (Arwood & Kaakinen, 2009).

The NsLLT thus outlines a neurobiological model for conceptual processing in which language requires the most interconnectedness (i.e., neuronal wiring in perisylvian and extrasylvian networks in both hemispheres) to be learned effectively (see also Garagnani & Pulvermüller, 2016; Pulvermüller, 2013b; 2018a; 2018b). The NsLLT sits at the center of the neuroeducation model used for this study and supports the notion that concept acquisition and language function occur before surface structures of language emerge and develop in unison (Arwood, 1983; Dore, 1974; Vygotsky, 1986). Importantly, the development of concepts occurs by matching the sensory input to the way the student thinks and create concepts (Arwood, 2011). Regurgitating sounds and word structures in learning environments only leads to the imitation (or recitation) of patterns. Students need multiple opportunities to access meaningful visual input and use the ideas in meaningful interactions. Concepts are rarely learned in isolation but rather through social interaction with others, which generate referents (i.e., meaningful references to ideas through words). *Learning*, in the context of this study, therefore, refers to the act of learning based on the ways humans neurobiologically process, recognize, understand, and learn concepts that language represents (Arwood, 2011).

Language as a Representational System. Early dyadic interactions between parents and infant, create a structured environment that facilitates intersubjectivity allowing children to monitor their caregivers' intentions and develop strategies for how to behave (Brink & Liljenfors, 2013). Acquiring language helps the child to organize and reference ongoing perceptions and meaning of cultural symbols (Arwood, 2011; Pulvermüller, 2018a), particularly during play scenarios with other children (Vygotsky, 1978). Playful scenarios provide an intersubjective training ground for metacognitive monitoring and other inferential representations. In this context, a representation is a mental structure or object, with semantic properties that allow humans “to perceive, make sense of, process, understand, and recall all stimuli (Krcmar & Haberkorn, 2020, p.2).” Later, children will create representations of cognition (i.e., metarepresentations), which helps them monitor and regulate their thinking (Nelson, 1996). Social interaction permits intersubjectivity, which facilitates the semantic basis for understanding metarepresentations via the child’s lexicon (Brink & Liljenfors, 2013; Clark, 2005).

According to Arwood (2011) language patterns and concepts overlap and layer in the child’s neurobiological system to form networks that represent a hierarchical system of language-based concepts. These networks function synergistically across the brain to compose complex thought processes and representations of the external world. All language relies on concept and categorial representations based on sociocultural experiences, including relationships among more than one representation (Galaburda et al., 2002). Therefore, once the child develops and can use language, it will function as a *representational system* for perceiving, thinking about and restructuring concepts/ideas as well as communicating intentions (Gibson, 1979; Vygotsky, 1978). Representational system refers to a system of acquired symbols around which shared human activity is organized (Still & Costall, 1991). These systems contain shared historical, cultural, and social meaning. Brinck & Liljenfors (2013) suggest that metacognition is coupled to one’s representational system via language functionality, particularly in social settings where children perceive and interpret propositional meanings. Adolescents, consequently, use language to semantically orient their sociocultural experiences, thereby gathering various psychological and social meanings, which helps to raise their cognitive capacities (Arwood, 2011; Brink & Liljenfors, 2013; Vygotsky, 1986; 1978).

Visual Learning System

This subsection explores, how this study conceptualizes visual thinking and what it means to use visual thinking for learning. Learning, was previously operationalized as the act of learning based on the ways humans neurobiologically process, recognize, understand, and learn concepts that language represents (Arwood, 2011). Arwood and colleagues theorize that most students learn conceptually through a visual system, which means they use visual perceptual and/or motor perceptual patterns via neural pathways to form concepts and represent those concepts through mental images (or pictures) (Arwood, 2011; Arwood et al., 2002; 2009; Arwood & Kaakinen, 2004; Arwood & Brown, 2001; Robb; 2016). Therefore, this subsection will construct a framework for a visual learning system, drawing primarily from neuroscience and neuroeducation research, and discuss what it means to have a visual learning system in the context of the American educational system. The subsection will end by discussing rationale for assessing how people use visual or auditory cognition through natural language.

Distributed Semantic Networks. Pulvermüller and colleague's work on the brain's language and cortical circuitry substantiates much of the NsLLT framework of Dr. Ellyn Arwood, who theorized the brain functions neuro-semantically based on distributed language networks that develop based on the socio-cognitive process of learning language (Arwood, 2011). Pulvermüller et al. (2009) for instance, studied subjects who engaged in word learning when hearing and reading sentences. Using neuroimaging on subjects, connections (via cortical fiber systems) between the temporal and front-central language areas (i.e., perisylvian cell assemblies) were discovered during articulatory, phonological, and lexical word processing.

These language areas had long range regional connectivity via dorsal and ventral pathways. Action-related semantic networks utilized the dorsal (where) stream, whereas object semantics drew more from the ventral (what) stream. Therefore, meanings and word forms/gestures were grounded in perisylvian cell assemblies that extended to visual and (movement-related) motor areas.

Results from *embodied cognition* research, substantiate such evidence, and suggest that action words (e.g., verbs) evoke perceptual, spatial, and motor memories based on semantic processing of the word in sensory-motor circuitry (Barsalou, 1999*;* Borghi et al., 2004*;* Fischer & Zwaan, 2008; Kaschak et al., 2009). In other words, when humans think about the meaning of actions (e.g., verbs) the brain activates the same areas in the sensory-motor-cortex, that direct the body toward those action-based objectives. Findings from embodied cognition research generally suggest that the body, in terms of its sensory and motor properties, modulates conceptual processing via mental simulations (Barsalou 1999; Fischer and Zwaan 2008; Kaschak et al., 2009). This is because the meaning of some words tend to evoke perceptual and motor memories (via mental imagery) associated with referents in the social world, which help to guide the way people think and act (Chatterjee, 2010). Importantly, language is thought to provide the ability to move beyond embodied states to more complex, flexible, and abstract forms of thinking (Borghi & Cimatti, 2010; Chatterjee 2010; Dove, 2022).

Pulvermüller and colleagues more recent research has shown that a) phonemic processing (i.e., processing word sounds/meanings) is guided by lateral prefrontal, temporal and ventral motor areas, which provides proof for multimodal representations of predictive and perceptual word-sound processing (Grisoni & Pulvermüller, 2022); b) distributed semantic networks (i.e., neuronal circuits) including fronto-central motor regions underly the processing of different speech acts (e.g., motor regions activated before a speaker made a request of a partner) (Boux et al., 2020); and c) neuronal networks with distinct cortical distributions across higher-order association cortices encode and comprehend different representational properties of action and object word meanings according to hierarchical relationships (within and cross-category concepts like "plum" and "peach" as fruits) and distributional relationships in semantic information (e.g., word-word relations like "texts," "media," "discourse") (Corota et al., 2021). Cumulatively, these results suggest that a) the motor system facilitates perception and understanding of action, b) the visual system facilitates perception and understanding of objects, c) both visual and motor systems rely on language networks for processing specific word meanings (including phonemic, articulatory and lexical processing), and d) semantic representations (i.e., mental objects) are grounded in high-level networks that cooperate to encode specific semantic properties of words (Grisoni & Pulvermüller, 2022; Corota et al., 2021; Pulvermüller 1999; Pulvermüller et al., 2009; 2021).

Pulvermüller et al. (2021) summarized recent neuroscience literature on semantic processing in this way:

> It is well known that multimodal areas in the frontal, temporal and parietal lobe are important for conceptual and semantic processing generally, whereas modality-preferential sensory and motor areas contribute to the processing of specific semantic categories. Such integration of multimodal information requires connections bridging between modality-specific neural systems in different cortical areas (which are distant from each other), which implies a role of large-scale connectivity structure in conceptual processing (p.497).

Therefore, language-based concepts, are embodied by developing cortical circuitry through neuro-semantic linkages that supports how the mind functions to represent and learn these concepts (Pulvermüller, 2013). Language networks link to visual and motor systems allowing for multimodal processing of semantic information. Consequently, Arwood (2011) refers to the visual and motor systems as sites that function for learning.

The Visual System. Neuroscience research has identified more than 30 brain areas associated with visual processing (Krug, 2012). It would not be possible to cover the entirety of the visual system in this literature review, but in general the visual system functions via firing neurons that form visual pathways sending signals of light and motion from the retina to the midbrain to the visual cortex to tertiary/higher areas via ventral and dorsal streams (Gazzaley et al., 2007; Krug, 2012; Livingstone & Hubel, 1988; Roland & Gulyas, 1994; Rosen et al., 2019). This system governs the flow of information which functions via feedforward and feedback neuronal processing enabling the ability to visually perceive a three-dimensional representation from a two-dimensional image on the retina (i.e., visual imagery) (Kandel et al., 2014; Felleman & van Essen, 1991; Roland & Gulyas, 1994).

First, in the retina, photoreceptors translate incoming light into electrical signals, which travel through nerve fibers representing ganglion cell axons via the optic nerve, before dividing and partially crossing over to the opposite hemisphere at the optic chiasm (Kandel et al., 2014). Signals then travel to nuclei at the lateral geniculate nucleus (LGN) of the thalamus, and other areas of the midbrain - the superior colliculus and pretectum (Armstrong & Cubbidge, 2019). The optic tract transmits information from left and right visual fields of both eyes to the LGN, helping establish left and right visual fields, which will be reconfigured in the visual cortex (Baars & Gage, 2010; Kandel et al., 2014). A second and third pathway, connecting the superior colliculus and pretectum to the optic tract is responsible for control of eye movements, pupillary reflexes, and modulating motor responses (Butler and Hodos, 2005; Kandel et al., 2014).

Importantly, vision manifests from discrete episodes of rapid gaze shifts across visual fields, called saccades. During a saccade, a visual image sweeps rapidly across the retina, and retinal ganglion cells are initially suppressed. Following this fixation period, ganglion cells will fire a burst of spikes (i.e., spike trains) containing the retinal information needed to process an image (Gütig, et al. 2013). Each neuron can be thought of as a single pixel capturing bits of an image by photoreceptors (Samonds & Priebe. 2020). This process of neuronal information exchange occurs extremely fast (in milliseconds) and is hierarchical in nature – involving increasingly more complex perceptual and semantic features as information flows from the retina to the visual cortex to tertiary/higher cortical regions (Grill-Spector & Weiner, 2014; Jeanneroda & Jacob, 2005; Krug, 2012).

Feedback processes are occurring at various levels of the visual system helping to provide information to earlier visual processing areas. Feedback connections far exceed (at a ratio of 1:10) the number of feedforward connections (Salin & Bullier, 1995; Self et al., 2013), indicating top-down processes (e.g., memory) are instrumental in influencing representation (of an image) and perception (Layher et al., 2014; Rensink, 2014). An important step in perceiving an object is separating figures in the visual field from their background. Segmenting the figure from the background is dependent on specific geometric principles of vision but also on feedback connections (e.g., expectations, attentional features) that interact with a stimulus (Kandel et al., 2014; Ogmen & Herzog, 2010). For instance, top-down processing (i.e., feedback) of visual stimuli has been shown to occur very early within the visual system, involving the LGN, and can be selective dependent on attention and goal-orientation (Melloni et al., 2012; Poltoratski et al., 2017).

Humans do not perceive all that is ‘real’ in the external world, but rather are influenced by context, experience, expectations, and attentional focus (i.e., what a person is thinking about) that guide perception (Grossberg, 2001; Li et al., 2004; Kok et al., 2013; Seriès & Seitz, 2013; Yuille & Kersten, 2006). These factors are controlled by cortical regions, such as the visual cortex, which feedback previously processed information to sensory input, ‘biasing’ representations even at early stages of sensory processing (Kok et al., 2013). Kandel et al., (2014) states that “the brain has a way of looking at the world, a set of expectations that derives in part from experience and in part from built-in neural wiring.” Therefore, the early visual pathway, constituting the optic tract to the LGN, is well adapted for efficient coding of visual information of the external environment (Dan et al., 1996; Haynes et al., 2005).

Two distinct and parallel pathways, a magnocellular (M) and parvocellular (P) pathway account for most of the axons that leave the retina and extend to the LGN and visual cortex. Information arrives to the brain from the retina via the M and P pathways which respond to and analyze different aspects of a visual image. The magnocellular (M) pathway is highly sensitive to contrast, less sensitive to color, has lower spatial frequencies, and higher temporal frequency stimulation; while the parvocellular (P) pathway is highly sensitive to color (reds and greens), has lower contrast, is highly responsive to spatial frequencies, and has lower temporal frequency stimulation (Derrington & Lennie, 1984; Livingstone & Hubel, 1988).

Neurons of the magnocellular and parvocellular systems make up six cortical layers of the LGN and each receive different input from the two eyes. Parvocellular and magnocellular inputs from each LGN layer interact with one another and project to different sublayers of the visual cortex. This interaction supports the integration of visual features, such as color, depth, form, and movement, which lead to a perceivable, coherent image (Kandel et al., 2014). If either of these systems is compromised (e.g., due to lesions) there can be a loss in visual functions such as the processing of color, fine details, and movement (Merigan et al., 1991).

The LGN mutually projects information to the primary visual cortex (or V1), located in the occipital lobe, through a pathway called the optic radiation which contains afferent fibers that forms a neural map of the contralateral (opposite) field in V1 (Armstrong & Cubbidge, 2019; Kandel et al., 2014). Visual perceptual patterns of spatial form (e.g., edges, contrast, size) and movement are processed in V1, helping to segment objects from their background. This occurs via maps of circuits which provide components for neurons in subsequent areas to respond selectively (Molnár & Rockland, 2020). Information pertaining to motion, depth, form, and color then travels to other areas of the visual cortex called the extrastriate cortex (Self & Zeki, 2005; Skalicky, 2016). These visual features are aggregated through two interacting neural pathways that communicate with other regions via top-down and associative (vertical) connections distributed throughout the brain (Budisavljevic et al., 2018; Kandel et al., 2014).

A general consensus has been formed in neuroscience, after years of studying anatomical connections between visual areas, that the extrastriate cortex is organized into two separate systems that feed information pertaining to color, shape/form, and movement to association areas in the temporal and parietal lobes (Goodale & Milner, 1992; Purves et al., 2001). One of these systems, called the ventral stream (or pathway), leads from V1 to the inferior (lower) part of the temporal lobe. The ventral stream is termed the “what” stream as research suggests it is responsible for object/shape recognition of visual features including word meanings (Freud et al., 2017; Ishai et al., 1999). The other system, called the dorsal stream, moves from V1 to the parietal lobe to frontal lobes incorporating areas of the sensorimotor system. The dorsal stream has been called the “where” or “how” stream, as research has found it responsible for guiding actions, spatial orientation, and motion detection, including movement direction and relationships between objects in space (Milner & Goodale, 2006; Purves et al., 2001). Literature suggests the dorsal stream integrates visual and motor information, allowing the individual to *act* on visual inputs (Andersen, 1997; Rizzolatti et al., 1997). These two pathways share information via white matter tracts in the vertical occipital fasciculus and inferior temporo-parietal connection which convey semantic properties of objects including their motor use (Budisavljevic et al., 2018; Bullock et al., 2018; Takemura et al., 2016).

Once a scene has been processed by low and intermediate levels, integrating various details pertaining to movement, color, and shape, it can be matched with memories of shapes and meanings (i.e., semantic relationships) (Kandel et al., 2014). An internal representation of a concept is generated by the visual system via patterns of activation within a population of neurons (e.g., a circuit) and patterns of firing among cells which integrate new patterns with ‘memories’ of similar visual patterns. Learning associations between visual objects occurs in in the temporal cortex, via the ventral stream, through strengthening/developing neural connections that represent the objects (Kandel et al., 2014). Additionally, signals from the temporal cortex may be received by the prefrontal cortex which feeds back to the temporal circuits, influencing the contents of one’s conscious memory. Thus, an image received by the temporal cortex may be associated with other images in prefrontal regions, affecting what one mentally perceives or sees (Kandel et al., 2014). Recalling a visual relationship with another concept (i.e., an associative memory) is therefore, based on feedforward/feedback processes that setup functional connectivity between neurons that represent the association between concepts (Arwood, 2011; Layher et al., 2014).

Because visual information does not enter the eyes as whole visual images, primarily because the eyes are always shifting, the brain needs a way to generate a reliable image of the visual world. To do this, the motor system projects information (or programs/codes) via corollary discharges to adjust the receptive fields of neurons in the visual system, so that one's sense of external space and movement is discernable from internally generated thoughts (Kandel et al., 2014). The parietal cortex, which is involved in the dorsal stream, functions to provide the motor program to the premotor cortex to help control one's movements/actions in space. A dominant feature of the visual system is that its cells are structured to represent the visual field across the cortex, meaning the ventral/dorsal pathways both represent aspects of the visual space and function to operate in the visual space. Along ventral and dorsal paths, previous patterns of activation form cognitive maps embodied by cortical networks, which function to generate representations from present visual fields (Roland & Guylás, 1994). For instance, information about running while dribbling a basketball in space would be generated from the dorsal pathway while the perception of other players and the basketball hoop would be generated by the ventral pathway. Interactions between these pathways would also be functionally important for learning. Interestingly, research has shown that the act of thinking about a movement, such as dribbling a basketball in space, would activate the same visual-motor processing centers as actually dribbling a basketball in space (Gallese & Lakoff, 2005; Pulvermüller, 1999). This implies that the meaning of action words, like dribbling or shooting a basketball, is processed in parallel with the movement of the arm (Pulvermüller, 1999 Pulvermüller et al., 2009). Thinking about the meaning of an action is dependent on top-down processes guiding action/movement (e.g., preparing hands to dribble) and seeing the hand and basketball is largely dependent on lower-level visual processes. However, these feedforward and feedback processes function in tandem within visual and motor systems to perceive, think about, and act into one's environment (Arwood, 2011; Kandel et al., 2014). Gallese and Lakoff (2005) for instance, suggested that premotor and parietal regions, are specifically integrated to control action and construct integrated representations of actions, objects to be acted upon, and the respective locations of objects and actions. Therefore, sensory and motor representations acquired in real-life situations can be reactivated by the visual system during instances of conceptual processing/learning, though the function of the stimulus (i.e., the context and/or meaning of the word learning act) largely determines how this occurs (Barsalou, 1999; Martin & Chao, 2001; Watson et al., 2013).

Importantly, an auditory dorsal and ventral pathway has also been identified, which connects perisylvian language areas in frontal, temporal, and parietal cortices, helping to process acoustic speech signals into motor-articulatory representations and semantic representations for language comprehension (López-Barroso et al., 2017; Rauschecker, 2012). These pathways are also thought to be integral in language functionality and production (Hickock & Poeppel, 2004; Rauschecker & Tian, 2000; Rauschecker et al. 2012; Ries et al., 2019). Convergence of auditory and visual ventral/dorsal pathways, particularly in the prefrontal and ventral prefrontal cortex has shown to be responsible for semantic processing of visual, auditory, and somatosensory input (Mishkin, 1982; Van Polanen & Davare; 2015; Romanski, 2012; 2007). Therefore, these sites of convergence may function to acquire and represent language-based concepts (Goodale et al., 1991). Alain et al. (2001) suggests that integration in ventral and dorsal streams enables higher cognitive functions like language to develop (Alain et al., 2001).

Pulvermüller et al. (2009) for instance, showed that spoken words that related to actions, were processed in dorsal areas (via perisylvian cell assemblies) and the motor system, while written words that related to objects were processed in language areas via bottom-up and top-down activation in ventral visual streams. This corresponds with other studies that have shown activation of the ventral-visual and dorsal-auditory streams during word meaning processing (Carota et al., 2012; Sheth & Young, 2016). These pathways have consequently been identified as conceptual-representational systems that allow for object understanding (Victoria et al., 2019) and visual-motor understanding (Milner & Goodale, 1995). The further along in the visual pathways, the more complex and divergent the circuitry, indicating these pathways are highly plastic and more susceptible to acquiring integrative functions (Kandel et al., 2014). Therefore, visual processing is distributed across several different pathways of the visual system, which reach different functional outcomes in association areas (Jeanneroda & Jacob, 2005). Top-down processes facilitate recall of learned information, while prior knowledge facilitates association of a stimulus with an internal representation of an object shape to form a unified (mental) visual image or concept (Arwood, 2011; Gilbert & Li, 2013; Kandel et al., 2014).

An Integrated Visual and Motor System for Representing Language. Many researchers have pointed out that gesture and speech form a relationship during language acquisition (Alibali et al. 2000; Clark, 1996; Iverson & Goldin-Meadow, 2005; McNeill, 1992). An infant learns to gesture (e.g., shaking head) as they learn the word that is the underlying meaning of the gesture (means "no"). McNeill (1992; 2005) posited that while speech is dependent on linguistic conventions of the English language and is propositional in nature, gestures are more personal and imagistic. Kelly et al., (2008), suggested that if speech developed from gestural communication systems, as has been theorized in evolutional research, then the neural underpinnings of gesture and speech are likely to not solely be linguistic but also "imagistic, motoric, and even emotional."

Neural evidence over the last 25 years has supported the claims of an integrated or 'shared' neural system for representing linguistic and gestural meaning (Binder et al., 2009; Kelly et al., 2004; Özyürek et al., 2007; Straube et al., 2012; Xu et al; 2009; Willems et al., 2007). Bernstein & Liebenthal (2014) for instance, studied the brain activation of subjects when they were given visual speech stimuli, such as, face and body movements, written words, and sign language. The researchers found widespread patterns of activity in the posterior-temporal cortex, which is classically thought of as being specialized for auditory processing. The authors stated, "all levels of speech patterns that can be heard can also be seen, with the proviso that perception is subject to large individual differences." The authors attribute their findings not to the idea that auditory centers are responsible for processing visual speech patterns, but that feedback from ventral and dorsal visual streams may modulate the temporal area providing a 'high-level' vision for speech patterns. Additionally, the temporal region would still be capable of processing phonemic speech properties. In their review of literature, Bernstein & Liebenthal (2014) cited Möttönen et al. (2002) who stated, "visual speech has access to auditory sensory memory," while speech that is visually perceived "appears to have preferential access to auditory processing regions specialized for language (cited from Calvert & Campbell, 2003)." This means that visual and motor stimuli related to language comprehension, seems to be treated preferentially by multiple regions of the brain, including areas typically associated with language comprehension and production.

Additionally, Willems et al., 2007) showed that semantic processing of congruent visual-gestures with auditory-speech words (e.g., the word "climb," with the gesture of "up") had shared activation in a region associated with language production (Broca's area in the temporal cortex). The motor system was alternatively activated when gesture and speech were incongruent (i.e., didn't make sense together). Researchers have accordingly introduced "supramodal" (or "heteromodal") processing hubs (e.g., in the temporal lobe) that receives semantic information from multiple sensory areas, with the ability to integrate gestures (e.g., hand movements) and accompanying speech words (acoustic sounds) that describe actions and objects (Binder et al., 2009; Straube et al., 2012; Xu et al., 2009). While parietal and temporal areas have been found to process semantic information related to gesture and speech separately, other networks exist in these areas that seem to bind and extract meaning from speech and gesture (Straube et al., 2012). Dorsal streams in visual and auditory pathways primarily function to integrate sensorimotor patterns leading to movement/control and ventral streams primarily function to semantically process object/categories leading to conceptual representation and recognition. Evidence suggests these streams also interact and likely function to control actions and support thinking/learning about how to perform actions (Milner & Goodale 2008; Van Polanen & Davare, 2015; Verhagen et al., 2013).

The cognitive neuroscience research discussed here and in previous sections, complements the work in language and psychology research - that gesture influences the processing of speech, both in the act of speaking and listening, and therefore the mind is capable of representing language in image/movement forms. Evidence discussed in previous sections, suggests that visual and sensory-motor systems, what is termed here, 'the visual learning system', involves long-range connectivity in modality-preferential regions such as the visual cortex (V1) for visual processing and multimodal regions (e.g., dorsal premotor cortex, prefrontal cortex, perisylvian areas, occipital/temporal association networks) that processes visual, auditory, tactile/movement, and somatosensory stimuli (Hardwick et al., 2015; Büchel et al., 1998). Summarizing research of the brain during language learning, Pulvermüller (2013) stated "Anatomically, primary motor and sensory auditory and visual areas are not interlinked directly but by way of other areas, including "higher" motor and sensory as well as multimodal areas not dedicated to one specific sensorimotor system (p.92)." Visual and motor systems therefore, process modality-specific inputs (e.g., visual or acoustic patterns), but also process multimodal inputs (e.g., visual, motor, and auditory patterns) that develop concepts (i.e., word-related circuits) through communication with distributed perisylvian and extrasylvian language networks (Arwood, 2011; Pulvermüller, 1999; 2002; 2012; 2013). This would suggest that typical people are capable of integrating both the auditory and visual properties of language through representational (multimodal or perhaps 'supramodal') systems grounded in imagery and simulated action.

Adapting to a Visual System. Research, predominantly in the field of neuroeducation, suggests that most students do not interpret concepts from the auditory waves of a speakers' voice (e.g., during lecture), but rather use visual cognition (Arwood & Robb, 2008; Arwood, 2011; Arwood et al., 2009; Robb, 2016; Arwood, et al. 1986) – meaning they process visual patterns of movement and light to create conceptual representations in the form of mental images or mental pictures (Gallese & Lakoff, 2005; Pulvermüller, 2005). Arwood (2011) has posited that most students began to shift from thinking using auditory cognition sometime in the late 20th century. Students who are purported to use a visual system (or visual cognition) for learning have reported thinking in a language of pictures, rather than the phonetic sounds that make-up words, which causes a mismatch in the American educational system (Arwood, 1991, Arwood et al., 2009; Robb, 2016).

Cavanagh (2011) refers to visual cognition as “high-level vision, mid-level vision and top-down processing” that capture “decision-based scene analyses that combine prior knowledge with retinal input to generate representations (p.1538).” Visual cognition is associated with how the visual system makes inferences through the combination of perceivable visual stimuli and conceptual knowledge that evoke coherent visual scenes as visual images (Vernon, 2021). This can occur through various cognitive processes, such as visual attention, visual memory, and object recognition, among others (Vernon, 2021). Thus, some view visual cognition, as primarily a process and product of high-level perceptual processes. Pinker (1985) however, argued that visual cognition can be divided into two parts, the first being the representation of information presently in the visual world, and the second being a cognitive process of recalling or reasoning about visual objects/shapes not currently being perceived in the visual world. Objects/shapes when recalled are rarely, if ever devoid of meaning, therefore this view of visual cognition aligns with how this study perceives visual cognition – as both high-level visual perception and conceptual representation, whether visual stimuli is available or not available in the immediate environment.

Accordingly, Arwood (2011) posits that the visual system functions to learn concepts via visual cognition. This means that students process visual, motor (and sometimes auditory) patterns that overlap in neural pathways to form visual concepts capable of being perceived, understood, recalled, and further developed. Visual concepts are mental thoughts in the graphic forms of pictures, movies, systems for organizing words, etc. (Arwood et al., 2009). Educators have spoken with children and adults about their thinking in various settings and have reported students’ descriptions of thinking with various visual-mental phenomena particularly when drawing (e.g., still and/or moving pictures, rolodex of words/ideas) (Arwood, 1991, 2011;

Arwood et al., 2002; Arwood & Kaakinen, 2009; Robb; 2016; Gross et al. 2009). Thus, using a visual cognition to learn means that students represent language-based concepts in mental pictures or movies, as words bring to mind our personal experiences. For example, if a student engages in a learning act, such as reading about cytoplasm (i.e., fluid inside a cell) in biology class, the student might begin to imagine or 'picture' cytoplasm's location inside the cell as a way of understanding the written idea and a way to connect it to other ideas, such as the cell's overall structure. Once the student stops reading, they can still picture cytoplasm in their mind, because it is stored in short term or long term memory. Using their language to think about cytoplasm helps the student recall the image because the visual concept is language-based. Therefore, the mind uses language to think about ideas, which it then represents visually.

Arwood's theory about students' visual cognition originates in her extensive experience working with children with language and learning disorders over decades, and subsequent research studying these populations. In short, Arwood found that children regularly had auditory processing issues, which caused them to struggle with reading and learning the English language. Because the American educational system teaches English using its auditory properties (i.e., teaches word sounds to form a word to form an idea) students struggled forming ideas from the audio patterns of word sounds. Arwood's evidence corresponds with research showing abnormalities in phonological processing for those with speech/language or learning disorders, as well as those with autism spectrum disorder (ASD) (Hari & Kiesilä, 1996; Kellerman et al., 2005; Liégeois et al., 2014; Ludlow et al., 2014; McArthur et al., 2008; Del Rincon, 2008; Stevenson et al., 2011; Stevenson et al. 2014a; 2014b). Liégeois et al., (2014) for instance, conducted a systemic review of neuroimaging findings of speech and language disorders from the years 2008-2013. The researchers found that structural and functional anomalies existed, particularly atypical grey matter structures and regressive processes with typical speech development. Findings suggest that deficits in sensory feedback and integration between sensory and auditory motor systems may have existed among subjects. The findings, however, were limited by a lack of consistency in approaches and selection criteria among neuroimaging studies.

Interaction-dominant dynamics theory suggests the structure of the cognitive system is emergent and the organization is fluidly dependent on the ongoing flow of information through the system. Therefore, the individual parts of the visual system may assume new functions that change depending on language learning context (Stephena & Mirman, 2010; Tomasello et al., 2019). For instance, Stephen and Mirman, (2010) showed that visual cognition, through fine-grained eye movement tasks, is dominated by interactive processes of simple processing that makes the cognitive structure emergent (i.e., neural architecture will adapt/evolve based on flow of information processes). Interaction-dominant dynamic theory corresponds to Hebb's (1949) theory of neuronal organization, and neuroscience findings regarding neuroplasticity and epigenetics - that the brain develops and/or evolves based on dominant inputs and effects of social/physical environments (Begley, 2007; Keverne & Curley, 2008; Frangeul et al.; 2016).

Top-down processing influences neurons to respond differently to different stimuli, thereby altering their functionality and structures (Gallisten & Matzel, 2013). For instance, Büchel et al., 1999 showed that subjects who learned continuous associations between visual objects and their locations increased their level of functional connectivity for spatial and object processing. Gilbert and Li (2013) correspondingly argue that "rather than having a fixed functional role, neurons should be thought of as adaptive processors, changing their function according to the behavioural context (see webpage)." Learning and thinking about language is not localized to one region of the brain but is distributed across patterns of activation which are constantly changing the brain's structure and functionality for thinking (Gallisten & Matzel, 2013; Gazzaniga, 1999; Hebb, 1949; Merzenich et al., 1999; Simos et al., 2002).

For instance, subjects who experience hearing loss as children have been shown to have altered cortical representation both within primary sensory modalities (i.e., auditory and visual cortices) and between sensory modalities (i.e., functioning connections between auditory and visual systems), which can affect their oral language acquisition and production (Sharma & Mitchell, 2013). Smittenar et al. (2016) for example, compared receptive field properties of neuronal populations in the visual system, among 15 normal subjects and 15 subjects who had congenital deafness and learned sign language after the age of 10. The researchers found that deaf subjects had structural and functional plasticity adaptations. Specifically, the deaf group had an increased cortical receptive field, suggesting enhanced peripheral visual skills and decreased cortical thickness in V1, which corresponds to more precise visual functioning (Song et al., 2014) and higher spatial acuity (Jiang et al., 2009). This evidence coincides with Pénicaud et al. (2013) who studied changes in gray and white matter concentrations between 23 congenitally deaf subjects. Subjects were separated into three groups – 1) those who had learned sign language from infancy, 2) those who had learned at early ages (between 4-7), and 3) those who learned sign language between the ages of 11-14. The researchers asked all subjects to complete a grammatical (non-verbal) judgment task, e.g., someone signed, in American Sign Language (ASL), the signs for "why," "driving," and "eat". The researchers found that late signers when compared to infancy signers, had a decrease in gray-matter concentration and increase in white-matter concentration (associated with myelination) in the dorsal visual association cortex (i.e., dorsal visual stream), which suggests late signers relied on the visual-motor system for processing language signs (i.e., shapes/movements of hands). In a separate analysis, the researchers compared neuroimaging results of deaf and hearing subjects and found that hearing subjects had decreased white matter concentrations within the superior temporal gyrus, which is associated with perisylvian language areas in the auditory cortex. This corresponds with previous literature that shows lack of auditory stimuli from childhood correlates with reduced functional tissue in the auditory cortex (Shibata, 2007; Smith et al., 2011) and may suggest increased functional connectivity between visual and language areas of the brain for congenitally deaf people who use ASL (Smittenar et al., 2016; Song et al., 2014). Thus, studies of deaf subjects have consistently shown altered brain organization and functionality, preferential toward visual and motor systems.

Research shows that early sensory input facilitates establishment of cortical networks that function to represent concepts, and there are limits on how intrinsic brain systems or structures can constrain functional properties (Neville, 1990; Vetter et al., 2014). Blind subjects for example, have been shown to use occipital areas of the brain to process auditory information, showing the brain still uses higher-level visual feedback processes (of visual cortices) to generate representations even when early visual areas are deprived of stimuli. For instance, Röder et al. (2002) showed that blind and sighted adult subjects who completed syntactic and semantic pseudo-word tasks activated perisylvian language areas during speech comprehension, but the blind group additionally recruited the extrastriate (visual) cortex and primary visual cortex, though no visual stimuli was available to them. Neural activity varied as a result of difficulty and semantic content, as it does in most studies. The results suggest that cortical organization and functionality between brain systems (i.e., perisylvian and visual areas) are shaped by sensory and semantic inputs.

Vetter et al. (2014) additionally showed that blindfolded participants when asked to think about complex natural sounds and images (i.e., abstract information) recruited higher visual areas which provided feedback to early V1 to generate representations, even though no retinal information was available. This suggests the early visual cortex is supplied category-specific information from auditory and higher-imagery areas (among others) when no visual stimuli are available. Because the dominant inputs of most students are visual, particularly with the ubiquity of technological advancements (e.g., smart phones, tablets, etc.) it's therefore, possible, that the visual system (as well as the motor system) has adapted an architecture to be the dominant system of processing meaning for both visual and auditory stimuli. Hickok & Poeppel (2004) for instance, asserted from available evidence, that the cortical organization of language is organized via dorsal (motor) and parietal (sensory) streams that project conceptual and motor representations when mapping the meanings of speech acts (both sounds and articulations). In other words, speech acts are processed via sensory-motor systems that interface with language regions rather than being processed strictly in the temporal lobe.

Campus et al. (2017) additionally found that the processing of audio-spatial information occurred in early occipital areas indicating the visual system uses a visual map of connections in the occipital cortex to facilitate multimodal processing. Functional connectivity results from Ecker et al. (2008) for example, showed that distinct patterns of fiber connections and cross-modal organization existed between the primary visual and auditory cortices, supporting cross-modal organization in the primary visual cortex (i.e., integration of auditory and visual stimuli in the visual cortex). Martin & Chao (2001) gave participants objects from a category and asked them to either recognize, name, imagine, read or answer questions about the categories. The participants had overlapping activation in areas that function for visual motion, suggesting visual areas are recruited for various sensory and language-thinking tasks (e.g., visualizing, language production, reading, viewing, etc.). Lastly, dorsal and ventral language networks (involving perisylvian areas) have been shown to have individual differences involving plasticity depending on language learning instances (López-Barroso et al., 2017). Thus, the nature of sensory input (e.g., its semanticity), the type of inputs (auditory vs visual vs motor), the types of sensory tasks (e.g., reading, speaking, listening, thinking), and the timing of sensory processing (in terms of processing successive inputs) are all integral to the development of functioning networks responsible for conceptual-cortical representation. Gallistel and Matzel (2013) correspondingly asserted, "At the neuroscientific level of analysis, learning is the rewiring of a plastic nervous system by experience, and memory resides in the changed wiring."

Who are Visual Thinkers and Why Do They Need Metacognition?

English is a time-based, auditory, low-context language (Arwood, 2011). English is time-based (Traugott, 1975; Arwood, 1991) in that people are expected to think in time, listen in time, read and write in time, and develop other literacies that are time-based. For instance, people use time-based words like "yesterday," "tomorrow," "beginning," "after,", as well as morphemes such as "-ing" and "-ed," and verbs such as "going" to develop relationships between ideas that represent time-based events, e.g., "I'll be going to the store." These time-based properties of the English language represent temporal components of auditory processing (Sanda & Marsalek, 2009; Tallal, 1980), as the sounds of words (i.e., sound waves) take time to produce and process. The auditory system should help process the sounds of words onto the words' meaning, much like the visual system. Thus, the way humans process and think about auditory concepts is time-based (Arwood, 1991). Those who can use the English language with its auditory and time-based properties can create meaning from the sounds of words (and sight) to develop auditory concepts, which eventually allow them to think and speak about abstract ideas that are displaced from the here and now, e.g., "I believe he was one of our most ethical presidents."

Importantly, a person thinks in the way they've learned concepts (Arwood, 2011). A person who uses English auditory concepts to think, has learned the sounds and visual patterns of the English language, and uses the sound of their voice to think with spoken words. However, Arwood et al. (2009) posits that the majority of English speakers do not think in auditory concepts (nor in a time-based system) but rather use spatial, visual, and relational properties of high-context events to develop concepts for thinking. Because most people learn through the overlap of visual and motor patterns, this is also the way they think about concepts. A student who thinks with visual concepts (i.e., mental pictures) uses a lot of visual context in the learning task to understand new ideas (Arwood, 2011). Because most students are believed to think with visual cognition, Arwood and colleagues have worked to help students translate auditory properties of the English language into visual thinking properties to help them function at a concrete-to-formal level of thinking, thereby, facilitating the development of visual concepts and prosocial behaviors (Arwood, 2011; Robb, 2016; Green-Mitchell, 2016; Jaskowiak, 2018).

Visual Thinkers in Learning Contexts. By around three years of age, children begin to utilize language in play scenarios in which they act out or into imagined scenarios (Vygotsky, 1978). These play scenarios potentially develop the faculty of imagination, which facilitates the psychological processes in which mental representations are first visualized and accessed with language. Imagination in tandem with language allows children to think beyond what is perceivable, enabling children to construct new meanings that aid their psychological and cognitive growth (Vygotsky, 1986). From a functional perspective then, imagination may be the cognitive activity that initially facilitates thinking in mental pictures (i.e., imagery) (Vygotsky, 1986). A visual thinker draws meaning from perceivable *images*, which are visual representations of concepts held/produced in short-term or long-term memory (Kandel et al., 2014; Ishai & Sagi, 1997). Mental images are associated with one's cognitive functions involved in perception, memory, reflection, and thinking (Makarova et al., 2017). Visual memory and mental imagery are then connected processes (Pearson et al., 2015) that help people use their cognition to think through scenarios (Dias & Harris, 1990, solve problems (Athavankar; 1997; Kauffman, 1988) imagine the future, visualize specific scenarios, and think creatively (Antonietti & Colombo, 2011; Jung et al. 2016; Palmiero et al., 2015; Pickens & Speidel, 1979).

Arwood (2011; 2017) posits that mental images or 'pictures' are a relational form of visual language (like ASL) developed and used by the brain to make sense of new language-based concepts when learning. According to Arwood (2011) a visual thinker cannot learn language exclusively from the sounds of words because acoustic patterns alone will not develop concepts. Visual thinkers instead, use a visual system to process visual patterns of meaning to develop concepts for thinking (Arwood et al., 2009). The neuroeducation framework thus, defines visual thinking as *thinking in a language of pictures* (Arwood et al., 2009).

Using a visual system, in the context of this study, implies that one's neurobiological system encodes the visual properties of language (e.g., articulatory, word shapes) and represents language-based concepts through mental visual images (or mental pictures), rather than the auditory properties of language (Arwood, 2011). Students do this by integrating sensory input from across modalities (visual and visual, visual and motor, or visual and acoustic inputs) to form perceptual patterns that become visual concepts (i.e., concepts they can see) (Arwood, 2011). The brain requires overlap of patterns from multiple meaningful inputs to develop language-based concepts, e.g., seeing a written word and seeing a picture of a corresponding idea. Therefore, the brain would not technically, need acoustic inputs to create visual concepts for ‘seeing.’

Visual thinking when applied to education involves various resources and strategies including drawing, picture dictionaries, and storyboarding to generate deep meaning and thinking about ideas (Arwood et al., 2009; Fernández-Fontecha et al., 2019). For instance, Arwood & Brown (2001) discussed how teachers can help students implement visual thinking strategies to improve reading comprehension. Before reading a text students are asked to look at all the pictures or graphics on the page. They then scan the print rather than reading it directly. Students can put their writing hand on the page, making an “S” movement down the page, to scan all the words, which helps the eyes track the entirety of the text. Students are then directed to make mental pictures of what they ‘see’ on the page. Afterwards, students are directed to draw and/or write their visual ideas next to the text or on a separate piece of paper. The authors state, “Use your mental language to create meaning by “picturing” ideas from you see in print (no sounds!!!) (Arwood & Brown, p.11).” Next, students are asked to draw icons or write words (in their natural language) near the ideas they’ve already written to add more meaning and develop their visual knowledge (i.e., memory). Students are directed to arrange their visual ideas into a spatial format, such as a chart or other composition that makes sense. Lastly, students should “flowchart” their ideas by connecting ideas (pictures and/or words) to other ideas with arrows. The arrows represent and develop the semantic relationships between ideas. Students should continue to flowchart, adding ideas in connective order when they read each chapter of the text or when they take notes in class. The written ideas are the embodiment of the student’s visual thinking and circuitry and thus, support the student’s ability to understand what they’re seeing. Recording students’ ideas on the page, connecting those ideas, and adding language supports short-term to long-term memory transfer (Arwood, 2011). This multi-layered reading strategy is intended to help students comprehend and learn new ideas in the text, prevent more than on re-reading, and speed up the reading process. Students who've attuned to making mental images while reading, have been shown to be more proficient overall in reading comprehension (Snow, 2002; Hibbing & Rankin-Erickson, 2003).

Visual strategies such as the one previously described, are intended to facilitate processing of visual and motor patterns by associating the shapes of written words with pictures of the concept (e.g., the word "caterpillar" with a picture of a caterpillar) or visual movements associated with the concept (e.g., tracing the outline of the word "caterpillar" with the hand) allowing the visual thinker to process meaning and develops concepts (Arwood et al. 2009). Rather than relying solely on verbal language, visual thinkers rely on visual language properties, such as shapes, patterns, graphics, and symbols to conceptualize ideas (Arwood et al., 2009; Brumberger, 2007). Importantly, visual thinkers see both, 1) perceivable visual images (i.e., what they can see through the eyes and with the mind) as a result of overlapping visual-motor patterns in connection with prior knowledge, and 2) mental pictures, the ideas they 'see' in their minds (as the concept is called to mind) to conceptualize and continuously learn new concepts represented as language. Language assigns meaning to visual images (i.e., concepts) thereby, encoding the word form (i.e., language) with the visual concept, which integrates sensorimotor patterns into semantic networks effectively (Arwood, 2011). What this means for education among other things, is that most students will struggle to turn auditory information (i.e., lecture) into conceptual understandings unless multiple visual and motor patterns are presented or drawn by the student's hand - allowing for activation of the students' cortical circuitry.

Setting up Conceptual Representations as Mental Images. Concepts are mental representations of bodies of knowledge that contribute to higher-level thought processes. Neuroscience evidence suggests that concepts are the embodiment of circuits which are represented by mental images (i.e., mental pictures) (Gallese & Lakoff, 2005). Children build initial conceptual categories through shapes, textures, motions, and functions, which supplies information about their inferences about likely word meanings. As children grow older they construct more meaning for words (from their experiences) and connect words using extant meanings of categorical content, e.g., objects, relations, and actions (Clark, 2004). Language acquisition provides a vehicle for setting up multiple representations of experience, as the brain encodes conceptual understandings in various ‘languages’ which will affect how they categorize, identify, connect, understand, and recall ideas going forward (Clark, 2004). Therefore, the semantic relationship between words and the conceptual content to which they refer in speech acts (e.g., propositions) is based on experiences that facilitate encoding or ‘linking’ of representations into conceptual (lexical and functional) categories (Tomasello, 2005a). Objects within a specific conceptual category (e.g., Labrador as a category of dog), or that vary across categories (e.g., “dogs” as an object for all categories of dogs), have been found to be grouped under the same term, particularly when they serve the same communicative function, which facilitates the person’s ability to store and generate conceptual representations of experience from word meanings (Barsalou, 2008; Tomasello, 2005a; 2005b). Concepts are accessed and developed semiotically and intersubjectively (via purposeful, shared understandings) in human discourse where forms of external content becomes categorized and classified.

The brain uses language (or numerous languages of thought) as tools for the mind - ways to represent and process external and internal information (Galaburda et al., 2002). The two primary ‘languages’ that humans use to mediate external and internal experiences are linguistic (or symbolic) representations and visual representations. The brain is born with the structures (or machinery) to create representations but not the internal geography to makes sense of the external world. Experience provides stable patterns of neuronal activity that develops architecture for cognitively mapping one’s world, which enables perception of the mapped environment when encountering new stimuli (Gallistel & Matzel, 2013). Therefore, mental representations are generated via integration between bottom-up (sensory) and top-down (perceptual) neuronal activation of conceptual knowledge (Gallistel & Matzel, 2013; Mandler, 2000). As repeated and meaningful stimuli enter the senses - through life experiences/events, a sensory or motor representation of a concept is encoded in developing circuits, supporting “reactivation” and new knowledge integration (Binder & Desai, 2011). Language acquisition embodies cortical circuitry via neuro-semantic linkages that supports how the brain functions to represent (i.e., think about) and learn language-based concepts (Pulvermüller, 2013). Cognition, therefore, refers to the activation and/or reactivation of mental representations that form through conceptual learning - whereby new concepts are grounded to circuits that underly past sensorimotor experiences (Arwood, 2011; Barsalou, 1999, 2008; Pulvermüller, 2013a; 2013b).

Visual cognition helps to compose what people ‘see’ or perceive and how they view themselves acting into the world via circuitry linked to sensorimotor and visual systems. Jeanneroda and Jacob (2005) for instance, explained that higher order visual representations “get their conceptual content from the connections between visual cognition and other parts of the human cognitive system,” via pragmatic and semantic processing, “such as the planning of action and semantic memory (p.310).” Culture represents the brains’ semantic memory – the system of meanings (i.e., semantic circuitry) that the person has developed in their interactions with people (i.e., family, friends, teachers) and tools (i.e., language, books, video games) (Arwood & Merideth, 2017). This system affects how the brain processes input from the external environment and tells the 'hardware' (i.e., modular systems), places like the motor cortex, what it should be doing in response (Grisoni et al., 2016; Tomasello et al., 2017). Thus, culture and semantic memory jointly shape perceptions and conceptual learning, which is reflected in what one mentally sees and/or visualizes.

The mental image itself, is a representation of the students' perceptual processing across sensory modalities (e.g., visual and motor movements) (Arwood & Kaulitz, 2007; Krüger et al., 2020) that serves a key function in the organization and retrieval of verbal and visual thought during learning (Crespi et al., 2016, Sadoski et al. 1991; Sadoski & Paivio, 2013). Therefore, an image emerges in visual thought as a result of the integration of perceptual categories such as space, movement, shapes, etc. and intellectual (top-down processes) which allows a conceptual representation of one's reality (Makarova et al., 2017). A persons' imagery comes in various forms (Arwood et al., 2009; Barsalou, 1999), given individual differences in visuospatial abilities and metacognition (Katz, 1983). For instance, the depth of (metacognitive) knowledge one has attained for their visual ways of thinking is correlated with the creation of highly vivid and accessible pictures (Algozzine & Douville, 2004; Antonietti & Baldo, 1994; De Koning & Van der Schoot, 2013). Therefore, a connection between metacognition and imagery exists and impacts one's cognitive abilities.

Visualization and Metacognition for 'Seeing'. Piaget (1986) stated "knowledge of the world is not discovered but is created as an image (p.344) (via Makarova et al., 2017)." The image, whether perceived visually or mentally, is subjective, in that it's a perceptual object of the external world that is influenced by previous sensory-perceptual processing. People create mental images through acts of visualization to internally conceptualize their reality; that is, understand what it is they are looking at or thinking about (Makina, 2010). As a construct, visualization is made up of top-down processes involving mental imagery, visual memory, imagination, and visual attention.

Broadly, visualization is the process by which an internal representation is formed from an external representation (Gilbert et al., 2007). Evidence suggests that visualization is central to the process of thinking, in which memory is deployed toward intellectual enterprises (Gilbert, 2005). Visualization has shown to be a powerful cognitive tool that can, a) reduce stress (Berg & Karlsen, 2015; Margolin et al., 2011; Wilczynska et al., 2014), b) train athletic skills (Kearns & Crossman, 1992; Ridderinkhof & Brass, 2015; Yu et al., 2016), and improve learning and conceptual understandings (Bodemer et al., 2004; Evagorou et al., 2015; Gilbert, 2010; Wu & Shah, 2004), and help increase motivation in students (Sua, 2021).

In the context of this study, visualization refers to the formation of internal visual images (or mental images) allowing people to 'see' their current thinking (Gilbert, 2005; 2008). Visual and mental images, visual thinking, visualization, and metacognition are interconnected processes used in cognitive enterprises, which constitute essential components of learning as well as learning about one's own learning (Makarova et al., 2017). A section from Makarova et al. (2017, p.3) sums up connections among these several of the concepts in the following paragraph:

> Visual thinking is thinking through visual operations, and so it allows using human ability to see and understand images, then to analyze data received. Accordingly, the task of visualization is the transformation of huge arrays of information into graphic images that are comprehensible to human perception when connected by a single meaning.

> Visual images can range from detailed graphic images to abstract structures, graphs, charts, diagrams, etc. This is how visualization is connected to meta-cognition which is "one's stored knowledge or beliefs about oneself and others as cognitive agents, about tasks, about actions or strategies, and about how all these interact to affect the outcomes of any sort of intellectual enterprise" (in Flavell, 1979, p. 906).

Gilbert (2005) suggested educators think about visualization (in the context of learning) through lower and higher levels. At the lower level people can reflect about many concepts of the external world and compare them; however they likely cannot reflect about themselves as agents and the how their actions affect others (also see Von Wright, 1992). At the higher level, people can 'see' themselves and their own knowledge in their pictures, which allows them to reflect on and assess their actions and understandings. Therefore, visualization supposes a 'metamodel' at the higher level, in which one learns how to reason (also see Georghiades, 2004). Visualization can support the process of learning how to learn given self-reflection opportunities, by providing contents of the mind personal meaning, which directs metacognitive awareness to one's conceptual understandings and actions (Makarova et al., 2017). Therefore, teachers who facilitate visualizations in the context of learning or meta-learning, allows students to build their own conceptions of the world, while simultaneously developing metacognitive awareness towards their visual ways of thinking for learning.

Metacognition for Visual Thinking. Visual thinkers learn best through imagery (i.e., their visual representations of the world). Visual thinking involves an interconnected relationship between visual perception, conceptualization, and metafunctions (i.e., functions intrinsic to language) that compile various types of internal and external meaning for thinking and learning (Fernández-Fontecha et al., 2019). Because language and cognition are interdependent, language *functions* for thinking with mental pictures (i.e., visual concepts) (Arwood, 2011). In other words, language acquisition sets up one's visual concepts, and language function drives visual thinking of these concepts, particularly at a metacognitive level. This means that visual thinkers can draw, flowchart (i.e., connect ideas through conceptual pictures and words), or create concept maps to move from perception, to conceptualization, to thinking metacognitively with a language of pictures and words (Arwood, 2011). Brumberger (2007) correspondingly describes visual thinking as an "an interaction between seeing, imagining, and drawing that is as purposeful, recursive, and sophisticated as verbal thinking." Some educators have supported students' visual thinking in an effort to promote their ability to understand difficult or complex information across a range of mediums (Fernández-Fontecha et al., 2019).

Most researchers agree that visual thinking is an intellectual and intuitive process (Brumberger, 2007: Landa, 1998) involving perception (Arnheim, 1997; Barry, 1997); and mental imagery or pictures (Arwood et al., 2009; Brasseur, 1993, Goldschmidt, 1994; Laseau, 1986). Mental images are representations of knowledge in the form of perceivable pictures, movies, diagrams, etc., that are seen by the mind (not the eyes) (John-Steiner, 1997). Arnheim (1997) states that perception and thinking interact, and so visual thinking equates to visual perception (or perhaps more accurately, *visual-mental perception*). This means, that the act of seeing an object in the external world and a concept in one's internal world are central functions to visual thinking. One does not 'see' with the eyes, but rather the mind because the mind is what tells the eyes what is being perceived (Arwood, 2011). Therefore, 'seeing', in this context, is the ability to perceive and/or understand the meaning of something. Visual thinkers 'see' ideas, specifically word meanings, rather than hearing them (Arwood, 2011). Therefore, visual thinkers 'see' in a language of pictures and require visual strategies such as drawing, to unlock the way their mind processes meaning and learns language structures (Arwood et al., 2009). Thus, *seeing meaning is the visual thinker's language* (Arwood & Brown, 2001, p.15). Consequently, this study recognizes visual thinking as *the act of using one's visual cognition for learning* (Arwood et al., 2009; Arwood, 2011). Similar to Makarova et al. (2017) the researcher recognizes that students (in this case first-year college students) may not be metacognitively aware of most cognitive phenomena that occurs in the process of studying and learning. The researcher's definition of visual cognition, therefore, considers the likelihood that first-year college students may not be thinking of themselves or concepts in general at a formal level (4^{th} and highest level of the NsLLT) but rather oscillate between preoperational, conceptual, and formal ways of thinking about concepts and therefore, need higher functioning language to improve metacognition for their ways of thinking and learning. The ability to develop metacognitive awareness and visualization in tandem may allow students the ability to 'see' themselves and how they can improve their thinking and learning.

A person's visual thinking can be represented differently depending on social and cultural experiences and the person's own neural/cognitive makeup, but generally encompass mental images, including moving images (e.g., shapes of words, pictures, movies, rolodex of ideas etc.) (Arwood, 1991). Prominent author and speaker of animal behavior and autism, Temple Grandin (2009) explained her visual thinking this way: "My mind is similarly to an Internet search engine that searches for photographs. I use language to narrate the photo-realistic pictures that pop up in my imagination (p.1437)." Though rarely discussed, thinking with mental pictures strategically, such as Grandin describes, is the result of learning how to think with pictures (i.e., meta-learning). One cannot think in a language of pictures strategically (or consciously), without thinking metacognitively. Arwood (2011) correspondingly describes visual thinking as the use of a visual metacognition, which refers to the learners' underlying way of thinking that creates visual concepts for learning (see also Arwood, et al., 2009). 'Metacognition' in this sense refers to the *language of meanings that underlies the student's visual thinking*. In simpler terms, natural language supplies metacognition to one's visual thoughts. However, this study takes a granular approach to the relationship between metacognition and visual thinking, relying on cognitive psychology and developmental constructs (e.g., metacognitive knowledge and skills) to explore potential connections between metacognition and visual thinking through the lens of meta-learning. Importantly, this study supposes, based on previously discussed research, that a highly-functioning 'metacognition' is learned. At the conceptualization level (third level of the NsLLT), using visual cognition to learn, means that a student represents language-based concepts via mental pictures when learning new ideas in a real world context. However, as will be discussed momentarily, using one's visual cognition can occur at a conscious (metacognitive) level or an (unconscious) metacognitive level.

Some evidence suggests that metacognition and/or mindreading (i.e., mentalizing about others) arise from the same psychological mechanisms (involving inferential and interpretive processes) (Schneider, 2008; Weil et al., 2013) as visual imagery and forms of language (Carruthers, 2009). Fleming et al, (2012) for instance, found that the rostrolateral prefrontal cortex (rlPFC) integrates visual information from connectivity with the contralateral and occipital cortices during metacognitive reporting. This may suggest that metacognition, language, and mental imagery are interconnected processes that dictate inferential and/or interpretive processes. Carruthers (2009) correspondingly posited that conscious thoughts and forms of reasoning are "thoroughly imbued with metacognitive beliefs… (and) what appears to make such forms of thinking consciously accessible is that they are conducted in inner speech and other kinds of imagery (p.130)."

It stands to reason, based on what has been previously discussed that the more developed one's language functions the greater the ability to engage in metacognition (Arwood, 2011). Metacognition has consequently been found to be associated with activation in the mentalizing network (MN) and default mode network (DFN), both higher-order cortical areas that overlap with the temporoparietal junction (TPJ) – a region found to be responsible for semantic processing, social cognition, and language comprehension (Valk et al., 2016). The TPJ incorporates visual, auditory and somatosensory pathways and has been called a "transmodal gateway for language" (Dohmatob, 2020 p.3324; Matsuhashi et al., 2004; Mesulam, 2000). Metacognition in general, is linked to neural feedback (linking cellular fibers), associated with top-down modulation, making it possible to conceptualize sensory input (e.g., visual stimuli) from the environment or retrieve semantic knowledge (Baars & Gage, 2010, Arwood, 2011). Thus, there's a strong likelihood that metacognition is linked to language competency and the networks that overlap the TPJ support internalized, abstract thinking about semantic knowledge (e.g., visual concepts). Metacognition, however, is not likely controlled by one brain region but rather appropriates divisible neuronal networks through oscillatory or functional (top-down) activation (Rauss & Pourtois, 2013, Arwood, 2011).

Metacognition has accordingly been identified as having an intricate connection to internal mental representations (Hacker et. al, 1998; Kluwe, 1982). This connection can include, a) the knowledge one has gained about their thought processes, b) how those thought processes function, and c) affective states resulting from previous experiences (Borkowski et al., 1990; Flavell, 1979; Hacker et. al, 1998). Consequently, metacognition may develop in humans to provide the basis for elaboration of conceptual understandings, thereby connecting knowledge structures for advanced thinking and social development (Arwood, 2011; Halpern, 1998). Efklides (2001; 2006) has shown that learners engage in metacognitive experiences which are the outcomes of nonanalytic and unconscious inferential processes during learning tasks. In other words, a learner could metacognitively use mental pictures for learning without being metacognitively aware (or conscious) they were using them for learning. On the other hand, a learner who is metacognitively aware (has knowledge) of their visual thinking plus the task demands could apply intellectual/analytic processes toward their mental pictures to direct (or regulate) their learning and/or become metacognitively skilled at doing so.

Pearson et al. (2011) for instance, investigated subjects' metacognitive understanding of their mental imagery. Specifically, the researchers explored whether subjects could discern whether an object they were imagining was vivid or abstract in their mind. Additionally, the researchers investigated whether having skilled metacognitive understandings of mental images had subsequent effects on their perception. The researchers asked 20 college-age students to imagine an object and then rate the objects' vividness (in their mind) and the difficulty in imagining said object. The subjects were then given subsequent rivalry and attention tasks that related to the previously imagined patterns. Subjects who reported greater vividness in the imagination task were more likely to see the same pattern in visual-perception tasks later on; meaning, the degree of vividness was predictive of the impact of mental images on the subjects' conscious visual perception. The findings suggest that teachers could help students attend to mental imagery during learning tasks while subsequently supporting their perceptual abilities. Additionally, the researchers supported the idea that having command over mental imagery is an introspective process that requires effort and awareness to achieve.

‘Seeing’ one’s mental images supports concrete thinking at the third level of the NsLLT (Arwood, 2011). Therefore, in terms, of aligning the way one visually thinks to one’s visual system at the concrete to formal level of the NsLLT (i.e., understanding and using mental pictures) a student logically needs metacognitive knowledge of (or access to) their visual ways of thinking. Brasseur (1993, p.130) correspondingly stated that a students’ visual way of thinking involves “accessing one’s visual imagination, whether in mental imagery or through drawing.” This would be particularly important if the student was expected to learn how they learn best to facilitate future or life-long learning. In other words, a student would need to learn, a) how/why they think through meaningful visual stimuli, b) how/why they think in mental pictures, and c) what learning strategies support these visual thinking processes and how to implement them.

Visual cognition operates primarily on an unconscious level, as the retina rapidly scans for visual data much of which is never drawn to our attention (Vernon, 2021). The brain needs prior knowledge to draw its attention to specific ideas or behaviors. Without metacognitive knowledge or metacognitive skills, a student could not monitor their visual thoughts effectively, nor apply specific visual strategies successfully. Therefore, the development of metacognition for accessing and using visual thinking strategically is a logical necessity for students who use a visual system for thinking and learning at their best. Arwood, has personally described this logic to the researcher as ‘learning that increases language functions that develops thinking to be visually and metacognitively represented.’ In other words, students must learn to access and use their concepts (i.e., mental images) through language, if they are to think and learn effectively. Thus, according to the neuroeducation framework developed by Arwood (2011) a student must learn their learning system to be effective. Consequently, the academic success class in the context of this study, was focused on (among other objectives) helping first-generation college students develop metacognition (e.g., awareness, knowledge, strategies, and skills) for their visual thinking and learning.

College Academia and Visual Learners. A visual thinker is a learner who thinks in the meaning of mental pictures. However, for visual thinking to be effective, the language level of the pictures or graphics must match with the language level of the child or adult who is interpreting the visuals (i.e., sensorimotor, preoperational, concrete, formal). Arwood (2011) posited that because most students use 'visual learning systems' they need visual learning strategies (i.e., writing and seeing the shapes of words) to help them construct meaning and 'see' the way they conceptually think and learn (through mental pictures) to be effective. Adults can still learn auditorily but it is much more difficult to do so, and they require high levels of language function and semantic content to learn through auditory patterns. For children and adolescents however, learning auditorily is a difficult task especially if they do not know they have a visual learning system or understand they think and learn visually.

Cognitive processing theories lead many educators to assume that students learn by encoding external stimuli (i.e. acoustic waves) through processing systems such as short-term memory (Gentile, 2018) and therefore students (without disabilities) can build knowledge bases that are commensurate with those deemed 'foundational' within a field of academia if the student is engaged. Learning as a 'process' is seen as hierarchical, (i.e., bits of information building up to a whole idea), so, instructional methods must be limited, sequenced, and repetitive to ensure information is encoded into long-term memory (Shepard, 2000). Thus, transmission methods (i.e., lecture) focus on the storage, interpretation, and retrieval of knowledge by learners.

Higher education, like most all education systems in America, uses and promotes an English-based learning system, that is primarily auditory in nature, and uses primarily auditory listening and learning (e.g., lecture) instructional practices. Stains et al. (2018) for instance, looked at the landscape of teaching practices in higher education STEM classes. The investigators used an observational classroom protocol named COPUS, which provided a more comprehensive way to track and verify student and teacher behaviors in college classrooms. The investigators reviewed over 2000 classrooms, from 709 different STEM courses across the nation. Findings from this study showed that traditional lecture continues to be the most dominant form of teaching (74.9 ± 27.8%) and students primarily listen (87.1± 20.8%), and answer instructor questions (21.6 ± 19.8%) while in class. These findings highlighted minimal curricular innovations in STEM pedagogical practices despite repeated calls from educational researchers to develop more effective student-centered pedagogies. Hordern (2019) argues that higher education has not kept up with the challenges to epistemic knowledge (e.g., scientific inquiry) and the way people use knowledge to create meaning in modern formats. Cyrus (2009) also pointed out this instructional inconsistency - that modern society is permeated with visual media, yet American educators primarily use lecture (i.e., spoken words) to drive learning. Higher education classrooms may consequently disadvantage students who think visually through the primary means of teaching. This can occur through, 1) auditory methods used by the teacher that prevent students' from developing visual concepts, and 2) the silencing of students' language, which is their conceptual vehicle for assigning and making meaning.

To confront such negative learning experiences, some university educators have embraced students' *learning styles* (Dandy & Bendersky, 2014; Meyer & Murrell, 2014). The use of learning styles correlates with reliance on cognitive processing methods. Teachers focus on matching a modal input or *instructional style* (i.e., visual, auditory, kinesthetic) with the students' preferred 'learning style' (Newton & Miah, 2017; Pashler et al., 2008). Thus, students who are deemed ‘visual learners’, are given visual inputs (e.g., graphics, pictures, diagrams), so they can better encode information into memory. The ‘meshing’ of these styles is thought to help learners cognitively process (i.e., encode) information more effectively; but to date, there’s little evidence to suggest learning styles are beneficial to student learning or academic success (Knoll et al., 2017; Meyer & Murrell, 2014; Newton, 2015; Pashler et al., 2008; Rogowsky, et al., 2015). Learning style theories have garnered such heavy scientific criticism they’ve been designated a ‘neuromyth’ by researchers (Lilienfeld et al., 2011, p. 92; Dekker et al., 2012; Howard-Jones, 2014; Riener and Willingham, 2010; Rohrer and Pashler, 2012; Willingham et al., 2015). Additionally the embrace of ‘learning styles’ among students in combination with rote learning tasks may impart a view of learning as simple consumption and memorization of preferred information sources. Takeuchi and Liu (2021) for instance, detailed how some middle school students who perceived themselves as ‘visual learners’ actually disengaged from group problem solving in mathematics, when the activity conflicted with their perceived learning style ‘identity’.

Makina (2010) explains that some learners’ difficulties in education stem from the restriction of mental representations that allow the mind to conceptualize meaning. Lecture-based methods for instance, press students to process acoustic information into ideas, which often conflicts with the ways their learning systems visually represents concepts and learns language (Arwood, 2011). When visual elements such as pictures and drawings are encouraged in the classroom through cognitive processing frameworks, it’s often to help students see and process information effectively (Mayer & Massa, 2003), rather than to help students metacognitively ‘see’ and assign meaning to ideas (Arwood et al., 2009; Arwood & Merideth, 2017). Cognitive processing frameworks (i.e., learning styles) can therefore be inaccessible to students in the classroom because they create barriers to students' ability to engage with the learning process (Kirschner, et al., 2006; Kirschner, 2017) and actively construct meaning through visual-mental representations or 'mental pictures.'

It's inevitable that learning contexts reflect learning outcomes, which affects learners' development (i.e., critical thinking, agency, problem-solving, metacognition) (Sipos et al., 2008). Alters and Nelson (2002) posit that the ability to develop higher-thinking skills is often circumvented by the processes in which educators teach and evaluate students. University and high school science courses, for instance, regularly focus on teaching and evaluation approaches that promote surface-level processing of concrete ideas, which fails to promote deep learning (Biggs & Tang, 2011; Chin & Brown, 2000; Stains et al., 2018). Being metacognitive enhances the students' ability to develop and refine conceptual understandings, but this can be mediated by the students' current understanding of what learning constitutes, given prior conceptions and the epistemic demands of the learning environment (Clark & Schroth, 2010). Because teachers often tell students what to 'know' instead of how to represent their thinking with disciplinary concepts (Clement et al., 1980), students may not understand how to engage with the subject matter (Makina, 2010). Consequently, students often have misconceptions related to the depth of their understandings and may believe that the memorization of surface-level terminology passes for sufficient learning (Horrell et al., 2019). As a result, new students may not encounter instructional methods that facilitate the habits required to develop metacognitive skills (Bok, 2015). Despite unfavorable pedagogy and curriculum, many university educators still expect students to engage in deep conceptual learning, while consciously monitoring their own learning and thinking (Biggs, 1985, Craig, 1989).

Predominant learning theories do not account for student thinking from either a neurological or language-based perspective making it difficult for teachers to employ strategies that allow students to mentally ‘see’ (or visualize) their own thinking and learning (Arwood & Kaulitz, 2007). Arwood (2011) argued that academic learning when matched to the students’ learning system, is a process of learning about academic concepts with language and simultaneously about how one learns and thinks best. Therefore, a misalignment in higher education likely exists between curriculum, learning, and the expectations placed on students to succeed. One of the primary goals that have come out of neuroeducation research, is to explicate the need to transition from auditory teaching methods to visual strategies that match the way students think and learn to become literate (in reading, writing, calculating, thinking, etc.) (Robb, 2016). Alt & Gutman (2009) suggest transitioning from auditory methods such as lecture, to opportunities for students to learn in environments that provide visual-spatial information. Such a strategy should help students actively *represent, articulate, and learn* language-based concepts with mental pictures (Šmajdek & Selan, 2016).

Researchers have suggested that metacognitive strategies be taught to students early in their programs of focus, because such strategies can optimize students’ learning (Halpern, 1998; Mutambuki et al., Muteti et al., 2021; Lawson et al., 2021; Schraw & Dennison, 1994). Students who are actively metacognitive have been shown to construct and/or reconstruct knowledge about their own learning processes, formations of self, and affective aspects of achievement (Butler & Winne, 1995). Students with visual learning systems likely need visual learning strategies to layer semantic-based inputs to ‘see’ and connect conceptual thoughts (e.g., mental images) to reach higher levels of cognition (Robb, 2006). Mental images (i.e., pictures in the mind’s eye) function as objects of knowledge, allowing people to acquire meaning through interaction with the external world (Pelaprat & Cole, 2011). When students become metacognitive in their learning, they can layer mental imagery (i.e., pictures) with language, to form deeper conceptual understandings and take control of their learning (Arwood, 2011; Bertschi & Bubenhofer; 2005; Makarova et al., 2017; Mudaly, 2014).

Visual thinking and visualization are similar cognitive processes that are important to students' learning; the key difference being that visual thinking has a basis in language acquisition and discourse (e.g., semiotics, semantics, and pragmatics), particularly in educational contexts where the goal is to develop higher-levels of linguistic thinking for language-based learning (Arwood, 2011; Fernández-Fontecha et al., 2019; Fernández-Fontecha et al., 2020; Yenawine, 2013). Because humans integrate and represent meaning through language and pictures, supplying meaning through multiple modes (i.e., multimodally), via language and pictures, provides a rich context for facilitating student learning processes, given the academic content is semiotic in nature (Fernández-Fontecha et al., 2020). Therefore, linguistic and visual resources can produce visual thoughts (i.e., conceptual representations) which at once provides a) evidence of language learning, b) gaps in conceptual knowledge, and c) opportunities to learn concepts more deeply through language scaffolds (Arwood, 2011; Bobek and Tversky 2016).

Visual thinkers with a conceptual-to-formal level of thinking can 'visualize' ways to act on their environment, which means they are using learned concepts to think. Visualization strategies that focus solely on external representations (e.g., charts, models, diagrams, etc.) provided by the teacher are unlikely to help students' metacognitively 'access' and control their reasoning (Gilbert, 2005; Von Wright, 1992). In contrast, educational researchers refer to a 'meta' level of visualization in which learners engage in reflective processes of translation, actively constructing and reconstructing knowledge that has been communicated, allowing for deeper understandings (Georghiades, 2004; Gilbert, 2005; Makarova et al., 2017; Šmajdek & Selan, 2017). Helping students become metacognitively ‘skilled’ at using their visual thoughts (or visualizations), has been discussed as a worthwhile educational objective to help students develop higher thinking and learning capabilities (Arwood, 2011; Gilbert, 2005; Villalon & Calvo, 2011). For instance, Šmajdek & Selan, (2017) stated that students should create their own “drawings, images, models, schemas, diagrams” because the student’s “active engagement in visualization is linked to (their) individual ability to construct knowledge, and therefore plays a key role in achieving higher levels in learning (via Twissel, 2014).

The *visualization of* concepts (as mental pictures) in the process of learning, has been shown to promote a) motivation, b) problem-solving, c) conceptual learning, d) representational understandings, e) and construction and retention of knowledge (Cetina, 1999; Latour & Woolgar, 1979; Lynch, 2006; Makina, 2010; Pauwels, 2006; Šmajdek & Selan, 2016). Visualizations, make the learners’ thinking visible, thereby allowing learners to develop metacognitive awareness toward their own conceptual representations and inferential thought processes (Jacobson, 2004). Opportunities to reflect about their learning confronts the learner with visual thoughts of their own disciplinary knowledge, and knowledge about their learning, which may allow for scaffolding by an expert/teacher (Villalon & Calvo, 2011). Thus, learning environments that provide ‘knowledge of’ and ‘access to’ mental imagery, can be said to promote meta-learning for one’s learning and thinking processes. Jagals & Walt (2018), argue that learning opportunities that are framed around “exploring, questioning, understanding and imaginative experiences are exemplary of the role metacognitive awareness plays in the imagination (p.2).”

The use of visual thinking and/or visualization in education has the potential to support immersive, engaging and equity-driven learning experiences (Mendelson, 2004; Schaffer, 2017). Opportunities for first-generation students to learn how to learn and self-reflect on their visual thinking and learning processes, may consequently, help them transition from *passive, listener-oriented roles*, to roles that promote self-directed learning early in their college careers (De Villiers, 1990). It's, therefore, important to verify whether first-generation college students use a visual system for learning; understand what they already know about their thinking and learning, and how they might change when learning about their own thinking and learning processes. Doing so, may help educational practitioners develop equitable and impactful curricular programs for FGCS that center upon lifelong learning and development.

Rationale for TEMPro Analysis

The Temporal Analysis of Propositions (TEMPro) is a tool that documents differences in language function by examining spoken auditory propositions (Arwood & Beggs, 1992). In the English language, people are expected to refer to time through formal propositions, which represents the underlying meaning for time-based events (Arwood, 2011). Propositions are expressed via utterances in declarative sentences, which can be true or false (Carrara & Sacchi, 2006). Because propositions are made in exchanges between people, the underlying meaning of the utterance is cognitively and logically shared (Carrara & Sacchi, 2006; Searle, 1969). Students with differences in language function are likely to represent ideas spatially and/or linearly which suggests they use a visual system (or visual cognition) for learning language (Arwood, 2011). The TEMPro was used in this study to determine whether students used a visual cognition for learning, which would suggest they think in a language of pictures. The background for TEMPro analysis is discussed here and its procedures are discussed in Chapter 3.

Propositional analysis examines the meaning of a declarative sentence rather than the sentence itself. A formal-operational level of cognition, as stated by Piaget (1955), is needed to discuss displaced ideas using temporal elements of language as well as a linguistic level of development, which means people can think and communicate flexibly and productively using temporal elements in social contexts (Arwood, 2011; Arwood & Beggs, 1992). In the TEMPro, students are asked to vocally respond to the prompt, "What do you do on a typical day?" Students who use a language function for learning/speaking with auditory concepts can understand and refer to the interviewers' use of the idea *typical day* rather than communicating what occurred on a specific day. This shows the student understands what is being asked and can adjust their thinking to explain what 'usually' occurs. Students with a language function for auditory concepts, are able to connect ideas using temporal markers ("and, then, before, after, during while, since, then, now, later, sooner, also, to, etc.") as well as using proper use for inflectional morphemes (tenses such as -ed, -ing, and -es), modalities ('can vs. could', 'will vs. would', 'may vs. might'), and words representing time (morning, noon, afternoon, evening, night). Given the interdependence of language and cognition the TEMPro assesses the way a person represents their thinking with language, either visually or auditorily, hence the way they learn conceptually with language is revealed. Thus, the TEMPro tool assesses language function in terms of the level of semantic development, and how participants represent ideas based on time.

It's supposed that the internal conversations that subjects have with themselves that pertain to their daily routine, helps to create a narrative of mental pictures, that help orient subjects in time and space, and where they will be in time and space. This is because conceptual information of an utterance is contained in its propositions. If participants list spatial/linear information (akin to visual moments), it indicates they use a visual system for learning and representing ideas (a visual cognition); contrarily if they provide time-based propositions to connect ideas it indicates they use an auditory system for learning and representing ideas. For instance, a person interprets a visual scene by semantically representing the scene through functional networks that provide identification and cognitive representation of properties, objects, and relationships (Frederiksen, 2001). Talking about the visual scene with a friend will require the construction of propositions, which consist of semantic representations that have been developed from neural networks of experience. Therefore, the process for talking about a typical day requires representation of general and abstract conceptual knowledge stored in semantic memory. There's inherent modality information present in propositions that allows the person to semantically represent and think about how they act into the world when speaking (Frederiksen, 2001). Consequently, propositional statements made through one's natural language can be evaluated (for functional properties) and serve as a basis for cognition (Frederiksen, 1976; van Dijk & Kintsch, 1983).

The following is an excerpt from Arwood & Beggs (1992) of an 11-year-old boy with language function for auditory concepts, answering the question "what do you do on a typical day?":

> Well, we start out usually with this early bird math class. I go there at 7:45 and we do harder 6th grade math stuff with our teacher then at 8:20 all the other kids start coming in. It's only half the class that goes to early bird math. (Arwood & Beggs, 1992, p. 3)

Notice the subject is able to connect three ideas in time. He states, "I go there (the early bird math class) at 7:45", then he connects the idea by saying "and we do harder 6th grade math stuff with our teacher." This new idea represents a clear time-based relationship with the former idea. Lastly the subject states at “8:20 all the other kids start coming in,” which is the final idea connected in time. This language sample provides an example of a subject connecting three ideas (or events) with temporal elements to create a *temporal proposition*.

The following is an example of another 11-year-old boy who language function signifies a visual cognition for learning/speaking about auditory concepts:

> Sometimes, I, then, go to my bus stop, get on the bus at 8:16. Then I go to other bus stops and I go to school and she talks to us about something and she doesn’t. She lets us off, so I went to the classroom, said “Hi” to my friends. I walked around places and stuff, came back in the classroom and it was time to do our journals. So I did my journal (Arwood & Beggs, 1992, p. 4).

Notice the subject does not clearly use language to refer to what he ‘usually’ does on a typical day. He shifts between different tenses (present and past) in referring to ideas. The subject is referring to ideas that have come into his mind and is unable to connect these ideas temporally with the English language. As a result, the evaluator may struggle to understand when specific ideas take place (in time) or what the subject is specifically referring to. When the evaluator cannot clearly judge what the subject is stating in time, the subject is said to possess a pre-language function, denoted by pre-operational thinking, meaning their ability to use language to represent concepts at higher levels of cognition is restricted (Arwood, 2011). In this situation, the subjects’ language function is a sign that the student learns language differently than someone with typical language function.

TEMPro Background. The TEMPro was developed from three research studies compiled over five years. The first study (Arwood, 1985) was conducted at a school in Abilene, Texas for learning disabled students. The researchers studied a group of 52 subjects. Twenty-six students were assigned to an experimental group, all of whom were enrolled at the school for learning disabled; while the other 26 students were assigned to a control group and considered to be developing typically. After a language analysis was conducted, none of the 26 students in the experimental group showed the ability to establish time-based propositions (connecting three ideas temporally) when referring to a picture or engaged in conversational tasks. Everyone in the control group on the other hand was able to use linguistic time functions that established time-based propositions. The control group's mean number for propositions within a conversation was 3.68 (range of 2 - 4).

The second study enlisted six trained Speech-Language Pathologists (SLPs) to collect five oral language samples from children with language disorders who were assigned as cases. A total of 30 language samples were collected and then sent around to each of the SLPs for analysis. Of the 180 analyses conducted by the SLPs using the TEMPro (on the children's 30 language samples) only 10 language samples showed a single proposition. This statistical finding was below the mean found by the control group, which suggests the TEMPro tool is highly reliable in assessing typical language function (.96).

To further validate the TEMPro, a third study was conducted which enlisted 24 total college students - 12 with known learning disabilities and 12 with no known learning disabilities. TEMPro analysis revealed that college students with learning disabilities showed no ability to communicate temporal propositions while the control group who had no reported learning disabilities were able to communicate at least three propositions in a conversation. Cumulating the statistical results of the three studies establishes a norm between two groups of learners. Students who have typical language function (at a linguistic level) produce three or more time-based propositions, while people with learning/language disorders produce on average less than one (Arwood & Beggs, 1992). These findings support Arwood (1991), who posits that students with atypical language function have differences in their neurological learning system that relates to how they acquire meaning and represent ideas conceptually. The evaluator/s of the TEMPro in this study therefore analyzed how many temporal propositions students created in a conversation as a measure of typical language function, which represented the way they think and learn conceptually.

Summary

The purpose of this mixed-methods study was to investigate how first-year, first-generation college students assessed the way they visually thought and learned when entering college, and what changes occurred to their visual thinking and learning in the context of a course that facilitated meta-learning. An extensive review of literature was conducted to thoroughly explain these constructs and how they interact. This review of literature was broken into four parts – 1) exploring first-generation college students and their academic learning, 2) the relationship between, metacognition, meta-learning, and first-generation students, 3) exploring the connection between language, cognition, and metacognition, and 4) constructing the framework for visual thinking and learning. The first part of this chapter operationalized the term "first-generation college students" (FGCS) and discussed the various criteria for labeling students as first-generation in education and research and the implications of those labels. Next, the demographics, characteristics, and challenges of first-generation college students was discussed in detail. First-generation students identify primarily as racial minorities, are more likely to come from lower socioeconomic backgrounds, and experience challenges such as cultural mismatch in college, which impacts their ability to succeed academically. Frameworks for studying first generation college students as learners in the American education system were then explored. Some of these frameworks focus on first-generation students from a deficit lens, meaning they focus on areas they are deficient, while newer research is exploring ways educators can magnify and integrate first-generation students' strengths. The remainder of the first-generation section focused primarily on supporting first-generation students as academic leaners by providing equitable and effective educational practices to support their integration into college, particularly during their first year. These practices were considered by the researcher when designing the academic success class. Effective pedagogical practices such as learning communities, constructivist environments that support dialogue, mentorship, multicultural learning, reflective writing, and integrating previous experiences were discussed as ways to support first-generation students' learning, development, and overall well-being. Various constructs such as self-efficacy, agency, self-authorship, sense of belonging, and knowledge construction were discussed improved outcomes for first-generation students.

The second part of this chapter explored the construct of metacognition and its relationship to meta-learning. Meta-learning was discussed a process that can help college students develop metacognition, as well knowledge, strategies, and positive dispositions that support learning (e.g., motivations, attitudes, confidence-based factors). Literature on metacognition showed, 1) how metacognition is measured and operationalized in the literature (including its sub-constructs), 2) how metacognition positively impacts thinking/learning, particularly among first-generation college students, 3) how implementing metacognitive strategies impacts students, and 4) how meta-learning affects students' learning and development. Overall, metacognition was discussed as a developmental ability that college practitioners facilitate to help first-year and first-generation students develop social and cognitive skills which supports their academic success. To fully construct the concept of meta-learning in this study, a neuroeducation theoretical framework was explained, which integrated literature on cognitive psychology, language acquisition, and neuroscience. This helped to illustrate how people visually think, learn, and reach higher levels of thought.

In the third part of this chapter, language was discussed as a vehicle for learning, thinking, development, and metacognition. The third and fourth parts of this chapter discussed how language sets up an integrated system for thinking about visual concepts. Neuroeducation literature was introduced that suggested students in the 21st century predominantly think and learn with a visual system; meaning they, 1) use overlapping visual and motor patterns to process language-based concepts, 2) use visual mental imagery to semantically encode and represent concepts, and 3) use language to layer/scaffold visual concepts to reach higher level thought processes. Therefore, in the fourth part of this chapter, the researcher introduced the term visual learning system to describe how the brain functions with language for learning, thinking, reaching higher-levels of thinking, and thinking about thinking within the visual and motor systems. Findings were presented in part three and four of this chapter that showed an interdependence between language and cognition, which supports the neuroeducation hypothesis that language represents and layers a persons' visual way of thinking and learning. Because language and cognition are interdependent, language functions for extending one's thinking and thinking in mental pictures (i.e., visual concepts).

Accordingly, a conceptual framework for *visual thinking and learning* was outlined to support this study's findings. This was done through alignment of research in language (acquisition and function), conceptual learning and development, the visual system, mental imagery, visualization, embodied semantic circuitry, and metacognition. Neuroscience literature, particularly in embodied cognition and semantic word learning, was comprehensively discussed to show how people’s conceptual learning is embodied by their neurobiological system and how learning is supported by distributed neural language networks. This literature showed that humans predominantly rely on linguistic and simulated representations grounded in visual and motor systems to process and construct conceptual meaning from language. Additionally, part four outlined how the visual and motor systems function for learning and how the constructs of visual cognition and visual thinking fit within these systems. Research that explained how metacognition supports visual thinking was also discussed.

Therefore, parts two, three, and four of this study supported the theoretical and conceptual frameworks of this study, showing how the mind functions with language and how the brain develops neurobiologically in the context of learning. The framework for students’ *visual thinking and learning* was discussed to legitimate how FYFG students’ language supports their visual or auditory way of thinking - as will be assessed by the TEMPro analysis in Chapter 3. Rationale for the TEMPro analysis was discussed at the end of part four of this chapter. Therefore, this chapter framed the constructs of visual thinking, learning, meta-learning, visual learning system, and metacognition and summarized the literature that set up the following research questions:

4. What does functional language analysis of language samples of first-year, first-generation students', suggest about participants’ auditory or visual cognition?
5. What changes occur to first-year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fourteen of an academic success course?

6. What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first-year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?
    a. What do participants in a first-year, first-generation student cohort report as previous experiences with learning in an academic success course?
    b. What do focal participants in a first-year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course?
    c. What do focal participants in a first-year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course.
    d. What meta-learning themes become apparent in two class activities, during an academic success course, that relates to first-year, first-generation students' visual thinking and learning?

Chapter Three: Methods

The purpose of this research was to observe and assess changes to FYFG students' visual thinking and learning in an academic success course (ASC) that facilitated meta-learning. "Change" in this study is operationalized as cumulative, consistent, and/or emergent themes that appear in focal participants' responses over time, which indicate positive difference and/or growth of said themes (Saldaña, 2021). This chapter details the methodology used to conduct a mixed-methods case study investigating how first year, first-generation college students, understood the way they thought and learned, and what changes occurred to their visual thinking and learning during a 15-week academic success course. The chapter includes the research questions, rationale for the chosen methodology, interview procedures, participants and their selection process, materials and instruments used, data collection and analysis methods, challenges, ethical considerations, researchers' role, and limitations of the study.

Research Questions

The following research questions were articulated to explore the research purpose through systematically designed methods:

1. What does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition?
2. What changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fifteen of an academic success course?
3. What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?

a. What do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course?
b. What do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course?
c. What do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course.
d. What meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students' visual thinking and learning?

Research Design

In order to understand FYFG students' visual thinking and learning, the researcher sought a detailed and complex analysis of participants' language that (metacognitively) assessed their thinking and learning throughout an academic success course. Qualitative research methods were implemented as they provided a suitable framework for collecting and analyzing participant data. A qualitative approach allowed theoretical and operational frameworks to connect with exploratory inquiry (i.e., reflective assessments), to affirm aspects of observable phenomena in a systematic manner (Brun, 2016). The academic success course (ASC) served as a contemporary single bounded system (a case), which allowed for "in-depth data collection involving multiple sources of information" (Creswell & Poth, 2018, p. 96). The phenomenon under study was first year, first-generation students' metacognition (i.e., metacognitive knowledge) for their visual thinking (i.e., mental pictures) and learning in the context of meta-learning. The researcher reported the data as case *themes*, patterns of themes, categories of themes, and relationships among themes/patterned themes (Brooks et al., 2015; King & Brooks, 2016). To assess change themes for FYFG students' visual thinking and learning, the researcher collected and analyzed focal participants' language at time-ordered points during the ASC (Saldaña 2003; 2021).

Clear statements and objectives are provided in this chapter, related to the focus and extent of participants' roles in the case study (Creswell, 2007; Creswell, 2002). The researcher also lists any *foreshadowed* problems to consider issues within the bounds of the case, that may be recontextualized when the data analysis is concluded (Stake, 2003). Foreshadowing potential problems, allows the researcher to concentrate on specific topics drawn from the literature, to add further understanding to the case outside of the research questions.

The researcher's utilization of instrumental case study is in line with Stake (1995), as a tool to 'facilitate general understanding of a phenomenon.' This case is 'instrumental' in that the study's focus is central to critical issues in higher education (discussed in Chapters 1 & 2) which will inform future educational practice. In this approach, *the case*, which is set within the parameters of an academic success course during FYFG students first-semester of college is secondary and plays a supportive role to the phenomena under study, which is participants' visual thinking and learning processes (Mills et al., 2009; Stake, 1995; 2000). The case, therefore, contextualizes the phenomena while acting as a tool to understand the phenomena more deeply. Case study is appropriate to this research, as it provides a methodological framework to be *theory affirming* and *theory building*.

This case is theory affirming in the sense that participants were identified by use of a visual or auditory cognition, which supports the theoretical and operational frameworks in

Chapter 2. The case is theory building in the sense that new themes were explored among first year, first-generation students (Creswell, 2013) that may explain cognitive phenomena related to learning not yet addressed in educational research. In using one bounded case to build theory, this study sought to “create constructs” and “midrange theory…from case based, empirical evidence” (Eisenhardt & Graebner, 2007, p. 25).

Quantitative research methods were also employed to potentially validate the findings revealed in the qualitative analysis. Quantitative methods will allow the researcher to assess metacognitive gains in the bounds of the case, to respond to research questions two (RQ2) and three (RQ3). Using multiple-method approaches has been recommended by Baten et al. (2017) and Veenman, et al. (2006) to study metacognition because of the difficulty of comparing metacognition between studies and the influence that specific assessments have on metacognitive research (Desoete 2008; Desoete & Roeyers 2002; 2006). Using multiple methods in the context of this research provides further validation of the phenomena under study and increases the likelihood that the findings are applicable to broader educational research and practice.

Research Rationale

A neuroeducation model was used as the theoretical framework for this study. Neuroeducation is a triangulation of the fields of cognitive psychology, neuroscience, and language that substantiates the ways that students learn, think, and develop neurobiologically and sociocognitively. This interdisciplinary approach provides a triangulation for participants’ thinking, learning and metacognition that is applicable to the field of education. Qualitative methods provided a way to analyze metacognition in depth, particularly as it relates to alternative cognitive phenomena that may not be factored into quantitative protocols.

The researcher explored changes to metacognition as it relates to students' visual thinking in the context of conceptual learning. Previous findings suggest that most students use visual cognition for acquiring concepts (Arwood; 2011; Robb, 2016). Based on these findings, the researcher will investigate whether FYFG participants in the bounds of this case possess a visual learning system; meaning they learn conceptually by processing the visual properties of language and represent ideas as mental pictures (Arwood, 2011). Metacognition provides access to one's visual thinking (Gilbert, 2005, Rademaker & Pearson, 2012; Pearson et al., 2011) and refinement of that thinking with language (Arwood 2011). Metacognitive knowledge, for instance, can be used by learners to gauge when and why it's important to use specific cognitive strategies (Zimmerman & Schunk, 2011). Therefore, metacognition is a critical concept to research, as it will almost certainly impact students' ability to use their visual thinking in learning contexts.

Within the theoretical framework of this study, metacognition is recognized as a language-based function (as detailed in Chapter 2), allowing conceptual thought to come under conscious control of the learner (Arwood, 2011). Thus, using students' natural language as a *tool*, in dialogic and reflective contexts to facilitate metacognition for learning is suitable for engendering metacognitive thought. It's demonstrated in the Arwood Neuroeducation Model (ANM) that students need outside meaning assigned to their visual cognition for students to acquire the language that allows them to 'know' their own visual thinking, to act in support of their learning system (Arwood, 2011). A strength-based approach to meta-learning for the purposes of this study is therefore conceived as *developing literacy for one's thinking and learning* to help students who think visually to learn visually in an auditory-based culture (Arwood, 2011, p. 109). When members of a community, or *learning community* in this instance, assign meaning to a students' actions and language, those concepts represented as language, become integrated into the students' language function (Arwood, 2011). Supporting students' visual thinking, in the context of an academic success course, therefore functions to help students use the English language as a tool for higher-level thinking about the ways they learn (Arwood, 2011). Using language to think about thinking or learning, consequently, may facilitate students' metacognitive access to their visual ways of thinking.

Rationale for Research in the Context of an Academic Success Course

Research indicates that young adults, the age of most first year college students, have a higher capacity for metacognitive ability than adolescents (Kawata et al., 2021) and that children's metacognitive knowledge is mediated by language development (Schneider, 2008). The curriculum for the academic success course is consequently designed, in part, to promote students' language use for their visual (or auditory) thinking and learning. Students who understand the ways they use language to acquire meaning, can visualize specific concepts stored in memory and assign new meaning to those concepts thereby, creating new points of access to represent an idea (i.e., layering conceptual understandings) (Arwood, 2011). Such a language-based view of cognition emphasizes a learner-centered, dialogic approach to classroom learning that makes apparent the meaning-making processes of students. By facilitating students' internal discourse for their own learning (meta-learning), the academic success course sought to cultivate students' self-reflection of their thinking and learning processes. In so doing, the researcher explored whether any changes occurred to students' visual thinking and learning during their time in the course.

Setting

The research was conducted within the bounds (Creswell, 2002) of a 15-week academic success course, offered by a Catholic, liberal arts university, in the pacific northwest during the

Fall 2021-2022 semester. The academic success course was a pilot initiative with first year, first-generation students designed to allow an immersion experience in the culture of the University. All students were provided opportunities to gain knowledge of their own learning and thinking processes. The ASC supported first-generation, low income, or underrepresented students' integration into university life while facilitating the development of competencies, knowledge, and support systems to confront the implicit challenges they face in college academia. Students worked within learning communities that functioned to support their academic achievement, empowerment, persistence, and well-being. An intended goal of the class was to help students understand elements of the hidden curriculum to acquire cultural capital during their first semester of college. Other class objectives are included in Appendix B.

Attendance was mandatory for the course and participation was the primary component of students' grade. Class activities consisted of weekly journal entries that asked students to reflect on a range of topics discussed in class and assignments that asked students to apply the concepts discussed in class. A portion of these reflections and course assignments were collected as qualitative data (e.g., artifacts) to be analyzed and/or included as visual examples in the study. The academic success course enlisted lecture-based components to introduce new concepts into the learning environment but relied primarily on dialogue in small groups (e.g., learning communities) (Siegesmund, 2016) to facilitate the sharing of diverse perspectives, and active construction of meaning.

The class was facilitated by an instructor employed in the Academic Services department at the university with prior experience in first-generation studies and teaching academic success courses. The instructor is also a student of the same doctoral cohort as the researcher, which made for a convenient pairing. The instructor and the researcher worked together on crafting a curriculum that was informed by research on FYFG students, while embedding objectives pertaining to meta-learning and self-regulation that have been shown to support students' success and development at the higher education level. In addition to being the co-designer of the curriculum, the researcher was a guest instructor, facilitating five classes that focused on meta-learning within a neuroeducation framework. The researcher was thus, a participant in the research as well as an observer. This positionality increased bias but may also increase construct validity in terms of whether changes to visual thinking and learning occur by facilitating meta-learning in a classroom.

The curriculum was constructed over five different meetings with the researcher and the instructor. The researcher was asked by the instructor to review and integrate components of a syllabus from a course offered at a prestigious University in the northeast. The curricular components integrated into the academic success course pertained to helping students 1) develop self-concept through storytelling; 2) identify strength-based characteristics such as resilience, shown to help students succeed academically (Yeager & Dweck, 2020); 3) develop knowledge for resources that can provide academic and psychological assistance; and 4) manage issues related to racism and microaggressions. Curricular objectives were developed with the intent to support the needs of FYFG students as detailed in Chapter 2. Other class objectives pertained to 1) using voice as an opportunity for self-expression; 2) reflecting and thinking about one's academic identity; 3) developing learning communities; 4) cultivating metacognition for learning; 5) developing strategies to improve conceptual thinking/learning, and 6) reflecting and thinking about higher education processes and expectations (see Appendix B for all course objectives).

The researcher and the instructor agreed that the academic success course should contextualize the academic and socio-economic challenges facing first year, first-generation students, and help them overcome these challenges by developing knowledge, strategies, skills, and dispositions to support their academic and career trajectories. “Dispositions” in this study, is a generic term for affectual elements of a person’s makeup, such as motivation, confidence, and attitudes which are generally associated with self-efficacy and agency (see Chapter 2). To facilitate this effort, the instructor and researcher cultivated *learning communities* within the class that functioned to support each other's individual success. Course objectives were made explicit to students to provide them opportunities to invest in the development of their own competencies. A high-level of attention was paid to the processes, objectives, and decisions that went into creating and delivering the class curriculum to ensure transparency as it pertained to how the course impacted students’ conceptions of thinking and learning. For a full course schedule with key takeaways from classes see Appendix A.

Class activities incorporated students’ previous educational/cultural experiences as an entry point to their meta-learning. For instance, FYFG students, within the context of the class, were asked to discuss what they previously experienced in education, how those experiences shaped their understanding of education, and how ideas discussed in class can be integrated into their lives. Students were encouraged to use language for self-expression, self-reflection and growth in discussion groups and reflective journal entries. As co-curriculum designer and guest-instructor in the ASC, a primary goal was to help first year, first-generation students develop knowledge for their thinking and learning to develop strategies that supported their conceptual learning.

The course drew on the neuroeducation model to frame learning and thinking as a neurobiological and socio-cognitive set of processes. The ASC was designed to help FYFG students engage in meta-learning, as operationalized in the literature review to facilitate 1) the development of metacognitive knowledge for their thinking and learning, 2) use of metacognitive strategies for conceptual learning, 3) self-regulatory behaviors, skills, and attitudes beneficial for academic success, and 4) strategic use of language as a source of thinking, empowerment, and discovery (e.g., meaning making). These cognitive resources were intended to develop FYFG students' conceptual learning and positive dispositions (e.g., confidence) towards learning to help them succeed academically. The ASC also focused on other topics such as racial identity/barriers, forms of effective communication, career skills/readiness, and aspects of agency that fell outside the scope of this research.

Implementation of PSL Framework

The instructor introduced the PSL framework to students the sixth week of class, asking them to be mindful and reflect on the three roles (person, student, learner) and their relationships throughout their first semester in college. The PSL framework was beneficial to orient students to the various roles that they are expected to occupy at University that may otherwise not be explicitly stated. The PSL framework is also helpful as it provides flexibility in incorporating knowledge/expectations as they evolve within a dialogic context that is intended to account for diverse perspectives. In the early weeks of class, the instructor focused on what students were used to in terms of their education. FYFG students will be asked to share their educational experiences with the entire class, in small discussion groups, and in reflective journal entries. In week five, when the learning and thinking block began, students were asked to reflect on their prior experiences with learning. Because experience plays a critical role in shaping all aspects of the Person level, incorporating students' prior educational experiences in dialogic and reflective contexts may help FYFG students assign new meaning to their education and to their learning. Therefore, the PSL framework was implemented to 1) flexibly incorporate how FYFG students understood their thinking/learning to regulate thinking/learning in learning tasks, and 2) make explicit the expectations placed on FYFG students in university life. Most class objectives fell outside the scope of this study, but those that aligned with meta-learning objectives can be found in Appendix B (items 3 and 7).

Academic Success Course Structure

The ASC was broken into three blocks of classes that incorporated specific aspects of the PSL framework. The first four classes in the ASC focused on acclimating students to the Person and Student roles they'll occupy at university. During this 'block' in the ASC, the instructor and guest speakers focused on potential challenges to first-generation students (e.g., the hidden curriculum, microaggressions, attrition) as well as ways to support them, (e.g., building communities/networks, integrating previous educational experiences into their current education, and managing their time effectively). The instructor focused on helping students build community through a) the first gen program on campus and b) their respective learning communities in the ASC.

The next block of classes focused on students' conceptual learning and thinking from a neurobiological perspective. Entitled the "learning and thinking block," these five classes focused on the Student and Learner roles and connections between these roles. The researcher helped to design and implement the learning and thinking block, to explore changes to students visual thinking and learning. The researcher, occupying the role of guest instructor, spoke in all five classes, leading the discussion/activities in three weeks, and introducing/bookending guest speakers (also specialists in neuroeducation) the other two weeks. These five classes were designed/implemented to help students better understand their thinking and learning and thereby regulate their learning as students in academia. To support this goal, the researcher, acting as guest instructor, provided constructive/supportive feedback (via email) to FYFG students after each of the class activities in the learning and thinking block.

The last block, entitled “Identity, Community, and Society,” consisted of four classes, led by a different expert who asked FYFG students to think deeply about sociocultural subject matter. In this last block, FYFG students were asked to reflect on themes such as, a) the stories they tell, b) how those stories shape their communities and their own reality, c) their positionality in society, c) where they feel like they belong and where they feel excluded, d) their career competencies and skills, d) their mindset related to growth, and e) and their relationship with technology, among others. The curricular objective for this block of classes, was to help students become more reflective/metacognitive in relation to issues/concepts/topics they may encounter as educated adults. The “Identity, Community, and Society,” classes were focused on the Person role, helping students think about how they will live and grow as a person situated within a community (or communities), and as a person who is part of a community situated within a society. In the previous two blocks, the ASC facilitated FYFG students’ thinking about being successful students and learners. The curricular goal in the third block of classes, was for students to orient their knowledge about being a Student and Learner within the larger construct of being a Person; and to think about the type of person they are and want to become. Such reflection was intended to help students build knowledge and metacognitive knowledge thereby, helping students self-regulate and develop positive dispositions (e.g., agency, lifelong learning mindset, growth mindset). See Appendix A for a full course schedule with key takeaways and Appendix B for course objectives.

Participants

Thirty first year, first-generation students met once a week for fifty-five minutes of class time in an academic success course. All thirty students engaged in a self-report questionnaire (pre and post MAI) given during the fifth and 15^{th} weeks of an academic success course along with reflective journal entries and assignments, which were a focus of data collection in this study. Students who gave consent to make their submissions available in this study, allowed the researcher access to the self-reports, reflective journal entries, in-class exercises, and out-of-class assignments. Therefore, all thirty students had the potential to be research participants in the study.

The instructor discussed the study during the first week of class to inform FYFG students about the study and the researcher's role in the class. The researcher then gave a quick overview of the study and its goals. All students were informed that participation in the study would not affect their grade in the class. The instructor encouraged those students interested in learning more about their thinking and learning, and had time to invest, to sign up for the interview portion of the study. The researcher anticipated at least six (N = 6) FYFG students enrolled in the ASC would register to be participants in the interview portion of the study. Students were given an online consent form, during the fifth week of class, which if they chose to sign, allowed the researcher access to their data for inclusion in the study. As an incentive to enroll, the instructor and guest instructor conveyed that participation would provide a better understanding of FYFG students' thinking and learning so that informed, equitable initiatives could be developed for

FGCS. Students were also informed that interview participation could help them learn more about their thinking and learning.

During the last twenty-five minutes of class in week five, students used their smart devices to complete, a) an online consent form, b) an online demographic and education history form, and c) an online self-report questionnaire. The consent form included information pertaining to the purpose of the study, confidentiality procedures, and an explanation of what participation involved (see Appendix C). The researcher asked all students to review the consent form, and electronically sign the form. Students were told the demographic form was voluntary and they did not need to fill it out if they chose not to participate in the study. All documents were completed via Qualtrics, an online survey tool, which only the researcher had access to.

The consent form had three options for consent. Students could agree to participate in the “class” portion of the study, which consisted of allowing the researcher access to two self-report questionnaires (the MAIs), and class activities in the ASC (e.g., journal entries, class exercises, and class assignments) for the purpose of data analysis. Students could also agree to participate in the “interview” portion of the study, which consisted of two 45–60-minute interviews, and two member checks, each estimated to be 30-45 minutes. The interviews and member checks were estimated to take a total of three and a half hours. The consent form stated that only six participants would be chosen to participate in the interviews. If more than six students’ expressed interest in participating in the study, the instructor and researcher would draw names from a hat to randomly choose six interview participants. The researcher determined this was the best way to ensure randomness and a representative sample of first year, first-generation students. Any additional students who expressed interest in the interview portion of the study would have the opportunity to act as alternates in case somebody dropped out of the study.

Last, students could agree to participate in both the interview and class activity portions of the study. If students signed up to participate in the interviews they would need to confirm participation through email and set up a time with the researcher to conduct the first interview. Students interested in interview participation had 48 hours to confirm their participation in the study. If needed, registration would be extended to enroll six participants. If, by the Friday of week five, six students did not sign up the study would move forward with up to three students. If more than six students' expressed interest in participating in the interview portion of the study, the instructor and researcher would draw names from a hat to select the six participants.

Participant Selection for Interviews

All FYFG students enrolled in the ASC represented the specific criteria required to study the phenomena in the intended population. Therefore, the researcher chose the participants for the interviews based on purposive convenience sampling, in order "to collect extensive detail about each... individual studied (Creswell & Poth, 2018, p.159)." A representative population of first-generation students at the university would be composed of about 66% identifying as 'underrepresented minority' and 51% identifying as such nationally. The researcher sought to enroll six (N = 6) FYFG students into the interview portion of the study, and one additional student as an alternate, in case a participant dropped out. There is no agreed upon sample size in qualitative research, rather this study utilizes enough participants to provide a rich contextual analysis (Creswell & Poth, 2018). Because the goal of this study is to understand the experiences of a specific group more clearly, rather than to generalize the findings (Pinnegar & Daynes, 2007), the number of participants should prove ample to gather enough data to identify themes and relationships/interrelationships among themes.

Six participants, from the 30 enrolled in the course were chosen to participate in semi-structured interviews. Participants were chosen for the interview portion of the study based on the following criteria: 1) must be enrolled in the academic success course during the Fall 2021-2022 semester; 2) must be a first year, first-generation student and 3) must show interest in participating in the interview portion of the study. Nine students originally consented to participate in the interview portion of the study. Names were drawn from a hat, at random, and six students were chosen to tentatively participate in interviews. Students chosen for interview participation were informed via email they had been selected to participate in the interview portion of the study (see Appendix H). Students originally not chosen to participate in the interview were also informed via email (see Appendix I). Students selected for interview participation had to reply to the researchers' email confirming their participation in the interview portion of the study. Three students confirmed their interview participation within 48 hours and three students did not confirm their participation. The researcher sent follow-up emails to the three students who had not confirmed on the second day after not hearing a response. However, these students did not answer emails confirming their interview participation. The researcher then reached out to the three students whose names were not originally chosen for interview participation. All three of these students confirmed they would like to participate in the interview portion of the study within 48 hours. One student, Lilly, chose to participate in the interviews but not the class portion of the study.

The researcher then scheduled the first interview (i.e., pre-assessment) with students who confirmed participation. Pre- and post-assessments occurred primarily during the fifth and fifteenth weeks of class. While the consent form mentioned that all studies would be conducted via Zoom, (due to Covid precautions), five of six focal participants said they would rather conduct the pre-assessment interview in-person with masks. Additionally, all focal participants chose to conduct the post-assessment in person with masks. In these assessments, the researcher collected language samples for identification of themes, particularly as they pertained to students' visual thinking and learning. Member checks occurred approximately 6-8 weeks after each assessment to verify segments of the interview transcription and the researchers' interpretations of the interview transcription. The six students who participated in the interviews were assessed for changes over the course of the semester, to answer the primary research question (RQ3), and are therefore termed the "focal participants."

Participant Selection for Self-reports and Reflective Journal Entries

An online consent form was given to students in the academic success class during week five. The consent form had three separate forms of consent. The first form of consent allowed the researcher access to the self-report questionnaires (i.e., MAIs) and class activities; the second form of consent conveyed interest in participating in the interview portion of the study; and the third form of consent expressed interest in the interview and class portions of the study.

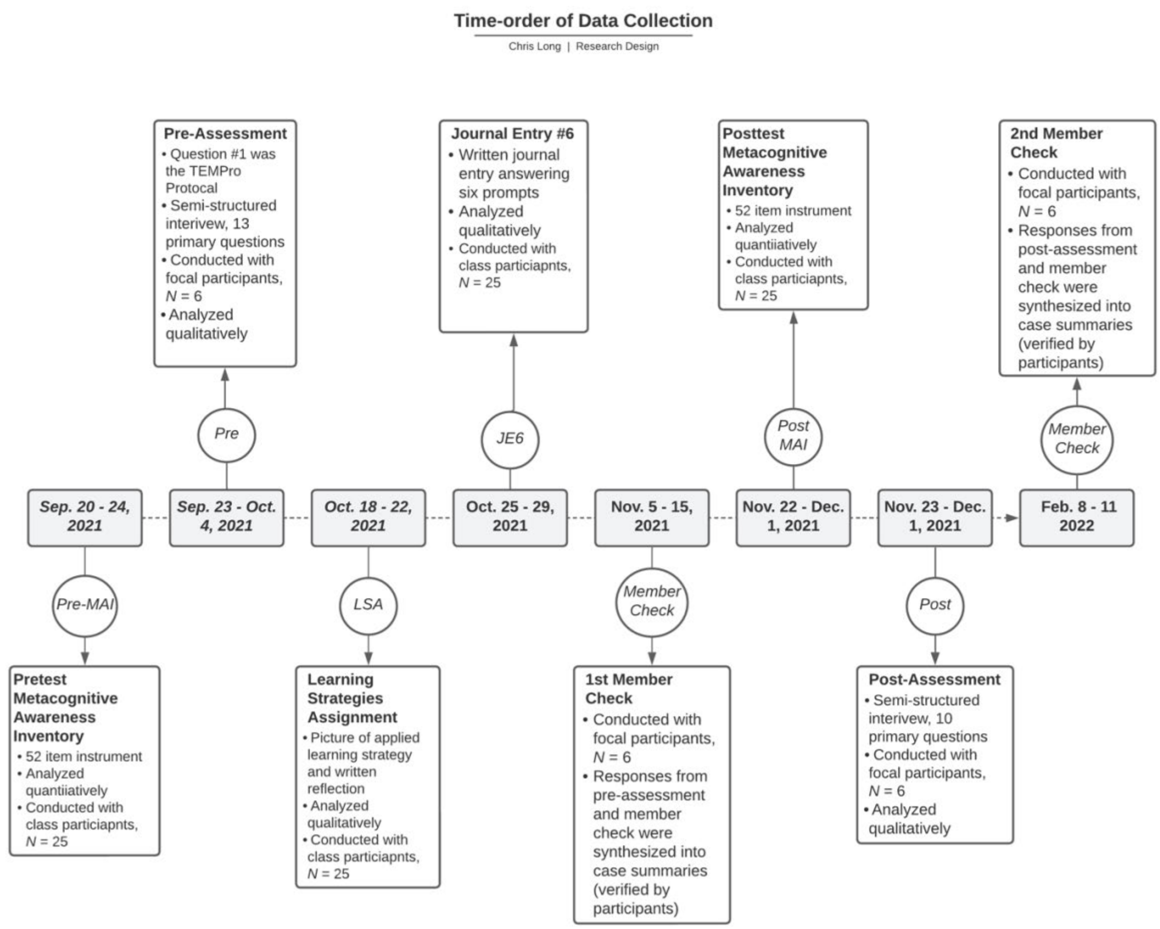
Twenty-eight students consented to participate in the *class portion* of the study. Six students originally answered "no" on the first form of consent and "yes" on the third form of consent or vice versa. These students were later contacted via email for clarity on their participation. Five of these students agreed via email to participate in the class portion of the study. These students make up the twenty-eight students who consented to participate in the class portion of the study. However, three students were later removed from consideration. One of these students did not qualify because it was later found this individual did not identify as "first-generation." A second student dropped out of the class near the end of the semester. And a third student consented via email to the class portion of the study, but beyond a cutoff when analysis had begun. As a result, these students' data were removed from all subsequent analysis. Thus, twenty-five first year, first-generation students were selected as class participants (N = 25) and six participants (N = 6) were selected as focal participants. Five of six focal participants also participated in the class portion of the study. Participants who consented to a) the class portion of the study only, or b) the class portion of the study and the interview portion of the study are termed the "class participants." The researcher used pseudonyms in Chapter 4 of the dissertation, to protect participants' identities. Participants' demographic and background information is included in Chapter 4.

Data Collection

Pre- and post-assessments were conducted, as well as class activities, to compare qualitative data at the beginning, middle and end of an academic success course. The researcher used semi-structured interviews to collect language samples from focal participants to investigate students visual or auditory cognition (utilizing the TEMPro) and to *generate themes* that helped describe, 1) what students previous experiences with learning entailed, 2) what students understood about their thinking and learning initially, 3) what strategies they used to support their thinking and learning, 4) what they came to understand or believe as they engaged in meta-learning, and 5) what changes occurred to students' visual thinking and learning in terms of knowledge, strategies, and dispositions. A single case study design was implemented to study the metacognitive assessments of FYFG students during an academic success course. To collect data pertaining to focal participants' changes to visual thinking and learning in the context of the academic success course, pre- and post-assessments, member checks, a reflective journal entry, a learning strategy assignment, and pre- and post-self-report questionnaires (MAIs) were administered to focal and/or class participants. Figure 2 below lists relevant criteria for each instrument, such as who participated in the data collection and the method of analysis. Figure 2 also shows when the data collection instruments were administered (e.g., pre-assessment, class activities, post-assessment, metacognitive awareness inventory, and member checks), in order from left to right.

Figure 2

Time-order for Implementation of Data-Collection Instruments in Study



Note. The ASC started on August 27, 2021, and the last day of class was Nov. 30, 2021. Another note. JE6 and the LSA make up the mid-point of the study and are referred to as the “class activities.” Last note. JE6 = Journal entry #6, LSA = Learning strategies assignment, Pre = Pre-assessment, Post = Post-assessment, Pre MAI = pretest-Metacognitive awareness inventory, Post MAI = posttest-Metacognitive Awareness Inventory.

As illustrated in Figure 2, the pre- and post-assessments took place between September 2021 and December 2021. The implementation of pre- and post-assessments using semi-structured interviews with six ($N = 6$) first year, first-generation students provided a rich contextualization of students' thinking and metacognition, within the bounds of an academic success course (Creswell & Poth, 2018). Focal participants were also encouraged to provide the researcher any strategies for learning (e.g., class notes) as artifacts for inclusion in the research.

Additionally, two member checks were administered between November 2021 and February 2022, to verify focal participants' responses from the pre- and post-assessments and provide further contextualization. Case summaries were written with each focal participant in the member check and were utilized as validation instruments for themes deduced during qualitative analysis.

As illustrated in Figure 2, one reflective journal entry, entitled "JE6" and one class assignment, entitled "LSA" were collected to assess meta-learning during a five-week block of the ASC that focused on learning and thinking from a neuroeducation framework. The class activities were administered over two weeks in mid-to-late October 2021. The researcher incorporated relevant artifacts from these class activities (e.g., pictures of students learning strategies) into the study.

The Metacognitive Awareness Inventory (MAI), a self-report questionnaire, was administered to all FYFG students as a class assignment during the fifth and fifteenth weeks of class, i.e., between September 2021 and November 2021. The MAI functioned as pre- and post-tests of students' metacognitive knowledge and metacognitive regulation in the context of meta-learning. Quantitative analysis of pretest and posttest MAIs were conducted from class participants responses ($N = 25$).

The semi-structured interviews, written class activities, and visual examples (i.e., artifacts) provided the researcher the opportunity to extract a triangulation of qualitative data points that facilitated validation of *changes* to students' visual thinking and learning by controlling for internal threats that could influence the findings. The quantitative assessment improved validity and provide added contextualization of changes to students' metacognition in the context of an academic success course.

Interviews

Semi-structured interviews were utilized in a pre- and post-assessment during an academic success course. The researcher's decision to use semi-structured interviews was based on the value placed on each students' language as a rich source of data and introspection. Semi-structured interviews provided contextualization for unique experiences allowing the researcher to "discover links or relationships among things," as opposed to the probabilities of those relationships (Merriam, 2009). Interviews were predominantly conducted in-person, as this was the focal participants' preference. Research instruments are embedded within the semi-structured interviews and will provide prompts for the collection of oral language samples (see Appendices E & F).

The interview protocol was developed in alignment with literature that details how to elicit metacognition in participants. Semi-structured interview questions were adapted from previous studies that used both qualitative and quantitative instruments to assess metacognition. Because there is no one way to measure metacognition (Baten et al., 2017), and studies often employ unique instruments, specifically questionnaires to measure metacognitive phenomena, it's logical to support the inclusion of an instrument designed to elicit metacognitive phenomenon for visual thinking/learning rather than utilizing an instrument that does not fit within the parameters of the research. Kreutzer et al. (1975) and Myers & Paris (1978) for instance, used interviews to assess metacognitive awareness of memory and learning strategies among other variables with young students. Semi-structured interview questions provided access to the following themes: (1) assessments of learning and thinking processes; (2) assessments of learning and/or thinking strategies, and (3) dispositions related to students' thinking and learning. Because the ASC was focused on providing a broader spectrum of psychological and cultural resources for FYFG students, the study was also prepared to investigate themes such as (4) self-regulating attitudes; (5) self-regulating behaviors; (6) and self-concept (i.e., identity).

Interview Question Development for Pre- and Post-assessment. Research has shown that metacognitive findings are highly amenable to the methods and instruments that are implemented in the study (Desoete, 2008; Desoete & Roeyers 2002, 2006). In other words, 'what' is measured, and 'how' it is measured is sure to shape the findings (Baten et al., 2017). Metacognition is a difficult construct to qualitatively or quantitatively measure because its observability is dependent on protocols designed to guide thought to cognitive phenomena. In studying metacognition researchers must take care to operationalize the construct carefully and transparently so they can ensure they are assessing metacognition and not another other form of cognition. In the bounds of this case study, the researcher is interested in investigating the metacognitive knowledge and regulation of participants upon entering college and the internal discourse they develop as they actively construct knowledge (Torbert, 2000) in a class focused on meta-learning (i.e., learning about their own thinking and learning). Using metacognitive assessments, this study seeks to gather participants' discourses for their thinking and learning, which reflects the active assignment of meaning to their thinking and learning based on what the student has come to understand and found to be *valid* thus far (Efklides, 2006). Meyer (2004) states that instruments that assess meta-learning in students "should ideally possess the capacity to capture variation in contextualized student learning engagement...in a response domain that appeals for its validity in reflecting authenticity in everyday academic learning contexts as derived from students' experiences (p.491)." Qualitative data provides a rich contextualization of experience and knowledge as it pertains to meta-learning and is therefore a suitable means of developing understandings of metacognitive relationships among specific groups of students.

Taking this into consideration, the researcher designed the pre- and post-assessment interview questions to account for participants' thinking in various learning contexts. Questions are aligned with Patton's (2002) recommendations for eliciting responses that bring the interviewer 'into the interviewee's world,' through questions that evoke feelings, knowledge, experiences, sensations, opinions, and background information. Interview questions were structured into four different sections. Themes that emerged from these sections were compared during longitudinal analysis. The first section entitled "Understanding of Learning" explores how participants understand/feel about their learning. The second section of the pre-and post-assessment, entitled "Previous Knowledge," asks students about previous learning experiences. Two other sections, the "Awareness of Cognition" and "Strategies and Skills" sections, place students in authentic (sometimes casual) learning scenarios and asks them how they think and/or what they would 'do' to support their learning (see Appendix E & F). Literature has suggested that overlap in metacognitive phenomena is substantial, therefore parsing out interview questions into sections that target specific thinking/learning phenomena is strategic to ensure the appropriate metacognitive phenomena can be assessed preemptively, directly, and accurately. It was expected that participants would answer interview questions with themes (categorized phenomena) that fell outside the section intended to assess that theme. For this reason, template analysis was chosen as a method of analyzing the data as it provided a flexible way to organize qualitative data into predetermined themes and modify those themes when necessary (King & Brooks, 2016).

All metacognitive phenomena within the parameters of this study align with Arwood's Neuroeducation Model that regards metacognition as a developmental language function accessed by concrete-to-formal-level of thinking (Arwood, 2011). Language that *represents cognition* demonstrates metacognitive phenomena as framed in Chapter 2. Therefore, semi-structured interview questions provide an optimal source of data because they provide participants access to their internal (mental) states and a medium to communicate those states to the interviewer through language (Efklides, 2009).

In developing the questions for the pre-assessment and post-assessments the researcher borrowed from several research-based sources to legitimize the phenomenon of 'seeing' one's own thinking and having a metacognitive awareness of learning and thinking strategies. The following sources helped shape the questions for the pre- and post- assessments in this study:

1. Ibrahim et al., (2015) used semi-structured interview questions with surgeons to assess the use of mental imagery in pre-operative planning when performing surgery. Some of these questions related directly to *awareness of visualization processes* for use of imagery in completing medical tasks. For instance, question number three in the Ibrahim et al., (2015) study asks, "What steps or parts, if any, did you visualise through mental imagery?" Could you describe how this process plays out (p. 891)?" Responses to such questions provided the researchers with the understanding that trauma surgeons use mental imagery in pre-operative planning as a "near essential tool" to be successful in surgeries that are challenging (p.899). Question number three of the Ibrahim et al., (2015) study influenced the *awareness of cognition* (AoC) sections in the pre- and post-

assessments, which sought to assess (among other things) students' awareness of mental imagery.

2. Meyer's (2004) Reflections on Learning Inventory (RoLI) was consulted for this study as it thematically segments qualitative data into sixteen subscales that explain the meta-learning capacities of students. Two of these subscales are pertinent to this study; 1) *Knowledge of objects* - "An awareness that what has been learned exists as a visual 'mental object'"; and 2) *Knowing about learning* - "Knowing when learning has occurred through an experience of personal acquisition of meaning (p.492). This illustrates that the one's conceptual thinking and learning can be known through visual representations and that such understandings are critical to meta-learning. Justification for the RoLI inventory helped shape questions in the AoC section in the pre- and post- assessments (Appendices E and F).
3. The researcher also consulted Arwood (2011), when considering adults' metacognitive assessments of their thinking in relation to hearing the English language. One adult interviewee in a study conducted by Arwood (1991a) stated, "Well, I don't hear what is said, I see what is said… Like right now, I don't hear what you say, I see what you say (p.356)." This indicates the adult interviewee can assign meaning to their visual cognition with language, and therefore used metacognition to see their own visual thinking. Questions related to whether people are aware of their ways of thinking, in relation to what they hear are utilized throughout the pre- and post-assessments. These questions do not refer to mental imagery specifically, as the participant must show an awareness of their visual cognition in a hypothetical learning task to determine whether they possess metacognition for their visual thinking. The interviewer took care not to lead participants

to any determination, lest they conflict with how students know and ‘come to know’ their own learning systems.

4. Jackson (2014, p. 394) lists various meta-learning phenomena (Figure 2) such as “awareness and understanding of the phenomenon of learning” and “consciousness/awareness of own learning practices and study strategies” that were integrated into meta-learning objectives for students in the context of an academic success course. Because the metacognitive assessments in this study are developed in response to meta-learning objectives in the course, the Jackson (2014) study provided clear themes to utilize when designing the interview questions.
5. The metacognitive awareness inventory (MAI) (Schraw & Dennison, 1994), a true-false, 52-question quantitative assessment, was consulted for developing interview questions for the pre- and post-assessments. Questions in the MAI refer to a person’s overall awareness of their thinking and learning while engaging in learning tasks and are thus helpful in understanding what types of questions elicit metacognitive awareness; specifically, as they relate to the construction of meaning. Questions in the MAI that were adapted for the open-ended question format of the pre- and post-assessments include 1) “I draw pictures or diagrams to help me understand while learning;” 2) “I create my own examples to make information more meaningful;” 3) “I focus on overall meaning rather than specifics.”
6. Efklides (2009) states that metacognition is not a ‘mirror’ of cognition, but rather a model or representation of cognition that is informed by the representation (i.e., concept) through the brain's monitoring function and informs the representation through the control function. Control processes are, however, dependent on metacognitive knowledge

(i.e., conceptual frameworks of cognition) to provide an accurate model of cognition to act upon (Efklides 2006; 2009). Therefore, assessing metacognitive knowledge is a vital entry point to understanding the progression from metacognitive awareness to metacognitive control.

In connection with these sources, the pre- and post-assessments were designed and implemented. These assessments, spread over the course of approximately ten weeks, helped determine themes inherent in participants' discourse that represented awareness or knowledge of visual thinking. The pre- and post-assessments also helped the researcher deduce themes that revealed whether/how participants came to use visual thinking (i.e., control processes) when engaged in meta-learning processes.

Interview questions also evoked affective elements of a students' education and/or learning. For instance, focal participants were asked to rate (1-10) how well they understood their learning near the beginning and end of each assessment.. Such ratings evoked feelings of metacognitive confidence (MC) for participants' knowledge of their learning. Additionally, journal entry #6 (one of two class activities used) targeted affective states related to students learning. Therefore, the pre- and post- assessments, combined with the class activities observe various domains of metacognitive phenomena, including feelings/judgements (i.e., metacognitive experiences).

The semi-structured interview questions and protocols underwent peer review, by two members of the researcher's cohort committee. The researcher adapted the interview questions based on the committee's feedback. The interview questions and protocols were also critiqued by one expert in the field of neuroeducation and one graduate in the field of neuroeducation to ensure clarity and best use of verbiage to elicit metacognitive phenomena. The researcher refined the questions after each review. The pre-assessment was pilot tested with one person, a close relation of the researcher. The researcher debriefed the participant who pilot tested the interview questions to understand their perceptions of the assessment. The review and pilot-testing of the assessments improved the credibility of this study's methodology (Merriam, 2009).

Pre-assessment. The pre-assessment is designed to answer the following sub-questions:

RQ3a: What do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course?

RQ3b: What do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course?

RQ3c: What do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course?

The researcher utilized longitudinal analysis to compare themes between the pre-assessment, class activities and post-assessment, which answered the primary research question:

RQ3: What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?

The pre-assessment interview questions were designed to elicit discursive themes that allowed the researcher to assess whether students understood aspects of their visual thinking and whether they used strategies to support their visual thinking and learning. The semi-structured interview protocol for the pre-assessment (Appendix E) contains 13 questions, 12 of which test for metacognitive phenomenon. Pre- and post- assessments, along with two class activities (JE6 and LSA) also allowed the researcher to discover prominent themes in participants' meta-learning.

The first question of the pre-assessment enlisted the prompt for TEMPro analysis. The subsequent 12 questions were broken into four sections, which explored, a) previous experiences with learning, b) utilization of strategies, c) metacognitive confidence, d) knowledge of one's thinking/learning (i.e., metacognitive phenomenon), f) perceptions of learning, and g) perceptions of the interview. The second and last questions (including follow-up questions) of the pre-assessment, assessed the impact of the interview as an intervention, primarily in terms of metacognitive confidence. The last question, question 13, is broken into two parts, with the first part assessing perceptions of the interview (i.e., what participants thought about the interview) and the second part assessing metacognitive confidence. Answers to these questions helped clarify the impact the researchers' instruments may have had on the phenomena under study. These questions were structured into the "Understanding of Learning" (UoL) section. Metacognitive confidence in the UoL section is operationalized as a subject belief and/or judgement (i.e., rating) about oneself, regarding the validity of a primary cognition (i.e., understanding of learning) (Moreno et al., 2022, p.140).

The subsequent 10 questions assessed different domains of learning and were segmented into three sections; 1) previous knowledge (PK); 2) awareness of cognition (AoC); and 3) strategies and skills (S&S). Each of these sections contain three-to-four questions. The design rationale for these questions is based on literature from Chapter 2 that segments cognitive and metacognitive phenomena into specific domains for the purposes of explaining metacognitive functioning holistically or in its totality. Segmenting metacognitive phenomena into such domains allows for precise observation of domains (e.g., metacognitive knowledge, skills, experiences, etc.) and assessment of relationships (e.g., metacognitive knowledge and metacognitive regulation).

Questions three through six in the pre-metacognitive assessment assessed *personal experiences* in education that may have impacted metacognitive knowledge. It was important to gather data pertaining to previous educational experiences that could have impacted FYFG students' thinking/learning, as it may impact how they function when entering college. Additionally, it's been shown that direct procedural knowledge is needed for students to develop metacognitive skills (i.e., monitoring) (Van der Stel & Veenman, 2014). Students that have had few experiences attuning to their own thinking and learning in their education may show a limited capacity for doing so. There is still much to be understood about metacognition for learning among undergraduate students (Tanner, 2012). Thus, it's important to understand the dynamic of how students come to understand their thinking and learning processes to be used effectively.

Questions seven through nine assessed *awareness of cognition* (AoC). These questions depend on a participant's awareness/understanding of their thinking without specific prompts from the interviewer that would indicate to the interviewee a visual or auditory way of thinking. Instead, descriptive, story-based language was used to help participants mentally place themselves in specific learning scenarios and respond effectively. These questions assessed whether participants had metacognitive awareness or *knowing* of the ways that they thought and/or constructed meaning in learning contexts. Metacognitive knowledge provided the conceptual framework for understanding one's cognition (e.g., monitoring) to guide "the interpretation of situational data (e.g., declarative knowledge) so that proper control decisions are made (Nelson et al., 1998 in Efklides 2006, p.4)." Theoretically, metacognitive knowledge should influence metacognitive regulation/skills by guiding implementation of learned strategies in a conscious and deliberate manner. The AoC section is structured strategically into the pre- and post-assessments, as metacognitive awareness (or 'knowing of cognition') may be a mediator between students' visual cognition and their ability to use visual thinking strategically/skillfully.

Questions 10 through 12 assessed *strategies and skills.* As opposed to the previous section, which focused on 'how a person constructs meaning mentally', these questions focused on 'what you do in specific learning situations to support thinking and/or learning'. The questions were posed in a way that led students to think about specific strategies/behaviors they might employ in a learning task.

Questions in the pre-assessment are predominantly open-ended questions, though one question was multiple choice. Question number three of the pre-assessment reads, "People have a variety of experiences in education. Some people have had teachers or counselors that talk about thinking and leaning specifically, and some people haven't had experiences like that, which is okay. Which one of those situations sounds more like you? You can answer as 'Never,' 'Few experiences like that,' 'More than a few, or 'A lot'". Question number four then has specific prompts that the interviewer asked depending on how the focal participant answered question three. Interview prompts (i.e., follow-ups) such as these were built into the interview questions (Appendices E & F) to capitalize on the unique experiences and knowledge of the participants. Thus, the researcher used follow-up questions based on the responses of participants to explore the ideas they shared more fully.

The role of the interviewer carries with it specific responsibilities to ensure accuracy, protect the participants, and limit bias. The researcher thus, designed the interview questions with the intent that all responses could be accurate reflections of students' life experiences and knowledge. Visual, story-based prompts were integrated into the PK, AoC, and S&S sections, so students could visualize themselves in specific scenarios, and help them draw more meaning to answer the questions. The next section will detail the procedures of the pre-assessment.

Pre-assessment Procedures with Participants. After the TEMPRO prompt was completed, the researcher moved on to the four sections that composed the pre-assessment. The researcher prompted participants with questions that directed them to describe their thinking/learning in educational and/or learning contexts. Language samples collected from each participant during the pre-assessment, helped show what subjects understood about their thinking and learning (potentially based on prior experiences), while the TEMPRO analysis results showed whether participants used visual or auditory thinking, or whether the results were inconclusive. The pre-assessment thus, helped the researcher identify participants' learning systems and deduce prominent themes related to a) previous experiences with learning, b) understanding of thinking and learning (i.e., learning system), c) strategies to support thinking and learning, and d) dispositions toward learning (e.g., metacognitive confidence), among others.

The researcher presented the pre-assessment interview questions to participants during the fifth and sixth weeks of the ASC. Participants were given as much time as they needed to answer the questions. If participants struggled to answer a question, the interviewer offered prompts to help the participant answer the question. Focal participants were also given the option to skip questions when confused, which occurred (with follow-up questions) twice during the study. The researcher followed-up with questions that were not in the protocol on occasion, to better understand what the participant was speaking about.

The interviewer recorded all in-person semi-structured interview conversations for transcription and later analysis. Interviews were recorded with the researcher's phone (as a primary) and laptop (as a backup). One interview was conducted via Zoom (teleconferencing application), and the interviewer recorded the interview via the Zoom application (as a primary) and a computer (as a backup).

Interview questions were presented primarily via paper handouts. The researcher wrote about interview experiences in a research journal. All names in the research journal, along with other electric documents were kept anonymous through use of pseudonyms. Interview recordings and transcripts were saved on the researchers' computer drive and backed up on an external hard drive, for redundancy. Both the computer drive and external drive are password protected and encrypted so no one but the researcher can access and observe the data. The next section covers the adjustments made from the pre-assessment to the post-assessment, along with post-assessment procedures.

Post-assessment. The post-assessment, when compared to the pre- assessment and class activities via Saldaña's (2003; 2021) longitudinal criteria aided in answering research question three.

> RQ3: What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?

Sections in the post-assessment as well as rationale for interview questions are identical to the pre-assessment. Interview questions for the post-assessment (Appendix F) were adjusted to contextualize participants experiences over the last semester and generate responses that could reflect changes to focal participants' a) metacognition, b) visual thinking, c) conceptual learning,

d) learning strategies, and e) dispositions towards learning, as a result of participation in the ASC (see Appendix F).

Question one of the post-assessment, asked focal participants to rate how well they understood their learning. This question was meant to assess metacognitive confidence in focal participants' knowledge of their learning. Question one sought to record the specific impact that the ASC may have had on students' thinking and learning. Question ten, the last question of the post-assessment, also asked participants to rate how well they understood their learning. Question 10 is broken into two parts, with the first part assessing potential changes to one's approach to learning (i.e., knowledge of learning) and the second part assessing metacognitive confidence. Answers to these questions helped clarify the impact the ASC and the researchers' instruments (e.g., post-assessment) may have had on the phenomena under study. These questions were structured into the "Understanding of Learning" (UoL) section.

Questions two through four of the post-assessment assessed meta-learning and/or potential changes to participants visual thinking/learning in the context of the ASC. Because the pre-assessment focused on knowledge from previous learning experiences, the PK section in the post-assessment is designed to be contrasted with the PK section in the pre-assessment during analysis.

Questions five through seven assessed facets of metacognitive awareness that directly relate to knowledge of thinking and learning processes (Efklides, 2006). The responses to these questions, when compared with the pre-assessment (and themes from class activities), provided changes themes that related to focal participants' metacognitive knowledge and regulation.

Questions eight and nine assessed strategies that supported thinking and learning. The way participants discussed these strategies could indicate metacognitive knowledge (i.e., monitoring processes) and metacognitive strategies/skills (i.e., control processes) for their visual thinking/learning. Responses to these questions, when compared with the pre-assessment (and themes from class activities), provided change themes that related to focal participants' thinking and/or learning strategies (and behaviors that supported learning). The researcher structured follow-up questions into S&S section pertaining to the learning strategies shown to the researcher during the interview (e.g., lecture notes and/or drawings). The researcher asked follow-up questions (some improvised) to better understand what strategies entailed and why/how they supported thinking/learning. The researcher took pictures of focal participants' strategies for inclusion as artifacts in the study.

The pre- and post-assessments were compared to the class activities (JE6 and LSA) to assess themes that showed changes to participants' visual thinking/learning during the ASC. The pre- and post-assessment instruments were designed specifically to assess 'change themes' related to metacognitive knowledge and regulation for visual thinking and learning.

The next section provides a description of the Temporal Analysis of Propositions (TEMPro) instrument (Arwood & Beggs, 1989) which was implemented during the pre-assessment.

Post-assessment Procedures with Participants. The researcher conducted a post-assessment with focal participants in Week 15 of the ASC, utilizing a semi-structured interview format. The post-assessment was designed to gather data based upon the same metacognitive and/or experiential domains as the pre-assessment, allowing for comparison during analysis. Therefore, both assessments have similar designs with similar questions, as they should overlap to ensure comparability in the findings. Slight adjustments were made to the post-assessment questions to contextualize the impact of meta-learning. All questions in the pre- and post-assessments are purposefully aligned with the literature from Chapter 2 and rationale for the academic success curriculum in Chapter Three. No participants have taken a neuroeducation course.

The same participants from the pre-assessment participated in the post-assessment. The interview protocol for the post-assessment was conducted similar to the pre-assessment with two important changes. The first change was a purposeful omission of the TEMPro prompt. The TEMPro was only conducted during the pre-assessment to assess visual or auditory cognition. The second change, dealt with the interview format. The researcher asked focal participants (via email) to bring any learning strategies that had or hadn't worked for them over the course of the semester. The researcher added the strategy (or strategies) could be something discussed in the ASC, or something they learned elsewhere. Focal participants' strategies (i.e., artifacts) were discussed in the S&S section of the post-assessment. Five of six focal participants brought strategies they used to support their thinking/learning during the semester. The researcher took pictures of the strategies and included some as artifacts in this study.

All interviews were conducted in-person, per interviewees' preference. The interviewer recorded all in-person semi-structured interview conversations for transcription and later analysis. The interviewer stored the transcriptions and audio recordings on encrypted, password protected computer drives.

Temporal Analysis of Propositions

The Temporal Analysis of Propositions (TEMPro) is a language assessment tool designed to discriminate between typical language and atypical language users (Arwood & Beggs, 1989). The TEMPro is given to students over the age of eight years old, who should possess a full English grammatical system for communicating time-based relationships (Arwood & Beggs, 1989). The TEMPro is designed to evaluate whether participants can connect three ideas temporally by communicating the time-based relationships inherent in the English language or whether participants connect time using spatial and/or linear relationships. Students with language function for auditory concepts can represent and connect ideas temporally in a conversation, while students with a difference in language function struggle to connect ideas in time. This is important for several reasons but in the context of this study it's critical because the type of language function a student possesses indicates the way that student learns language and represents concepts mentally (Arwood, 1991a).

Procedure. The TEMPro prompt was given to focal participants at the beginning of the pre-assessment. Using the TEMPro prompt, the researcher asked the participant the question: "Tell me what you do on a typical day?," which requested the student think about ideas displaced from the present time and place. If the student struggled with the question or had questions for the researcher, the researcher would not be allowed to elaborate in terms of the phrase *typical day*, as any visual prompts could alter the findings. The researcher was allowed to say, "whatever you think it (as in the phrase *typical day*) means". If the student still struggled to answer the question, the interviewer would move on to the next phase of the assessment. Two participants had questions about the prompt. In response to these questions, the researcher gave short, direct answers which did not provide for elaboration on the phrase "typical day." The researcher recorded and transcribed all conversations for later analysis.

Interviewee responses were analyzed using the TEMPro, which allowed the evaluators to assess whether focal participants used temporal clauses for thinking about time, which indicates an auditory learning system, or non-temporal visual clauses, which indicates a visual learning system. If participants formed temporal propositions, represented as three ideas connected in time in the English language, they would use an auditory cognition for representing language-based concepts. If participants listed ideas spatially and/or linearly, they would have a difference in language function, signifying a difference in their learning system based on how they learn and represent language-based concepts (Arwood, 2011). The TEMPro helped answer RQ1 – "What does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition?" The next section discusses prompts given by the ASC instructor for class activities used in this study.

Class Activities

Two class activities were selected to act as the mid-point of the study, which aided in longitudinal comparison between the pre-assessment and post-assessment, helping answer research question three.

> RQ3: What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?

Journal Entry #6 (JE6) and the Learning Strategies Assignment (LSA) were selected to represent FYFG students' meta-learning and applied/integrated strategies for learning at the mid-point of the study, which helped answer research sub-question RQ3d.

> RQ3d: What meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students' visual thinking and learning?

Twenty-five FYFG students (N = 25), participated in the class activities. Five FYFG students who participated in the interview portion of the study also participated in the class activities. The themes that were deduced from class participants responses provided validation of changes to focal participants visual thinking and learning. Rationale for pre- and post-assessment interview questions are identical for class activities. This study's rationale for implementation of reflective journal entries is discussed next.

Reflective Journal Entries. The ASC in the bounds of this case study was designed to embrace a learner-centered, metacognitively rich curriculum that provided opportunities, as suggested by Baten et al. (2017), for students to reflect on their learning and thinking processes and monitor their strategy effectiveness. Research suggests metacognitive knowledge and skills can be enhanced through reflective discourse (Kramarski, 2009). Reflective discourse in journal entries therefore, provided an entry into metacognitive thought through questions about participants' learning and learning strategies. Journal entries were helpful in assessing FYFG students meta-learning at the midway point of the study.

Reflective journal entries provided a way for students to reflect on their thoughts and provide meaningful conclusions that they may not have been able to formulate during an interview process. Additionally, using reflective journal entries allowed the researcher to use a source of discourse for triangulation that fell outside the interview process, thereby reducing unknown interview biases to increase the credibility of the findings.

The concept of *valid knowledge* in the context of meta-learning (i.e., learning about one's learning) refers to the development of *attention* for seeing, embracing, and correcting the ways which an individual acts into the world (Bamber, 2008; Meyer, 2003; Torbert, 1999). Development of metacognition for one's visual thinking, within a meta-learning context, may therefore be dependent on 'seeing, embracing, and correction of behavior' (Torbert, 1999). FYFG students' writing provided a suitable means of observation for meta-learning and change, as participants developed internal discourses and understood valid ways of thinking and learning over time.

The reflective journal questions (Appendix A) utilized in the ASC during the learning and thinking block modeled Siegesmund (2016), who used self-assessment questions in reflective journal entries to facilitate metacognitive awareness in an undergraduate biology course. The following questions used in Siegesmund (2016, p. 207) were used for adaptation in this study.

1. Comment on how the class activities helped your learning.
2. How has this class changed the ways you learn/study?
3. Please comment on what skills you have gained because of this class.

For comparison, here are the questions included in journal entry #6 in week ten of the ASC (i.e., end of the learning and thinking block):

1. What are some challenges that you faced in the past (like in high school) when learning?
2. Think for a minute about ideas or strategies you've learned in class so far. Which, if any, have you integrated into your own life?
3. Why have you integrated these new ideas or strategies?
4. How do you think you learn best?
5. Does learning about your own learning help you to feel empowered – as in you have power over the ways that you learn?
    a) If yes, what have you learned in this class thus far that has helped you to feel empowered?

b) If not, please explain why you don't feel like you have power over your own learning? What do you think would help you to feel empowered in terms of your own learning?

Findings from the Siegesmund study (2016) demonstrated that use of self-assessments in reflective journals and facilitation of learning communities (through a learner-centered curriculum) in an undergraduate biology class, had a positive, significant impact on increasing undergraduate students' metacognitive awareness and epistemological beliefs. Siegesmund's (2016) intervention also resulted in positive changes to students self-regulated learning (as denoted by metacognitive behaviors such as planning, evaluating, monitoring, and reflecting on learning). Therefore, the questions included in the reflective journal entries during the learning and thinking block of classes, were meant to elicit students' metacognitive awareness for their thinking and learning, and challenge students to assess what types of knowledge (i.e., strategies, content, skills, behaviors, beliefs, perceptions, etc.) were valid to their own thinking and learning. Unlike the Siegesmund (2016) study, the questions in this instrument did not directly ask about skills use, because this would likely show a perception of skills gained; rather the researcher sought to investigate whether participants reported 'conscious and deliberate use of strategies', which would denote development of metacognitive skills (Efklides, 2006).

Procedure. Self-reflective journal entries were employed in the ASC to, 1) facilitate metacognitive thought, 2) observe meta-learning; and 3) provide feedback to participants. Reflective journal entry questions were additionally intended to elicit some feelings or judgements of learning and meta-learning. Such discourses allowed the researcher to capture the construct of meta-learning more holistically.

Reflective journal entries were the primary source of participation in the ASC and made up a majority of the grade. Reflective journal entries were assigned to all FYFG students during multiple weeks in the ASC. Journal entries were assigned/collected three times in conjunction with the five weeks of classes dedicated to *learning and thinking* from a neuroscience perspective (see Appendix A for class schedule). The instructor provided formative feedback to students' journal entries to improve self-monitoring (Siegesmund, 2016) during the learning and thinking block.

The researcher selected the final journal of the learning and thinking block (i.e., week 10 of the ASC) for inclusion in this study. This journal entry was the sixth entry overall in the ASC and is therefore termed journal entry #6 (JE6). Capturing the data at the mid-way point of the study, directly following five classes with a meta-learning focus, was a strategic way to identify meta-learning themes and reference changes that may have occurred to students' visual thinking/learning over the duration of the semester.

Hand-written entries were encouraged as they provided a source of visual-motor input, for improved conceptual processing, but electronic entries were also accepted. Students submitted journal entries to the university's learning management system (LMS), which the researcher had access to. Students who used hand-written journal entries, took pictures of their entries, and uploaded them to the LMS. The researcher later transcribed pictures of written entries verbatim. Reflective journal entries were stored on two encrypted, password protected computer drives.

Learning Strategies Assignment. Class assignments were structured into the curriculum at various weeks (see Appendix A). Class assignments were generally completed outside-of-class, independently. Two class assignments were conducted during the 'learning and thinking' block. One of these assignments, the learning strategies assignment (LSA), asked students to utilize metacognitive, language, and/or visual learning strategies and write about the experience. The LSA was structured into the curriculum to provide students an opportunity to gain metacognitive knowledge for strategy usage based on the way they think/learn best. The researcher selected the learning strategies assignment (LSA), as it came near the mid-point of the study and could represent students meta-learning and strategy usage. The LSA and JE6 make up the “class activities” chosen by the researcher to represent themes at the mid-point of the study that may indicate ‘changes’ to participants visual thinking/learning. The research rationale for the LSA is identical to the reflective journal entries, as the assignment was designed/implemented as a written reflection of an applied strategy.

Procedure. Participants were asked to “try one or two visual, metacognitive, and/or language learning strategies” discussed in the ASC that they believed “could be impactful.” FYFG students were instructed to use the strategy all week. Class participants uploaded a picture of their learning strategies to the university’s LMS and answered reflective prompts. One reflective prompt read “How is this strategy helpful if you feel that it is helpful?” See Appendix J for directions and reflective prompts. The researcher collected class participants’ visual examples (i.e., pictures) from the LSA, and utilized them as artifacts for inclusion in the study. Artifacts can support an assertion of ‘change’ by supporting change themes with visual examples that describe, detail, and/or validate said themes. The LSA was stored on two encrypted, password protected computer drives.

Visual Examples. Class and focal participants were encouraged to provide examples of any learning strategies they used during the class. These examples were used as artifacts for inclusion in the study which helped assess/support assertions of ‘change’. The researcher first encouraged students to provide examples of learning strategies after the pre-assessment was completed, then again at the midway point of the class, and again before the post-assessment. Specifically, the researcher asked participants before the post-metacognitive assessment to bring to the interview anything that helps them think or learn, such as lecture notes, drawings, visual flowcharts, etc. A portion of the post-metacognitive assessment is dedicated to reviewing these examples. Visual examples were also collected from class participants during the LSA, to support assertions of change for the focal participant group. Artifacts were stored on two encrypted, password protected computer drives.

Case Summaries and Member Checks

The researcher synthesized segments of the pre- and post-assessment transcripts relevant to this research into case summaries. Case summaries acted as an entry point to analysis for each focal participants' data, and the synthesized findings were used to foreground member check interviews (Harvey, 2015). The researcher utilized case summaries per King & Brooks (2017) to protect against fragmentation of individual accounts during coding and retain each participants' meanings in whole form. Case summaries supported the researcher in verifying themes identified during language analysis and provided depth to qualitative themes by illustrating how phenomenon manifested in students' experiences.

Procedures. Two member check interviews (Birt et al., 2016) were conducted with focal participants six-to-eight weeks after the pre- and post-assessment. During member check interviews participants clarified sections in the case summary that were unclear and provided details (e.g., examples) about their original responses (providing second order meaning) and the researchers' interpretations.. Participants' statements during member check interviews were structured into the case summary documents and used to verify, modify, and/or provide depth to the themes that developed during qualitative analysis. See Appendix G for member check protocol and case summary outlines. The quantitative instrument utilized in the study is discussed next.

Metacognitive Awareness Inventory

The Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994) is a comprehensive assessment of the primary theoretical components of metacognition (Brown, 1987; Flavell, 1987; Jacobs & Paris, 1987; Young & Fry, 2008). The MAI measures metacognition in two domains: 1) knowledge of cognition, and 2) regulation of cognition (Schraw & Dennison, 1994). Knowledge of cognition in this instance, measures "an awareness of one's strengths and weaknesses, knowledge about strategies and why and when to use those strategies," while regulation of cognition measures "knowledge about planning, implementing, monitoring, and evaluating strategy use (Schraw & Dennison, 1994, p.471)." The knowledge of cognition factor and the regulation of cognition factor are significantly correlated (i.e., r = .54 and .45, respectively) (Schraw and Dennison, 1994; Sperling et al, 2004) and have been shown to have external validity given the high correlation of MAI scores with students' academic achievement (i.e., GPA, specific class grades) (Pintrich, 2000; Young & Fry, 2008). The MAI provides a validated means of assessing metacognition and metacognitive gains (Siegesmund, 2016), with the potential to layer understanding of meta-learning and changes to students' metacognition within the context of the ASC. Therefore, inclusion of the MAI in this study helped answer research question two (RQ2).

> RQ2: What changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fifteen of an academic success course?

Procedure. The Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994) was given to FYFG students in the ASC during the fifth week of class and again in the 15^{th} week of class to assess gains (i.e., growth) in students' metacognitive awareness. Thus, a standard pretest-posttest comparative format was used to assess metacognitive gains over approximately ten weeks. Benefits of using the MAI include 1) its reliability in assessing metacognitive awareness; 2) the ease in which it can be developed, administered, and assessed by educators; and 3) the mitigated burden it places on subjects to respond (as compared to other metacognitive measures). The MAI was hosted in an online survey software called Qualtrics, which allowed students to access the MAI online with their smart devices (i.e., phones, laptops, tablets) and gave the researcher the ability to store and score the assessments within the software. Previous pilot testing by Schraw & Dennison (1994) found the inventory took approximately 10 minutes on average to complete. The instructor and researcher gave FYFG students 25 minutes at the end of week five's class to complete the a) consent form, b) demographic and education history form, and c) pretest MAI, estimating students would have at least ten minutes to complete the pretest MAI. All FYFG students who took the pretest MAI in class finished the MAI.

In week 15, students were given 15 minutes to complete the posttest MAI at the end of class. FYFG students were also allowed to take the MAI outside-of-class leading up to the week 15 class or shortly after the class before the cutoff date, which coincided with the end of the ASC. All FYFG students enrolled in the ASC finished the posttest MAI before the cutoff date. All FYFG students who signed the consent form to be class participants completed both the pretest and posttest MAI surveys, although one class participant, Chea, did not take the pretest (first) MAI during the week five class. Chea did complete the pretest MAI several weeks later. Because Chea's MAI responses did not match the timeline of other class participants' responses, the researcher decided not to consider Chea's MAI responses during analysis as they could create issues of reliability and/or validity. Another student, Emanuel, gave the same answer to all questions on the posttest MAI. As a result, Emanuel's MAI data were removed as an outlier. Thus, twenty-three class participants provided valid pretest and posttest MAI responses, which were considered during analysis. MAI pretest and posttest scores were stored behind a secure password in Qualtrics as well on two encrypted, password protected computer drives. This study's data analysis methods are discussed next.

Data Analysis

A mixed-methods approach was utilized to analyze data pertaining to participants' metacognition, meta-learning, and visual thinking/learning within an academic success class. A neuroeducation lens (e.g., cognitive psychology, neuroscience, and language) was used to assess and translate the data (Arwood, 2011; Dove, 2014; Perlovsky, 2013; Pulvermüller et al., 2014; Barsalou, 1999; Gallese & Lakoff, 2005; Palmiero et al., 2019, Van Dantzig et al., 2008). Research pertaining to metacognition/meta-learning/self-regulation and developmental literature on higher-order thinking helped interpret the themes recorded from language samples in the context of the ASC (Biggs 1985; Craig 1989; Efklides; 2006, 2009, 2011; Flavell, 1979; Fox & Riconscente, 2008; Kuhn; 2000). Table 3 aligns each research question with the participants, instruments, and methods used to investigate and identify change themes across time.

Table 3

Aligning Research Questions with Data Collection and Analysis

Research Question	Participant Group	Data Collection Instrument	Data Analysis Methods	Analyzed Across Time
RQ1 – Auditory or visual cognition?	Focal participants, *N* = 6	TEMPro Prompt in Pre-assessment	TEMPro functional language	N/A

			analysis (qualitative)	
RQ2 – Changes to metacognitive awareness during the ASC?	Class participants, *N* = 25	Metacognitive Awareness Inventory, 52 items (self-report questionnaire)	Paired samples *t*-test, Cohen's d (quantitative)	Pretest compared to posttest questionnaire
RQ3 (primary) – What changes occur to visual thinking/learning during the ASC?	Focal participants with validation from class participants, *N* = 25	Pre-assessment, class activities, and post-assessment	Template analysis and longitudinal analysis within a time-order matrix (qualitative)	Beginning point compared to mid-point, compared to endpoint
RQ3a – What do participants report about their previous experiences with learning?	Focal participants and class participants, *N* =25	Pre-assessment	Template analysis (qualitative)	Marked beginning point
RQ3b – What do participants report about how they learn?	Focal participants, *N* = 6	Pre-assessment	Template analysis (qualitative)	Marked beginning point
RQ3c - What do participants report about strategies they use that support thinking and learning?	Focal participants, *N* = 6	Pre-assessment	Template analysis (qualitative)	Marked beginning point
RQ3d – What meta-learning themes become apparent during the ASC?	Class participants, *N* = 25	Class activities (journal entry #6 and learning strategy assignment)	Template analysis (qualitative)	Marked mid-point

The data analysis methods in Table 3 are discussed next.

TEMPro Analysis

The TEMPro (Arwood & Beggs, 1989) was utilized to analyze participants language function and make a final determination based on the following criteria:

1) If there are one or more sequential propositions, the language is functioning for auditory cognition (i.e., participants are using the English language to form a proposition which explains their “typical day” clearly).
2) If the focal participant cannot establish propositions, he, she, or they, is not performing temporally and therefore has differences in language function.

Students with differences in language function are likely to represent ideas spatially and/or linearly which suggests they use a visual system for learning language (Arwood, 2011). To increase credibility in the findings, the researcher enlisted an expert in language function, Dr. Ellyn Arwood, to assess participants' language samples using the TEMPro. Dr. Arwood is one of the developers of the TEMPro instrument and conducted the initial research on its reliability. Dr. Arwood has reviewed thousands of children/students’ language function in clinical/educational settings. The researcher scheduled a time for Dr. Arwood to review focal participants language samples over Zoom. Dr. Arwood and the researcher reviewed each focal participants response to the TEMPro prompt, “What do you do on a typical day?” The review session was recorded via Zoom, to support trustworthiness of the analysis, and to revisit the session if needed.

The researcher also assessed participants’ language samples using the TEMPro protocol, independently. If Dr. Arwood came to different conclusions than the researcher, and the issues could not be resolved, a third party expert would have been enlisted to make a final determination. However, a third party expert was not needed as both Dr. Arwood and the researcher came to the same determinations. Both Dr. Arwood and the researchers’ findings were recorded in a research journal prior to writing up the results in this study. Language samples were evaluated using the following questions:

1. Is there a logical sequence of events? Does an idea refer to a preceding idea?

2. Do temporal words function to connect one idea to another through time?
3. Does the tense usage function to create a natural sequence?
4. Is there shared meaning without the listener making inferences?
5. Are there a minimum of three related ideas that are connected temporally to establish a proposition?
6. Does the student demonstrate any of the following semantic language errors?

MAI Analysis

The MAI is a 52-item self-report questionnaire developed by Schraw & Dennison (1994). Each question is related to a specific metacognitive domain, either *knowledge of cognition* or *regulation of cognition*. This study modifies the traditional 100-point rating scale to a 5-point Likert scale (Siegesmund, 2016; Siqueira et al., 2020; Terlecki & McMahon, 2018). Such a change is intended to assess metacognitive gains more accurately. Higher scores are related to higher metacognitive performance. The directions stated to, "Think of yourself as a learner. After reading each question, consider which of the five statements below generally applies to you as a learner (a student who is actively attending classes and learning in college). Choose the option that corresponds with your current approaches as a learner." Each number correlated to the following response:

- "1" means "I never or almost never do this as a learner"
- "2" means "I do this occasionally as a learner"
- "3" means "I sometimes do this a learner" (50% of the time)
- "4" means "I usually do this as a learner"
- "5" means "I always do this as a learner"

The researcher tabulated participants' pre- and post-scores, based on the scoring of each question. Group scores were tabulated in Microsoft Excel and imported into SPSS for analysis. Statistical analysis was performed (using SPSS), to assess mean differences (i.e., changes) in metacognitive awareness between pre- and posttest scores. The researcher utilized quantitative analysis methods to determine significance in metacognitive awareness gains based on the intervention (e.g., academic success course) and to measure effect size. Gains in metacognition were calculated by finding the ratio of the actual average gain divided by the maximum possible average gain (post-MAI score % – pre-MAI score %)/(5 – pre-MAI score). Hake (1998), states this formula offers "consistent analysis over diverse student populations… (and provides) a rough measure of the effectiveness of a course in promoting conceptual understanding" (p. 64 & 66).

Utilizing the pretest and posttest MAI surveys in conjunction with the ASC provided a way to measure metacognition in the broader class participant group, while staying within the bounds of the study. The inclusion of a validated quantitative measure for metacognition was intended to provide further substantiation and validation for the phenomena under study. Analysis of the MAI began after week 15 and concluded before the language analysis was conducted. Analysis of MAI scores were used to help layer understanding of the themes discovered using template and longitudinal analysis and thus, helped to answer research question two (RQ2) and substantiate answers to research question three (RQ3). The next section focuses on the utilization of template analysis.

Template Analysis

Template analysis is often utilized to analyze individual interview transcripts and define significant themes across cases (Brooks et al., 2015; Versteeg et al., 2021). Template analysis is suitable to this methodology, as the research is focused on contextualized theoretical implications of the data, as it pertains to neuroeducation, metacognition, and first-generation research (King & Brooks, 2016). Data were interpreted based on metacognitive theory and the neuroeducation theoretical framework (Chapter 2). The development of a priori themes in advance of the study allowed the researcher to produce a codebook (Appendix L), to evaluate data based on specific theoretical criteria (Brooks et al., 2015). A priori themes were used to categorically assess metacognitive and meta-learning phenomena. A priori themes, however, were considered tentative and did undergo a process of examination and modification during analysis (King & Brooks, 2016). Maintaining flexibility in regard to a priori themes, allowed the researcher to code the data effectively and explore alternative concepts and the relationships between concepts comprehensively.

Five separate rounds of language coding from two separate interviews, and two class activities, were utilized to investigate themes primarily related to visual thinking/learning during the study. Participants' language samples were coded using template analysis, which provided a flexible means of developing and modifying a priori themes, as well as searching and identifying frequent threads across multiple interviews (King & Brooks, 2016). The researcher utilized various coding methods within the template analysis framework to identify codes that related to the research questions. Initial, structural, and provisional (a priori) coding were integrated into the preliminary coding phase of template analysis to break down, examine, structure, and compare codes before clustering codes into themes. Codes were structured into specific content or conceptual categories based on the categorical sections of the pre- and post-assessment (MacQueen et al., 2008; Namey et al., 2008). Several categories were inductively coded, while others adapted over time, and were therefore, deductively coded. Structural coding helped to align the large data set with the research questions. Initial and structural were also conducted on two written class activities involving class participants in the ASC (*N* = 25, including 5/6 focal participants) (Saldaña, 2021).

Clustering was undertaken using the rationale for pattern analysis (Saldaña; 2021; Stake, 1995). Utilizing pattern coding, the researcher arranged focal participants' codes into hierarchical groups with overlapping meaning. Each grouping was examined for accuracy and compared to analytic memos before the researcher determined groupings as "themes." Themes were arranged into templates hierarchically, which represented conceptual relationships between themes (King & Brooks, 2016). Each theme underwent a second round of provisional coding before templates were finalized. Three separate templates were created, which corresponded to three points in time: 1) a beginning (pre-assessment with focal participants), 2) a mid-point (class activities with class participants), and 3) an end (post-assessment with focal participants).

Following the development of a priori themes, based on the recommendations of King & Brooks (2016) the researcher, 1) reviewed the transcripts and case summaries multiple times to become familiarized with the data; 2) developed preliminary codes and recorded data that matched a priori themes; 3) clustered emerging and a priori codes into meaningful categories and ordered them hierarchically; 4) produced an initial coding template – an arrangement of themes which displayed the hierarchical organization of themes, 5) created a more developed template after a second round of provisional (a priori) coding, and comparisons to case summaries and observational notes; 6) finalized the template after reviewing all language samples; and 7) wrote findings from template analysis separately, focusing on the meaning of specific themes and relationships between themes.

A Priori Themes. Because this study assessed changes to visual thinking and learning (involving knowledge, strategies, and dispositions) in an academic success course, it was imperative that a priori themes be operationalized to qualify FYFG students' thinking and learning. Top-level a priori themes included in the codebook are *metacognitive processes (i.e., phenomena)* and *cognitive processes*, as it was important to distinguish between metacognition and other types of cognition up front (see Appendix L for codebook). *Metacognitive processes* (i.e., phenomenon) are defined in terms of discourse that reflects thinking about cognitive phenomena, including the assignment of meaning to cognitive phenomena while learning. The domains of metacognition were coded as sub-themes in the codebook. Metacognitive processes (apart from metacognitive confidence) can be taught conceptually (Versteeg et al., 2021); thus, their inclusion in the codebook, to interpret *meta-learning* was logical.

First-level sub-themes in the codebook are *metacognitive knowledge*, *metacognitive regulation*, and *metacognitive experiences*. Second-level sub themes include *metacognitive strategies*, *metacognitive skills, visual thinking, meta-learning,* and *metacognitive confidence*. Flavell (1979) states that knowledge that is 'metacognitive', is not fundamentally different from knowledge that is cognitive, rather metacognitive knowledge is activated because of 'conscious memory search' to meet a specific task demand and/or goal. Metacognitive knowledge (MK) is a product of learning about cognitive processes, primarily as it relates to one's own previous learning experiences (Wenden, 1998). Metacognitive regulation (MR) is how we control thinking to facilitate learning (Stanton et al., 2015), represented by knowledge of deliberate actions (e.g., strategies) to support learning (Saricoban, 2015). Metacognitive skills (MetSkills) are identified by deliberate thinking and/or learning strategies (e.g., orienting, planning, monitoring, and evaluation) that can be used to regulate cognition (Efklides, 2011, Veenman &

Elshout, 1999; Versteeg et al., 2021). The researcher distinguished MetSkills from MR by assessing whether learning strategies were, a) deliberate, b) recurrent, c) effective, and d) based on one's learning/meta-learning.

Metacognitive experiences (ME) such as confidence, are described as conscious feelings or judgements that arise "any time before, after, or during a cognitive enterprise" potentially in learning situations that require "highly conscious thinking (Flavell, 1979, p.908)." Because some questions in the metacognitive assessments refer to learning tasks, these questions may conjure in-task 'feelings'; therefore, the researcher included *metacognitive experiences* as a sub-theme to capture affectual aspects of metacognition.

The sub-themes *visual processing, visual thinking* and *visual learning* were used to compare data coded for metacognition to assess whether FYFG students had an awareness of various thinking/learning processes and whether they used strategies that supported the ways they learned best (as indicated by the TEMPro analysis and template analysis). These metacognitive and neuroeducation domains are considered 'hard' a priori themes, meaning they are well developed based on the literature review and the instrumentation (King & Brooks, 2016). Sub-themes that fall under the a priori theme *cognitive processes* include, 1) *cognitive knowledge*, which are knowledge, beliefs, perceptions and/or memories outside the metacognitive domain; 2) *dispositions towards learning*, an umbrella theme for sociocognitive aspects of self-regulation, such as affect, motivation, volition, self-efficacy, and self-concept; and 3) *behaviors*, such as strategy-use, forethought, and self-reflection (Bandura, 1986, 2001; Efklides; 2011).

Based on the article by Jackson (2004), *meta-learning themes* can be defined as *thinking about one's learning and thinking processes*, as well as strategies, skills, dispositions, and other self-regulatory behaviors that help students monitor and control their learning. Meta-learning, in terms of coding can therefore be categorized as cognitive and metacognitive phenomena that capture the knowledge, thought processes, dispositions (i.e., attitudes, habits, motivation, volition), and behaviors related to one's learning processes (Jackson, 2004). Identifying meta-learning themes during analysis would be one indication that students have developed knowledge for their learning during their time in the ASC, which would help answer RQ3d, and could be a precursor to 'changes' to visual thinking/learning, which would help answer RQ3. See Appendix L for descriptions of other a priori themes.

Processes for Coding, Within-case Analysis and Longitudinal Analysis

Three types of qualitative analysis were employed to code and interpret themes inherent in language samples to answer RQ3 and its sub-questions, 1) template analysis (King & Brooks, 2016), 2) within-case analysis using time ordered matrices (Miles et al., 1994), and 3) longitudinal analysis using criteria from Saldaña (2003; 2021). The TEMPro analysis protocol, was also utilized to answer RQ1 (Arwood & Beggs, 1989). Template analysis was used as the primary method to deduce themes (from written texts and spoken transcripts) during the case study. Template analysis allowed for a balance between inductive and deductive coding methods to investigate new themes while integrating established theoretical and conceptual frameworks (King & Brooks, 2016). Within-case analysis using displays or "matrices" were a valid way to draw and verify descriptive conclusions about the phenomenon under study between coding phases (Miles et al., 1994). As Miles et al. (1994) summarized, "You know what you display (p.91)." Lastly, Saldaña's criteria for longitudinal analysis, when integrated into a time order matrix, allowed the researcher to visually examine and identify change processes/events across time. The three iterative phases of qualitative analysis helped to triangulate the relational aspects of metacognition and visual thinking/learning to help answer RQ3 and its sub-questions.

The first round of analysis was conducted on language samples collected from question one of the pre-assessment. The researcher assessed participants' language samples for time-based propositions in the English language using the TEMPro analysis protocol to determine if students used visual or auditory cognition to speak about a "typical day." The second round of analysis was conducted with language samples collected from a pre-assessment the fifth week of the ASC, a post-assessment collected the 15th week of the ASC, and two class activities collected the ninth and tenth weeks of the ASC. Transcribed interview data was broken down into discrete parts using Saldaña's (2009) criteria for initial coding. The researcher utilized the Quirkos data analysis software to catalogue codes, take analytic memos, and arrange codes into themes. Structural coding was used to arrange codes into conceptual categories that represented sections of the pre- and post-assessment (MacQueen et al., 2008). Process codes were utilized for learning strategies and metacognitive behaviors, allowing the researcher to better track actions and behaviors across time (Saldaña, 2003; 2021). Codes were correspondingly given descriptive language, primarily based on the participants' own language within the study's conceptual framework, to better represent dynamic processes at latter stages of coding and analysis (Saldaña, 2021).

The researcher engaged in provisional (a priori) coding using research-based criteria established beforehand (Saldaña; 2021), which helped to assess codes for metacognitive phenomenon (see Appendix L for Codebook). This stage became a reflective process in which the researcher examined each code for meaning/understanding, and then labeled each code for the top-level a priori themes "cognitive processes" or "metacognitive processes," along with sub-themes that matched criteria in the codebook. Initial and provisional codes for each focal participant were then placed into conceptually clustered matrices (Miles et al., 1994), and arranged into rows based on when the data was submitted - beginning (pre-assessment), middle (class activities) and end (post-assessment). Relevant quotes from the pre- and post-assessment interviews, as well as member check interviews were inserted into cells to provide contextualization for more in-depth analysis. Analytic memos were derived by comparing codes within and across conceptual categories over the duration of time outlined in each matrix. Additionally, the researcher utilized Saldaña's (2003; 2021) criteria for longitudinal analysis (e.g., constant, cumulative, decrease, emergence, turning point) within matrices to assess changes in behavior and knowledge across time. Observable changes for each participant were captured within each matrix. The matrix helped to permeate the large data sets by allowing for systematic comparisons, identification of patterns/themes, and analytic notations (Miles et al., 1994).

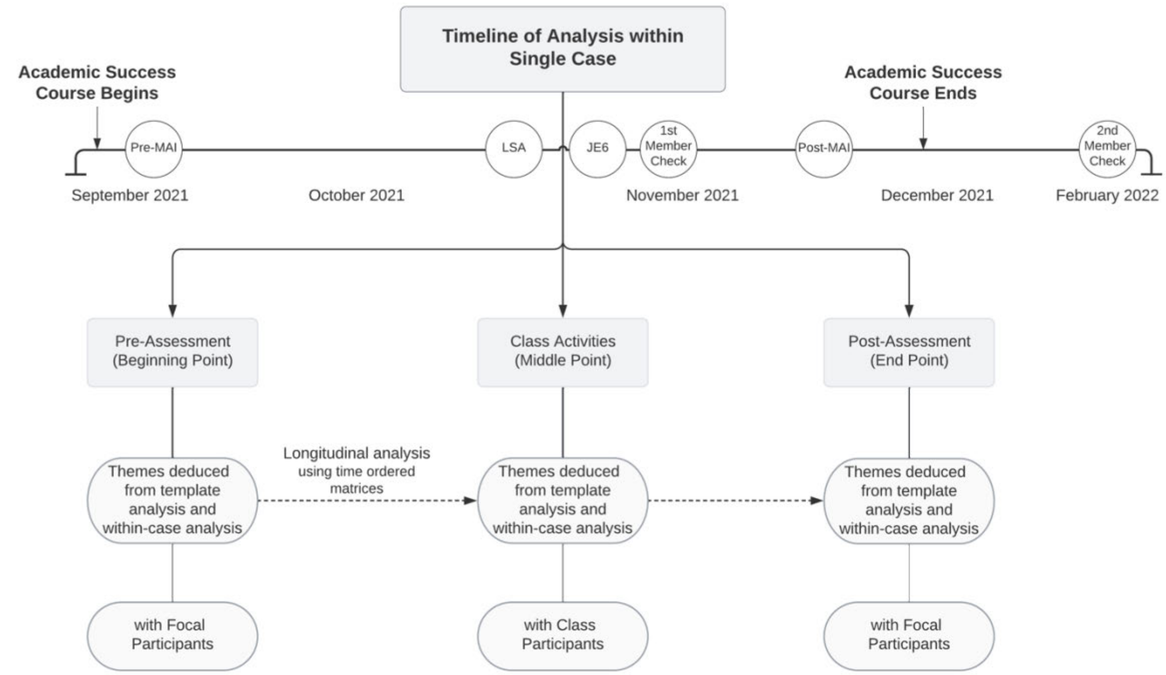
In the third round of analysis the researcher utilized pattern coding (Saldaña, 2021) to compare codes within and across structural categories and cluster codes into themes that applied to the focal participant group as a whole. Pattern coding was conducted first for the focal participants' who participated in the pre-and post-assessment, then for the class participants who participated in the class activities. Provisional coding was utilized again, based on the same criteria used to assess focal participants' codes, for focal and class participants' themes. Provisional coding allowed the researcher to identify each theme as cognitive or metacognitive phenomena, supporting determinations of whether themes could be constituted as metacognitive knowledge, metacognitive regulation, metacognitive strategies, metacognitive skills, etc.

In the fourth round of analysis, themes deduced during template analysis were arranged into three separate templates, which represented three points in time: 1) a beginning (pre-assessment with focal participants), 2) a mid-point (class activities with class participants), and 3) an end (post-assessment with focal participants). All themes were given descriptive names as suggested by Saldaña (2003) and provisional descriptors (metacognitive and/or cognitive acronyms associated with the theme). Themes were arranged as hierarchical structures, which represented the relationships among various themes in each template (Kings & Brooks, 2017). In conducting the final interpretations of the three templates, the researcher, 1) created an account of every theme in each template, 2) developed a synthesized account of the template overall, and 3) gave prioritization to those themes that were mentioned most, were most relevant to the study, and/or were perceived as profound (Kings & Brooks, 2017).

Change requires at least two time-based reference points (Saldaña, 2003). The pre-assessment, class activities and post-assessment templates were each treated as a time-based reference point, which helped effectively infer relationships amongst themes across time. For instance, the researcher utilized the pre-assessment as a baseline for participants' knowledge (i.e., awareness), strategies, dispositions, and skills coming into the ASC. This baseline was then compared to themes that emerged across two additional reference points (also taking into consideration analytic memos and case summaries) using longitudinal criteria (Saldaña 2003; 2021). Figure 3 shows a timeline of events within the bounds of this single case, giving priority to the pre-assessment, class activities, and post-assessment as reference points in longitudinal analysis.

Figure 3

Timeline of Data Analysis within Single Case



Note. The ASC started on August 27, 2021, and the last day of class was Nov. 30, 2021. Another note. JE6 and the LSA make up the mid-point of the study and are referred to as the "class activities." Last note. JE6 = Journal entry #6, LSA = Learning strategies assignment, Pre MAI = pretest-Metacognitive awareness inventory, Post MAI = posttest-Metacognitive Awareness Inventory.

The line at the top of Figure 3 represents a timeline of important events and instruments used in the context of the case study. The line underneath represents the instruments involved in analyzing change over time. As illustrated in Figure 3 themes deduced in template and within-case analysis were used as reference points for longitudinal analysis. After the fourth round of analysis and five cycles of coding (initial, structural, pattern and two rounds of provisional), the researcher utilized Saldaña's longitudinal criteria, (2003; 2021) to compare/contrast themes from the three separate templates. The following criteria from Saldaña (2003; 2021) were structured into cells within a time ordered matrix to deduce themes that showed change during the course of the ASC.

a) Emerge (i.e., increase): What emerges through time? This criteria documents change that occurs in smooth and average trajectories.

b) Cumulative: What is cumulative through time? Cumulative effects result from successive experiences across a span of time, such as improved technique or acquired knowledge (i.e., same, or similar but improved).

c) Turning Point: What turning points occur through time, if any? These types of changes result from experiences of sufficient magnitude that they significantly alter the perceptions and/or life course of the participant.

d) Decrease: What decreases or ceases through time? Like increases, qualitative decrease cells can include both quantitative and qualitative summary observations.

e) Constant (i.e., consistent): What remains constant through time? This is often the largest cell since the cell is tracking recurring and regularized features of experience Lofland et al., 2006)

The above criteria do not represent all criteria of longitudinal analysis but rather the criteria that were relevant to this study which assessed change over a shorter duration (approximately 10 weeks) than many longitudinal studies (Saldaña, 2003).

Themes from the pre- and post-assessment, as well as the class activities were arranged into a matrix based on criteria for arranging time-ordered matrices to assess *change* (Miles et al., 1994). As King & Brooks (2016) suggest, the themes were structured in a way to “capture the temporal dimension of the data” by indexing all codes to “…the time point to which it relates…", so the researcher could examine whether and how patterns of themes changed over the course of the study (p.11). Saldaña's (2003; 2021) longitudinal criteria (listed above) was used to analyze themes across time and determine "change themes," i.e., synthesis of themes representing the primary changes of focal participants, based on focal/class participants responses over time. Themes were analyzed across time for each focal participant and analyzed as a group which helped deduce and corroborate interpretations. Class participants responses in the class activities helped to substantiate changes occurring at the mid-point of the study.

Time-ordered matrices helped the researcher to visualize the origin, flow, and connection of participants' assigned meanings (e.g., behaviors, and knowledge) across time (Miles et al., 1994). The matrices also helped the researcher track which themes were mentioned consistently, by which participants, as well as those changes that became prominent (discussed by at least half of focal participants in response to specific questions/sections) across time. At this fifth stage of analysis, meta-learning themes identified at the mid-point and end of the ASC were compared to potential changes to visual thinking and learning (e.g., knowledge, strategies, and dispositions) over the duration of the semester. Two additional (within-case) matrices were generated to reduce/synthesize several dozen pages of analysis into single-page, time-ordered displays, which supported final interpretations (Miles et al., 1994). The researcher distilled the most essential themes related to the research questions into the displays for the researcher's understanding as well as others. The researcher details in Chapter 5 how the methodological approach in this study extended the researcher's understanding of the qualitative data and led to the interpretation of participants' experiences. The following section lists the foreshadowed problems that the researcher posed ahead of the data analysis.

Foreshadowed Problems

Posing foreshadowed problems is described by Stake (2003) as way for the researcher to focus on issues that may serve as a point of emphasis during analysis. Therefore, the researcher recognized the following issues which are informed by literature and initial observations of the learning environment:

1) Learning styles (e.g., preferences) are still taught in many schools. If participants use learning styles, do they represent these ideas as being helpful to their learning? These perceptions may interfere with ideas of visual thinking and learning from a neuroeducation approach.
2) First year students have been reported to have had minimal interaction in meta-learning (i.e., metacognitive) environments. Students with limited metacognition for their visual thinking may need forms of meta-learning (i.e., learning about one's learning processes) to make use of their visual thinking. It will be a focus of this research to investigate whether there are connections to participants' meta-learning and visual thinking.
3) Drawing can be a rewarding but time-intensive process. Another foreshadowed problem is whether FYFG students find drawing to be too time-consuming for practical use.
4) Because the instructor, students, and researcher wore facemasks in class to ensure safety in response to COVID-19, it will be a point of emphasis to see if this issue comes up in discussions and contributes to difficulties in learning or has any socioemotional implications.

The above issues were explored during the data analysis as potential factors impacting the study. The following section will list the limitations of this study.

Limitations

There are potential limitations to the utilization of template analysis in this study which should be addressed. While template analysis provided an effective and flexible means of analyzing interview transcripts across time, the utilization of a priori themes may contribute to some loss in the experiences that students represented (Brooks et al., 2015). To account for such limitations the researcher utilized full quotes of students in Chapter 4 and recorded analytic memos at multiple stages of analysis. Another limitation to this study, pertains to the inability for the researcher, nor experts, to assess students' language function level prior to participation in this study. Thus, it was difficult to ascertain if students had any language and/or learning disorders that may have impacted their learning in this case. Learning/language disorders could also impact findings of the TEMPro analysis. To guard against this limitation, the researcher asked participants to fill out a voluntary form that offered information about learning designations (or disorders) that may have been ascribed to them during their education (Appendix D). Designations are discussed in Chapter 4. Lastly, the inclusion of a limited sample size (N=6), could lead one to reasonably argue that the findings cannot be applied to a broader first-generation population. However, Smith et al. (2009) states that when studies capture participants' experiences transparently and in great detail, a researcher can reasonably apply the findings to alternate contexts. The utilization of the MAI, with a broader participant group, is additionally meant to safeguard against such limitations. The next section discusses the ethical considerations of the study.

Ethical Considerations

The researcher designed the interview questions so they would not lead subjects to an answer but allow them to freely share their thoughts. Ives & Castillo-Montoya (2020), suggest that researchers who want to support first-generation students as *learners* utilize instruments that take advantage of first-generation students' *strengths* rather than their *deficits*. Thus, first-generations students should be given opportunities to speak about their own lived experiences. Therefore, several of the interview questions in this study focused on students' education experiences and provided visual (story-based) context to previous experiences to allow for better understanding of the question/s. The researcher took care not to demoralize students nor lead them to an answer which might have distorted their experiences and thoughts.

The researcher reviewed a history and overview of the Belmont report, and applied its recommendations where applicable, to this study (Miracle, 2016). The researcher took care to respect all participants in this study and ensured the research was conducted in beneficence (support) of each student and their education. The researcher ensured students were provided with the intended purpose of the study, important events, as well as participant's role in the findings and an assessment of the risks and benefits. All participants were then required to give their informed consent through digital signature (Appendix C).

All participants' anonymity in this study was protected by keeping transcripts and findings in secure, password protected, and encrypted locations. The researcher will additionally utilize member checks (Appendix G) to ensure all participant responses are recorded and transcribed accurately. Lastly, the researcher sought and received international review board (IRB) approval to conduct the study early in the Fall semester of 2021. The IRB found that the rights and welfare of research subjects were appropriately considered in this study.

Potential Challenges

A difficulty of this research was assessing/identifying the difference between metacognitive and cognitive phenomenon. In other words, it was challenging at times to assess whether participants used their language to represent their cognition. To confront this foreseen challenge, the researcher utilized follow up questions that asked "how" and "why do you do that" in relation to a learning or thinking strategies to better understand how aware participants were of their thinking and learning and how their strategies followed from that awareness. Follow-up questions sometimes provided answers that more clearly represented the ways in which participants understood their thinking and learning, so that the researcher could better interpret/deduce themes during analysis. Additionally, the researcher developed definitions of various metacognitive phenomena based on metacognitive theory (see Appendix L for codebook). The researcher strictly adhered to these definitions when coding language samples.

Role of the Researcher

Braun and Clarke (2006) state that thematic analysis techniques (e.g., template analysis) can be used across a broad spectrum of studies but researchers should explain their epistemological assumptions in advance so that the theoretical underpinnings of the chosen methodology can be followed. In keeping with this recommendation, the researcher takes a limited realism or subtle realism (Hammersley, 1992) approach into the research. This means that the researcher believes that an objective reality exists, but humans cannot perceive this reality, because our perceptions are shaped by sociocultural experiences which makes our viewing of the world subjective. Therefore, the researcher holds a constructivist epistemology in parallel with a realist ontology (King & Brooks, 2016). What that means in the context of the research, is that any interpretation of the data is never fully objective because the researchers' positionality within the study affects the findings. Therefore, when analyzing the data, the researcher will go through a process of reflexivity, in which all assumptions based on previous experiences and understandings are bracketed outside of the researchers' decision-making within the study. Such a process will allow for the closest estimation of participants' 'real' experiences and understandings.

The researcher occupies several roles within the bounds of this case study. First, the researcher occupies the role as the author of this study, thus bias must be accounted for, so the other roles have limited impact on the researchers' interpretation of the data. The second role the research occupies is the interviewer of FYFG students in the pre- and post-assessment. Because of the amount of detail that an individual would need to understand about the neuroeducation theoretical framework, and the instruments involved, the researcher is best positioned to occupy the interviewer role. The researcher occupies a third role as co-curriculum designer of the academic success course. The researcher helped to design the curriculum, partly for this study, and to help FYFG students develop strategic ways of thinking and learning, among other objectives. Lastly, the researcher occupies a role as a guest-instructor in the academic success course. The researcher, occupying the role of guest instructor, facilitated five classes on learning and thinking, leading the discussion/activities in three weeks, and introducing/bookending guest speakers (also specialists in neuroeducation) the other two weeks. As guest instructor, the researcher also offered insights to the primary instructor about class ongoings throughout the course. The researcher thus, had a vested interest in the learning objectives of the class as the co-curriculum designer and guest instructor. This positionality made the process of bracketing and enlisting the help of an expert to analyze the findings of the TEMPro prompt all the more important. The next section discusses how the researcher took strides to ensure trustworthiness and efficacy in the data collection and analysis phases, so the study is able to inform future practice and research.

Trustworthiness

A *quality* approach to qualitative research is founded on specific criteria that the researcher establishes prior to the study to ensure results can be trusted (Korstjens & Moser, 2018). To establish trustworthiness in this study, the next sections document the steps taken to meet the specific criteria put forward by Lincoln & Guba (1985): credibility, transferability, dependability, and confirmability.

Credibility

Credibility is the confidence one can place in the findings based on how accurately the phenomenon under study is captured (Korstjens & Moserz, 2018). To establish credibility in the methodology, the researcher triangulated data utilizing multiple methods and sources of data collection (the TEMPro, two separate semi-structured interviews, two reflective class activities, visual examples, and the MAI assessment). Triangulating data, means integrating at least three data sources, to provide a more fully formed depiction of the data, so that plausible interpretations can be drawn (Creswell & Poth, 2018). Prior to the collection of data, the researcher engaged in a process of reflexivity through bracketing, to develop an awareness of any assumptions or bias the researcher carried into the study, based on the role the researcher occupied as co-designer of the curriculum (Glaser, 1992).

Bracketing was incorporated through monthly writings in a research journal which allowed for self-reflection, and examination of any preconceptions that might influence decision-making (Creswell & Poth, 2018). The researcher developed the mindset that the ASC was a learning experience and any deficiencies or accomplishments in the curriculum as it related to progress with FYFG students, would result in experiences that would help first-generation research. This mindset helped the researcher separate himself from the other roles he occupied in the ASC. The researcher conducted the interviews and analyzed the data with an open mind and continually checked in on his mindset throughout the analysis process to ensure the changes he reported were accurate.

To establish a more fully developed conception of the phenomenon under study the researcher observed participants in 12 of 13 weeks the ASC was in session (total of 13 classes, over 15 weeks). This involvement with participants allowed for prolonged engagement and persistent observation (Korstjens & Moserz, 2018). Detailed notes were recorded in a research journal to ensure the class learning environment was well-contextualized and that participants' experiences were captured. The research journal additionally allowed for contextualization of the researcher’s thoughts and feelings as it related to the study as well as any challenges faced. To limit bias, the researcher employed an expert in language function to assess participants’ language samples with the TEMPro analysis protocol.

To increase comprehensiveness and comparability between the pre-assessment and post-assessment, the questions asked of participants were designed to evoke similar thought processes, so an accurate assessment could be made of any changes that occurred during the study (in the context of the ASC). This strategy was built into the design of the interview questions and helped to reduce interviewer bias (Patton, 2002). Lastly, the researcher incorporated member checks (Appendix G) on all interview transcriptions to ensure accuracy and completeness of participants’ responses (Merriam, 1998). According to Lincoln & Guba (1985) member checks are one of the most critical aspects for establishing credibility in a qualitative study.

Transferability

The parameters of this single-case, mixed methods study are highly specific and contextualized. To increase trustworthiness the researcher provided detailed accounts of the ASC curriculum, the focal participants involved, the interview processes, the instruments utilized, and the data analysis, so that a reader may reasonably assess whether the findings are transferable to different settings (Merriam, 2009). Given the role of the researcher as a co-curriculum designer, who established meta-learning objectives for the class, the researcher had a degree of impact on the findings. To account for this impact, the researcher documented involvement in the classroom setting (in Chapters 3 and 4 as well as Appendix A), so that a reader can judge the potential influence the researchers' role had on participants' responses and whether the findings are applicable in specific contexts (Shenton, 2004). Additionally, the researcher took analytic memos between several coding phases to ensure transparency in interpretation of the data (Creswell & Poth, 2018). It should still be noted however, that the transferability of this study is constrained, given the limited number of participants, the focus on their individual experiences, and the nature of the researchers' role in the study.

Dependability

Trustworthiness also involves the aspect of dependability, which relates to establishing consistency and transparency in the decision-making process, based upon the standards of a specific research design and the rationale for using said design (Merriam, 2009). To establish dependability the researcher utilized an audit trail, made up of analytic memos, curriculum documents, weekly (recorded) debriefing videos with the instructor, and research journal entries that focused on bracketing processes and observational notes at all stages of the research process (Korstjens & Moserz, 2018). The researcher had the mindset that a reader should be able 'see' and understand the interpretation processes of the researcher, so that the study could be re-created in a separate context.

Confirmability

Confirmability relates to the extent another researcher could confirm the results of a study are based on how the data was interpreted (Merriam, 2009). To account for confirmability, the researcher implemented, 1) detailed analytic memos that captured interpretations of the data throughout the various phases of coding; and 2) research journal entries that captured reflections of the data and the bracketing process so that the researcher reached a level of awareness about the phenomena under study that helped to represent the data accurately and impartially (Korstjens & Moserz, 2018).

Summary

This chapter provided the research methods and design chosen to study changes to FYFG students visual thinking and learning in an academic success course. RQ3 asks, "What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?" RQ3 and its sub-questions were investigated through five phases of language coding and five rounds of qualitative data analysis. The pre- and post-assessments as well as the class activities were analyzed using template analysis, time ordered matrices, and longitudinal analysis (King & Brooks, 2016; Miles et al., 1994; Saldaña 2003; 2021), helping answer RQ3 and its sub-questions. The TEMPro analysis protocol was also utilized to assess visual or auditory cognition, which answered research question one (RQ1) (Arwood & Beggs, 1989). Finally, pretest and posttest MAI surveys were utilized to measure potential gains to metacognitive awareness (for learning processes and strategies/skills) within the context of the ASC, which answered research question two (RQ2).

The researcher sought to understand how focal participants understood and used their visual thinking in learning contexts over time, by assessing how they (metacognitively) assigned meaning to their thinking with language. To that end, semi-structured interviews, reflective journal entries, and class activities collected during the ASC, in addition to statistical analysis of the MAI, allowed the researcher to assess whether meta-learning had meaningful changes to students' visual thinking and learning.

When participants share their own experiences of thinking and learning, their language becomes a tool for enacting metacognitive and socio-cognitive phenomena (Arwood, 2011). Therefore, the metacognitive assessments (i.e., pre-, and post-assessments) in this study used language to analyze focal participants' *awareness, knowledge,* and *control* of their visual thinking in learning contexts, and simultaneously participants' educational/learning experiences. Some of these experiences were explicitly addressed in the interview questions and were intended to evoke focal participants' metacognitive knowledge. Template analysis was employed to code, analyze, and interpret prominent themes in students' language samples. Metacognitive processes discussed in the literature were aligned with themes discovered in participants' responses, particularly during two rounds of provisional coding, which helped ascribe labels to metacognitive phenomena. Longitudinal analysis within time order matrices provided a means to display and assess changes to visual thinking/learning across three reference points spanning approximately 10 weeks of the ASC.

Based on findings detailed in Chapters 1 & 2 that suggest undergraduates often lack metacognitive competencies, the researcher anticipated that most participants would lack a metacognitive awareness of their visual cognition. A developed awareness for one's visual cognition (or thinking) would mean that participants recognize they represent (i.e., think about) ideas visually and can use the visual properties of language and specific strategies to 'see' their conceptual thinking (Arwood, 2011). Therefore, using visual thinking for learning means that students use mental imagery to construct, layer, and/or integrate meaning to learn conceptually and/or self-regulate their learning. Results of this analysis may substantiate that students with visual thinking find forms of meta-learning helpful to make use of their visual learning system. Findings of this research are intended to extend the literature on meta-learning, metacognition, visual thinking (cognition), and the ways FYFG learners use strategies to learn conceptually.

Chapter 4: Results

The purpose of this mixed-methods study is to investigate how first year, first-generation undergraduate college students at a private, liberal arts university in the pacific northwest, metacognitively assess the way they think and learn, and what changes occur to their visual thinking and learning processes in the context of an academic success class with a focus on meta-learning.

This mixed-methods study had five objectives: (a) identify the learning systems of participants by analyzing language samples for temporal propositions (b) quantify the extent of metacognitive gains in the academic success course, (c) qualitatively report how students metacognitively assess their own learning and learning strategies, (d) qualitatively discuss meta-learning themes that emerge in an academic success course with first year, first-generation students and, (e) qualitatively identify and discuss changes that occurred to first year, first-generation students' visual thinking and learning. The operational definition of “change” in this study is cumulative, consistent, and/or emergent themes that appear in focal participants’ responses (i.e., language) over time, that indicate positive difference and/or growth of said themes (Saldaña, 2021).

The following chapter presents the results of quantitative and qualitative analysis conducted using data gathered from interviews, surveys, class assignments, and artifacts (i.e., examples of participants’ strategies). Typed transcripts are used throughout this chapter to support the results. Sub-questions are addressed first, followed by a synthesis of the key findings to answer the primary research question.

Role of the Researcher

The researcher taught, facilitated, and co-designed the curriculum for five classes, designated the ‘learning and thinking block,’ with the ASC. The five classes, which lasted from weeks five through ten of the 15-week course focused on facilitating FYFG students’ meta-learning through application and reflection of learning/learning strategies within an NsLLT framework. As an educational practitioner, with a focus in neuroeducation, the researcher sought to understand, 1) how FYFG students in the ASC thought about their learning upon entering college, 2) what they learned about their own learning/thinking processes while enrolled in the ASC, 3) what changes occurred during their first semester in college, and 4) how their meta-learning may have impacted those changes.

Given the role of the researcher as a guest instructor and co-curriculum designer, who established meta-learning objectives for the class, the researcher will have a degree of impact on the findings. To establish trustworthiness, the researcher utilized an audit trail, made up of analytic memos, curriculum documents, class observations and research journal entries that focused on clear interpretative processes at all stages of data collection and analysis (Korstjens & Moserz, 2018). To increase comprehensiveness and comparability between the pre-assessment and post-assessment, the questions asked of participants were designed to evoke similar thought processes within specific sections, so an accurate assessment could be made of what changes occurred during the ASC. This strategy was built into the design of the interview questions and helped reduce interviewer bias (Patton, 2002). Lastly, the researcher incorporated member checks on all transcriptions to ensure accuracy and completeness of all participant responses (Merriam, 1998). The following section addresses participation in the research.

Participation

Twenty-seven students originally consented to participate in the *class portion* of the study. Consenting to the class portion means that students agreed to have their journal entries, (MAI) surveys, exercises, and class assignments be used for the purposes of this research. Two students were later removed from consideration due to reasons detailed in the Demographic Information section below. Table 4 shows the distribution of involvement in the study for each participant.

Table 4

Students' Participation in Study

No.	Pseudonyms	Interviews	MAI	Class
1	Abby	x	x	x
2	Alena		x	x
3	Ana		x	x
4	Ashley	x	x	x
5	Cathleen		x	x
6	Chea*			x
7	Coreen	x	x	x
8	Dalisay	x	x	x
9	Daniel	x	x	x
10	Eduardo		x	x
11	Efrain		x	x
12	Eli		x	x
13	Emanuel*			x
14	Francisca		x	x
15	Kai		x	x
16	Kalani		x	x
17	Lilly*	x		
18	Lucía		x	x
19	Luna		x	x
20	Makaio		x	x
21	María		x	x
22	Melia		x	x
23	Miguel		x	x
24	Renzo		x	x
25	Valentina		x	x
26	Valeria		x	x

Note. *Emanuel answered "I always do this" to all questions in the second MAI. As a result, his MAI data were considered an outlier and removed during analysis. *Lilly consented to participating in interviews only, not the class portion of the study. *Chea took the 1st MAI too late to be considered a pre-assessment. As a result, her MAI data were removed from consideration during the analysis.

As shown in Table 4, 25 students agreed to participate in the class portion of the study and 2 students were removed from the MAI analysis (only). One student consented to the class portion of the study after the ASC had concluded but analysis had begun, so their responses were not considered. Six students agreed to participate in pre- and post-assessment (semi-structured) interviews and one student, Lilly, participated in the interviews but not the "class activities" portion of the study. The six students who participated in the interviews were assessed for changes over the course of the semester, and are therefore, termed the "focal participants."

Demographic Information

All students who enrolled in the academic success course identified as "first year, first-generation." Two students who agreed to participate in the study did not qualify for inclusion. One student did not qualify because it was later found this individual did not identify as "first-generation," and the second student dropped out of the class near the end of the semester. As a result, these students' data were removed from all subsequent analysis.

The online survey instrument used to gain participant consent also asked for demographic information. Demographic results are broken down by student in Table 5.

Table 5

Demographic Information and Spoken Languages of Participants

No.	Participant	First Language Learned	Primary Language to Communicate	Ethnic/Racial Identification	Gender Identification
1	Daniel	English	English	White and Asian	Male
2	Renzo	English	English	Latinx	Male
3	Eli	English	English	Latina	Female
4	Eduardo	Spanish	English	Latinx	Cis-Male
5	Francisca	Spanish	English	Latina	Female

6	Ana	Spanish	English	Latina	Female
7	María	English	English	Latina	Female
8	Lucía	English	English	Latina	Female
9	Kalani	English	English	PI and/or NH*	Female
10	Luna	English	English	Latina	Female
11	Efrain	Spanish	English	Latino	Male
12	Abby	English	English	Asian	Female
13	Dalisay	Tagalog	English	Asian	Female
14	Emanuel	English	English	Latino	Male
15	Miguel	Spanish	English	Latino	Male
16	Kai	English	English	PI and/or NH*	Male
17	Lilly	English	English	Latina	Female
18	Coreen	English	English	White and PI*	Female
19	Ashley	Korean	English	Asian	Female
20	Valentina	Spanish	English	Latina	Female
21	Alena	English	English	Asian	Female
22	Makaio	English	English	PI and/or NH*	Male
23	Valeria	Spanish	English	Latina	Female
24	Cathleen	English	English	White or Cau.*	Female
25	Melia	English	English	PI and/or NH*	Female
26	Chea	Khmer	Khmer	Asian	Female

Note. * PI and/or NH = Pacific Islander and/or Native Hawai'ian. PI = Pacific Islander. Cau. = Caucasian

Demographic results revealed that, 23 out of 26 respondents (88.4%) identified as an ethnicity/race other than “White or Caucasian” while 25 out of 26 students (96.2%) identified as an ethnicity/race other than “White or Caucasian” or mixed with “White”. Therefore 96.2% of participants are considered an underrepresented minority or an international student based on the criteria in this study (see Chapter 3).

Fourteen of the 26 students who consented to be involved in the study (53.8%) identified as LatinX, Latino, or Latina. Four students (15.4%) identified as Pacific Islander and/or Native Hawai'ian. Three students identified as Asian (11.5%). One student identified as White or Caucasian (3.8%). One student identified as White and Asian (3.8%). One student identified as White and Pacific Islander (3.8%).

As discussed in Chapter 3, eighteen of the 26 participants (69.2%) identified as female, or named pronouns associated with female. While, eight participants (30.8%) identified as male, or a gender identity associated with male. No learning disabilities or disorders were reported.

Research Question 1: Visual or Auditory Cognition

The first research question asks what does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition? To answer this question a TEMPro analysis was conducted on interview participants' responses to an auditory prompt – "What do you do on a typical day"?

The TEMPro helps the evaluator determine if the student can communicate temporal relationships between events, as defined by Arwood & Beggs (1992). This is done by determining if the speaker can connect ideas through, 1) the use of a temporal sequence of events (e.g., "I sit down to do my homework and usually make myself a snack after one hour of working on Math or English or something."); 2) the use of appropriate verb tenses consistent with the intended meaning (e.g., "I sit down to do my homework and usually make myself a snack after one hour of doing homework."); 3) and the use of temporal words (e.g., before, after, during, eventually, finally, following, tomorrow, yesterday, and, by, on, between, so, while, then, etc.). Analyzing a language sample for how ideas are organized with a temporal sequence of events provides information to evaluators about the person's language use (function) (Arwood & Beggs, p.1).

If focal participants form temporal propositions - represented as three ideas connected in time in the English language – they function linguistically with auditory concepts. If focal participants list ideas spatially and/or linearly, participants use visual cognition to create pictures to refer to their "typical" day, rather than auditory cognition (e.g., hearing their own voice). Such a result indicates that students have a visual learning system for processing and representing ideas. The implementation, efficacy, and research basis for the TEMPro is discussed in Chapters 2 and 3.

TEMPro Analysis

The following results reflect the researchers' analysis of focal participants' language samples. The complete TEMPro analysis was conducted by the researcher and validated by an expert in language analysis. Additionally, the write-up of the analysis was approved by a doctoral committee. The TEMPro analysis is not presented in full in this chapter, to honor the portrayal of first-generation participants through their responses/experiences, as well as their strengths.

Focal participants were asked to perform a linguistic task with a natural temporal sequence, by answering the question, "What you do on a typical day?" The researcher recorded the response and transcribed the sample verbatim. The researcher removed colloquial phrases such as "like" and "um" at the recommendation of Dr. Arwood, one of the creators of the TEMPro. Removing such phrases, helped the evaluator better identify temporal concepts by focusing on the intended meaning of the speaker. The results for each question are synthesized in the next section.

Synthesis of Research Question 1. See Table 6 to view the results to each prompt by participant.

Table 6

TEMPro Results by Question and Participant

Participants	TEMPro Questions						Learning System Indicated
	Q1a	Q1b	Q2	Q3	Q4	Q5	
Abby	no	yes	yes	partially	no	no	visual
Ashley	no	yes	no	no	no	no	visual

Lilly	yes	yes	partially	no	no	no	visual
Dalisay	no	yes	no	partially	no	no	visual
Daniel	no	yes	yes	partially	no	no	visual
Coreen	no	yes	no	no	no	no	visual

Note. Questions comprise the Temporal Analysis of Propositions (Arwood & Beggs, 1992). No auditory propositions were produced by the participants. Question 1a: Is there a logical sequence of events? 1b: Does an idea refer to a preceding idea? Question 2: Do temporal words function to connect one idea to another through time? Question 3: Does the tense usage function to create a natural sequence? Question 4: Is there shared meaning without the listener making inferences? Question 5: Are there a minimum of three related ideas that are connected temporally to establish a proposition?

As Table 6 shows (particularly for question five), no focal participants produced an auditory proposition during the pre-assessment of this study. This suggests that all six focal participants who responded to the TEMPro used a visual learning system to process and represent ideas. The six focal participants function using visual cognition to process auditory concepts, which is now considered typical for students (Arwood, 2011).

Research Question 2

The second research question asks what changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fourteen of an academic success course? The researcher used the MAI as a rating tool to identify a baseline for FYFG students' metacognition and track gains in metacognitive awareness through students' first semester while enrolled in the academic success course (ASC). The MAI is a validated 52-item measure (Schraw & Dennison, 1994) assessing two categories: knowledge of cognition (KnowCog) and regulation of cognition (RegCog). Metacognitive awareness of one's learning, particularly KnowCog and RegCog were targeted in the ASC curriculum. For instance, eight reflective journal entries assigned from weeks one through 12, prompted students to reflect on their own learning and learning strategies, among other topics. Items on the MAI asked participants to assess knowledge of their own learning and learning strategies as well as metacognitive skills, which makes the MAI a fit to assess overall changes in meta-learning in the bounds of the ASC.

MAI Scores

Students participated in the MAI for a participation grade in weeks five (pretest MAI) and 14 (posttest MAI) of the ASC. The total number of participants who qualified for inclusion in the MAI pretest and posttest was 24. Responses to the survey were reported as a 5-point rating scale, 1 = “I never or almost never do this”, 2 = “I occasionally do this”, 3 = “I do this sometimes (50% of the time), 4 = “I usually do this,” 5 = “I always do this.” One student was removed from consideration, because of answering “I always do this” on all 52 responses in the posttest MAI.

Mean scores for the MAI pretest and posttest were calculated and compared (in SPSS) using a paired samples *t*-test, with a significance level of $\alpha < 0.05$. Table 7 shows the collective MAI pretest and posttest scores.

Table 7

Comparing Means of MAI Pretest to Posttest

MAI Assessments	*M*	*SD*
Week 5: Pretest MAI	176.63	9.01
Week 14: Posttest MAI	196.38	5.84

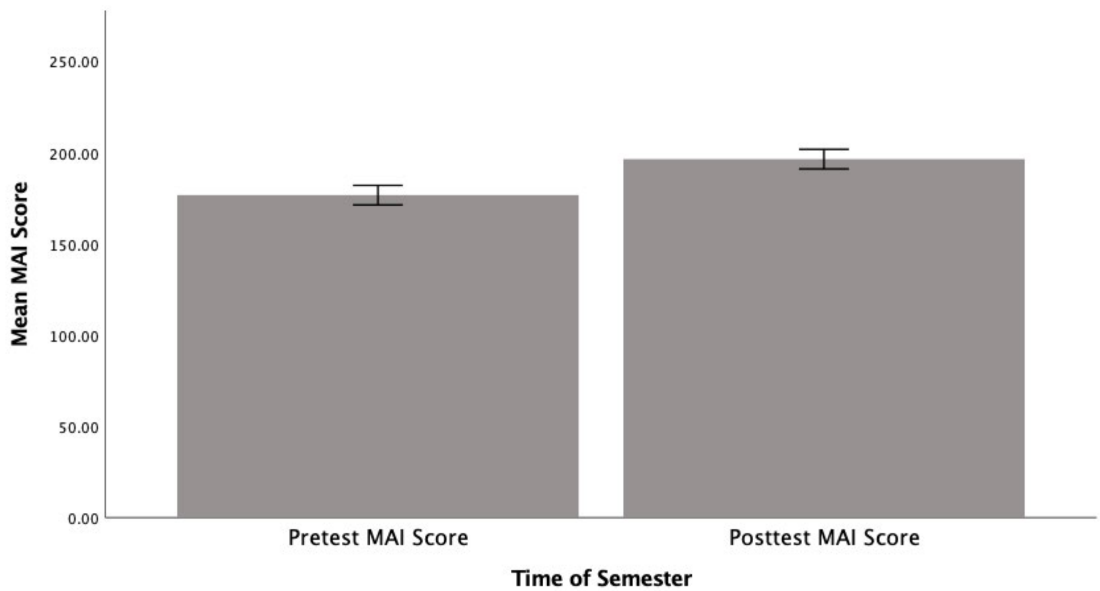
Note. $n = 24$, $*p < .001$

As seen in table 7 above, there was an increase in mean score by 19.75 points between the MAI pretest and posttest, which was statistically significant, $t(23)$, = 3.81, $p < .001$. A Cohen’s d was calculated and revealed a moderate effect size ($d = .78$). The increase in mean score accounted for 8% of the maximum possible MAI score, which is 260. This result suggests that FYFG students made statistically significant progress in metacognitive awareness from the

MAI pre to posttest that was likely due to the ASC. Figure 4 portrays the difference in means, along with the standard error for both mean scores (using error bars).

Figure 4

Pretest Compared to Posttest MAI Scores (Adjusted for Error)



Note. Error bars*:* 95% Confidence Intervals.

Running a paired samples *t*-test on individual MAI items, revealed that 13 of the 52 items had mean increases (from pretest to posttest) that were statistically significant $\alpha < 0.05$. Statistically significant items associated with the recognition of cognition (RecCog) variable include item 50, “I ask myself if I learned as much as I could have once I finish a task” (*MD* = 1.00, $p = .005$); item 37, “I draw pictures or diagrams to help me understand while learning” (*MD* = .83, $p < .001$); item 39, “I try to translate new information into my own words” (MD = .62, p = .001), and item 36, “I ask myself how well I accomplish my goals once I’m finished” (*MD* = .79, $p = .005$). Items 50, 39, and 37 were direct focuses of the ASC curriculum, while 36 could be attributed to metacognitive processes learned over the course of the semester.

Difference in means and significance for MAI items associated with the RecCog variable can be found in Table 8 below.

Table 8

Comparing Means on Individual MAI Items from Pretest to Posttest for RecCog Variable

Item Number on MAI	*MD*	*SD*	*t*	*Two-Sided P*
50. I ask myself if I learned as much as I could have once, I finish a task.	1.00	0.04	3.09	*.005
37. I draw pictures or diagrams to help me understand while learning.	.83	0.04	4.24	*<.001
36. I ask myself how well I accomplished my goals once I'm finished.	.79	0.04	3.10	*.005
43. I ask myself if what I'm reading is related to what I already know.	.75	0.04	3.30	*.003
4. I pace myself while learning in order to have enough time.	.67	0.04	2.50	*.020
39. I try to translate new information into my own words.	.62	0.04	3.71	*.001
30. I focus on the meaning and significance of new information.	.58	0.04	2.70	*.013
8. I set specific goals before I begin a task.	.58	0.04	1.87	.075
47. I try to break studying down into smaller steps.	.58	0.04	1.87	.075
11. I ask myself if I have considered all options when solving a problem.	.54	0.04	2.33	*.029
38. I ask myself if I have considered all options after I solve a problem.	.54	0.04	2.33	*.029
7. I know how well I did once I finish a test.	.50	0.04	2.08	*.049
40. I change strategies when I fail to understand.	.50	0.04	2.01	.056
41. I use the organizational structure of the text to help me learn.	.50	0.04	1.91	.069
21. I periodically review to help me understand important relationships.	.50	0.04	1.63	.117
6. I think about what I really need to learn before I begin a task.	.46	0.04	1.33	.198
24. I summarize what I've learned after I finish.	.46	0.04	1.31	.204
9. I slow down when I encounter important information.	.42	0.04	2.20	*.038
31. I create my own examples to make information more meaningful.	.42	0.04	1.12	.273
49. I ask myself questions about how well I am doing while I am learning something new.	.37	0.04	1.48	.153
34. I find myself pausing regularly to check my comprehension.	.37	0.04	1.12	.273
2. I consider several alternatives to a problem before I answer.	.33	0.04	1.28	.213
45. I organize my time to best accomplish my goals.	.29	0.04	2.07	.050
1. I ask myself periodically if I am meeting my goals.	.29	0.04	1.23	.231

19. I ask myself if there was an easier way to do things after I finish a task.	.29	0.04	.98	.338
42. I read instructions carefully before I begin a task.	.25	0.04	1.37	.185
28. I find myself analyzing the usefulness of strategies while I study.	.25	0.04	.92	.366
23. I think of several ways to solve a problem and choose the best one.	.25	0.04	.81	.426
51. I stop and go back over new information that is not clear.	.21	0.04	.96	.347
25. I ask others for help when I don't understand something.	.17	0.04	1.00	.328
44. I reevaluate my assumptions when I get confused.	.17	0.04	.75	.461
48. I focus on overall meaning rather than specifics.	.17	0.04	.61	.548
22. I ask myself questions about the material before I begin.	.12	0.04	.57	.575
13. I consciously focus my attention on important information.	.00	0.04	.00	1.000
52. I stop and reread when I get confused.	-.08	0.04	-.49	.627

Note. $*p < .001$. *MD* = Mean Difference from pretest to posttest. Items are arranged from highest mean difference to lowest mean difference. Items with the same mean difference, are arranged by *t*-statistic scores in descending order. Negative scores indicate a decrease in scores from pretest to posttest. Individual items represent ordinal data, which is a limitation when representing significance.

Four items (one in Table 8, three in Table 9) showed decreases in collective mean scores. Those items were 52, "I stop and reread when I get confused" (*MD* = -.08); item 3, "I try to use strategies that have worked in the past" (*MD* = -.25); item 29, "I use my intellectual strengths to compensate for my weaknesses" (*MD* = -.29); and item 46, "I learn more when I am interested in a topic" (*MD* = -.04). None of these three items were a focus of the ASC curriculum and are likely not good fits for evaluating *change*, as will be discussed in Chapter 5. Thirty items had mean increases that were not statistically significant. Some items that were directly covered in the ASC, that did show improvement, but were not statistically significant included item 34, "I find myself pausing regularly to check my comprehension," (*MD* = .37, $p = .273$); item 48, "I focus on overall meaning rather than specifics" (*MD* = .17, $p = .548$); and item 25, "I ask others for help when I don't understand something" (*MD* = .17, $p = .328$). Difference in means and significance for MAI items associated with the KnowCog variable can be found in Table 9 below.

Table 9

Comparing Means on Individual MAI Items from Pretest to Posttest for KnowCog Variable

Item Number on MAI	*MD*	*SD*	*t*	*Two-Sided P*
14. I have a specific purpose for each strategy I use.	.67	0.04	3.76	*.001
35. I know when each strategy I use will be most effective.	.67	0.04	1.91	.069
10. I know what kind of information is most important to learn.	.62	0.04	2.61	*.016
33. I find myself using helpful learning strategies automatically.	.54	0.04	1.67	.108
27. I am aware of what strategies I use when I study.	.50	0.04	1.96	.062
18. I use different learning strategies depending on the situation.	.50	0.04	1.73	.097
12. I am good at organizing information.	.33	0.04	1.50	.148
5. I understand my intellectual strengths and weaknesses.	.33	0.04	1.40	.175
20. I have control over how well I learn.	.33	0.04	1.25	.224
26. I can motivate myself to learn when I need to.	.29	0.04	1.66	.110
16. I know what the teacher expects me to learn.	.29	0.04	1.43	.166
32. I am a good judge of how well I understand something.	.29	0.04	1.37	.183
15. I learn best when I know something about the topic.	.12	0.04	.83	.417
17. I am good at remembering information.	.12	0.04	.62	.543
46. I learn more when I am interested in the topic.	-.04	0.04	-.24	.814
3. I try to use strategies that have worked in the past.	-.25	0.04	-1.24	.228
29. I use my intellectual strengths to compensate for my weaknesses.	-.29	0.04	1.13	.271

Note. $*p < .001$. *MD* = Mean Difference from pretest to posttest. Items are arranged from highest mean difference to lowest mean difference. Items with the same mean difference, are arranged by *t*-statistic scores in descending order. Negative scores indicate a decrease in scores from pretest to posttest. Individual items represent ordinal data, which is a limitation when representing significance.

After analyzing MAI pretest and posttest scores for individual items, the researcher broke down the overall score into two factors previously validated by Schraw and Dennison (1994) to test for significant increases in categories of metacognition. The two factors are 1) knowledge of cognition (KnowCog) and 2) regulation of cognition (RegCog). Seventeen items were factored into the metacognitive knowledge (KnowCog) variable, and 35 items were factored into the regulation (RegCog) variable as represented in Tables 8 and 9.

Statistical analysis with a paired samples *t*-test revealed both KnowCog and RegCog variables had gradual and statistically significant ($\alpha < 0.05$) increases in mean scores. Table 10 shows the difference in MAI mean scores from pretest to posttest on both KnowCog and RegCog variables.

Table 10

Comparing Means of Pre to Posttest When Factoring KnowCog and RegCog Variables

Two Factors of MAI	*M*	*SD*	*t*	*df*	*Two-Sided p*
KnowCog Mean Difference	5.04	8.11	3.05	23	.006*
RegCog Mean Difference	14.71	18.53	3.89	23	<.001*

Note. $n = 24$, *$p < .05$. [*Insert that this is Mean difference.]*

The KnowCog and RegCog gains, indicate an increase in students' metacognitive awareness for their own learning. The increase in metacognition is perceived to be due to students' exposure to reflective activities primarily related to their conceptual learning and thinking within the bounds of the ASC. However, interview participation in this study could have also been a factor.

Metacognitive Gains. To calculate the metacognitive gain (MG) score, consistent with Siegesmund (2016), the following formula was used: (posttest MAI score – pretest MAI score) / (260 – pretest MAI score). This formula, termed the "average normalized gain," is a measure of class effectiveness in promoting conceptual understanding, based on what was possible (a maximum score of 260) (Hake, 1998, p. 64). Applying this formula showed a mean metacognitive gain (MG) of 0.21 (21%) during FYFG students' first semester in college.

Twenty-one out of 24 students experienced positive MGs, while three participants experienced declines in average gain scores.

Summary of Quantitative Analysis

Running statistical analysis with a paired samples *t*-test in SPSS on MAI pretest and posttest scores revealed there was an increase in mean score by 19.75 points that was statistically significant, $t(23)$, = 3.81, $p < .001$. When factoring Cohen's d, there was a moderate effect size ($d = .78$), which means practical significance for the ASC curriculum likely exists. When segmenting the overall MAI score into two factors, KnowCog and RegCog, there was a statistically significant increase in both KnowCog and RegCog scores, $\alpha < 0.05$. Collectively, students had an average normalized gain, or metacognitive gain (MG) of 21% between the MAI pretest and posttest. Taken cumulatively, these results reveal that FYFG students' made gains in metacognitive awareness during their first semester in college, likely because of participation in the ASC. Thus, changes occurred to first year, first-generation students' metacognitive awareness in terms of gains for both knowledge of cognition (KnowCog) in relation to learning (i.e., knowledge of one's learning and learning strategies) and the regulation of cognition (RegCog), (i.e., monitoring/control of metacognitive strategies and skills for learning).

Qualitative Data Analysis

Pre- and post-assessment semi-structured interviews were conducted with six focal participants enrolled in the ASC. Interview recordings were then transcribed and reviewed. Interpretations of the interview responses as well as questions for participants were written and organized into individual reports. Member check interviews (Birt et al., 2016) were scheduled, during which participants clarified sections in the report that were unclear and provided details (e.g., examples) that related to their original responses and the researcher's interpretations.

Participants' statements during the member checks were organized into case summaries and used to verify, modify, and/or provide depth to the themes that developed during language analysis. Transcribed interview data was then broken down into discrete parts using Saldaña's (2009) criteria for initial coding. Process codes were utilized for learning strategies and metacognitive behaviors, allowing the researcher to better track actions and behaviors across time (Saldaña, 2003; 2021). Codes were correspondingly given descriptive language, primarily based on the participants' own language within the study's conceptual framework, to better represent dynamic processes at latter stages of coding and analysis (Saldaña, 2021).

Next, codes were structured into specific content or conceptual categories based on the categorical sections of the pre- and post-assessment (MacQueen et al., 2008). Several categories were inductively coded, while others adapted over time, and were therefore, deductively coded. Structural coding helped to align the large data set with the research questions. Initial and structural coding was also conducted on two written class activities that involved a broader group of students in the ASC (*N* = 25, which included 5/6 focal participants).

The researcher then engaged in provisional (a priori) coding using research-based criteria established beforehand (Saldaña; 2021), which helped to assess each code for metacognitive thinking, learning, and behavior (see Appendix L for Codebook). This stage became a reflective process in which the researcher examined each code for meaning/understanding, and then labeled each code as cognitive or metacognitive phenomenon. Initial and provisional codes for each participant were then placed into conceptually clustered matrices (Miles & Huberman, 1994), and arranged into rows based on when the data was submitted - beginning (pre-assessment), middle (class activities) and end (post-assessment). Relevant quotes from the pre- and post-assessment interviews, as well as member check interviews were inserted into cells to provide contextualization for more in-depth analysis. Analytic memos were derived by comparing codes within and across conceptual categories over the duration of time outlined in each matrix. Additionally, the researcher utilized Saldaña's (2003; 2021) criteria for longitudinal analysis (e.g., constant, cumulative, decrease, emergence, turning point) within matrices to assess changes in behavior and knowledge across time. Observable changes for each participant were captured within each matrix.

Once the within-case analysis for each focal participant was complete, pattern coding (Saldaña, 2021) was utilized to compare codes within and across structural categories allowing the researcher to cluster codes into themes that applied to the focal participant group as a whole. Pattern coding was conducted first for the focal participants' who participated in the pre-and post-assessment, then for the class participants who participated in the class activities. Provisional coding was utilized again, based on the same criteria used to assess individual participants' codes, for focal and class participants' themes. Again, provisional coding allowed the researcher to label each code as cognitive or metacognitive phenomena., supporting determinations of whether themes could be constituted as meta-learning, strategies, skills, etc.

Themes were arranged into three separate templates, which represented three points in time: 1) a beginning (pre-assessment with focal participants), 2) a mid-point (class activities with class participants), and 3) an end (post-assessment with focal participants). All themes were given descriptive names as suggested by Saldaña (2003) and provisional descriptors (metacognitive and/or cognitive acronyms associated with the theme). Themes were arranged as hierarchical structures, which represented the relationships among various themes in each template (Kings & Brooks, 2017). In conducting the final interpretations, the researcher, 1) created an account of every theme in each template, 2) developed a synthesized account of the template overall, and 3) gave prioritization to those themes that were mentioned most, were most relevant to the study, and/or were perceived as profound (Kings & Brooks, 2017).

Finally, the themes for the pre- and post-assessment, as well as the class activities were arranged into a visual matrix based on criteria for arranging time-ordered matrices to assess *change* (Miles & Huberman, 1994). As King & Brooks (2007) suggest, the themes were structured in a way to "capture the temporal dimension of the data" by indexing all codes to "…the time point to which it relates…", so the researcher could examine whether and how patterns of themes changed over the course of the study (p.11). Saldaña's (2003; 2021) longitudinal criteria was used, where relevant, to analyze themes across time and determine "change themes," i.e., synthesis of themes representing the primary changes of focal participants, based on focal/class participants responses over time. Themes representing change were identified and recorded into the time-ordered matrix, then elaborated upon in detail. Time-ordered matrices helped the researcher to visualize the origin, flow, and connection of participants' assigned meanings (e.g., behaviors, and knowledge) across time. Two additional (within-case) matrices were generated to reduce/synthesize several dozen pages of analysis into single-page displays, which supported final interpretations. The following sections will list themes identified over the course of the research, present analysis related to those themes, and provide participants' quotes to contextualize the phenomenon under study. 'Prominent' themes are those themes coded for at least three focal participants in relation to a specific question or section in the pre- and post-assessments. Themes that begin with a word with an "ing" suffix are process codes given for mental or physical (movement) strategies.

Research Question 3: Changes to Strategies, Skills, and Dispositions for Learning

The third research question is considered the primary research question of the study. It asks, what themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning? To answer this question, the results of each sub-question will be discussed, followed by a synthesis of key findings that address the primary research question.

Research Question 3a

What do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course? In RQ3a, the researcher explored students' previous experiences with learning/meta-learning to better understand the educational backgrounds of students and support any determinations of change over the course of FYFG students' first semester in college. Questions related to previous experiences were integrated into the pre-assessment and journal entry #6 (JE6) and are thus derived from both the focal participant group (N = 6) and the broader class participant group (N = 18), for a total of 24 students (N = 24). Two class participants did not complete the class activities included in this study, so they have been removed from the total number of class participants previously listed.

Focal Participants' Themes Related to Research Question #3a. The pre-assessment had four questions that asked six focal participants about previous observations and experiences in high school. This section of questions was termed the "previous knowledge" section (see Appendix E). Focal participants responses to these questions, as well as other references to their previous experiences were coded and organized into themes under the categories "previous experiences with learning" (PEwL), "previous experiences with meta-learning" (PEwMl), and "Previous and Ongoing Strategies" (PS/OS) in the pre-assessment template (see Appendix M).

All three categories were identified during structural coding or later as being representative of codes that embodied a “then” as opposed to a “now” context.

Previous Experiences with Meta-Learning. Question number four of the pre-assessment asks focal participants whether they’ve have had previous experiences where a teacher or counselor attempted to help them understand their own thinking and learning. Focal participants could answer as “never,” “few experiences,” “more than a few,” or “a lot”. Responses to that question were then structurally coded under the category PEwMl. Themes that emerged from the pre-assessment, structured under the category PEwMl are listed in table 11 below.

Table 11

Themes that Emerged in the Pre-assessment, Placed in the Category “PEwMl”

Category	Themes
Previous Experiences with Meta-Learning	Experiences Learning about Learning/Thinking Lacking [CK]
	Few to No Experiences that an Adult Helped Me with Learning [CK]

Note. Bracketed acronyms represent provisional codes based on metacognitive criteria found in the literature. “CK” stands for cognitive knowledge while “MK” stands for metacognitive knowledge.

Three focal participants affirmed they had few experiences that a teacher or counselor spoke with them about their learning/thinking. Two additional focal participants indicated they had ‘not had experiences like that.’ Therefore, five out of six focal participants affirmed they had *few to no experiences* that an adult (i.e., teacher or counselor) spoke with them about their own learning. Responses of “few experiences” and “no experiences” were merged into one theme, “few to no experiences that an adult helped me with learning” to condense the analysis. Abby was the only focal participant who mentioned she had “more than a few” experiences in which a teacher or counselor spoke with them about their learning and thinking. In the follow-up to that question, Abby did not directly relate her experiences to conceptual learning nor metacognition as it relates to learning but primarily discussed a previous study skills class, “Mostly in middle school, I had a particular class that was ingrained into our school year and our schedule, study skills. It was extremely helpful, it just went over the basics of organizing not only your work, but your environment because that also plays a big role in how you do things.”

Additionally, question five of the pre-assessment asked focal participants, to provide specific experiences, if there were any, where a teacher, counselor, or parent taught them about how they learn or think best (see Appendix E for follow-up questions). The intent of question five was to gauge the level of education students had for their own thinking/learning and the knowledge students have of their own thinking/learning. In response, three focal participants indicated that their previous experiences learning about their own learning and thinking were lacking. In other words, participants indicated that any experiences they might have had learning about their own learning were not robust. For instance, Daniel stated “Yeah, there have been (those experiences). I would say there's at least been three times in my life where I’ve taken those tests that determine whether or not you're like a physical, like hands on learner or if you're an auditory learner or whatever learning styles suits you. And I’ve always just like, I’ve always taken those tests and I thought to myself, ‘I wish I could have more to go into this. I wish there was like something more to offer than just like, oh, this is what I got.’” Additionally, in a follow-up to question five the researcher asked Ashley, “Okay, so were there many in-class experiences where they talked specifically about learning and thinking?” Ashley, responded, “Not really, and if they did, it would be a brief discussion maybe one to two sentences exchanged, like it wasn't a whole ordeal.”

Previous Experiences with Learning. Other prominent themes that emerged from focal participants responses to question 5 were "Taught to Use Cornell Notes [CK]" and "Teachers Supporting Students Learning [CK]". Regarding the support of learning - three participants mentioned previous experiences (before college) that teachers supported their learning of academic material. These responses were not related to learning about learning.

Regarding the use of Cornell notes - two participants, Abby and Dalisay, mention that they were taught to use Cornell Notes in school prior to college. Cornell notes involve systematic notetaking in a format that incorporates keywords, questions, and a summary section. Use of Cornell notes is relevant because of how Abby and Dalisay adapt (i.e., make "changes" to) their notetaking based on meta-learning over the course of the semester.

Question six of the pre-assessment asked focal participants to discuss a time in school, if there was a time, when they were confused about something, and then able to figure it out on their own; specifically, how did they go about figuring it out? The researcher assessed the assigned meanings participants gave to their confusion; specifically, how they previously went about creating meaning for themselves to better understand the material. Themes in response to question 6 were primarily coded under the category PEwL. Relevant themes that emerged from the pre-assessment, primarily in response to question 5 and 6 are listed in table 11 below.

Table 12

Themes that Emerged in the Pre-assessment, Placed under Categories "PEwL" and "PS/OS"

Category	Themes
Previous Experiences with Learning	Communication in Groups Helps with Challenging Ideas [CK]
	Taught to Use Cornell Notes [CK]
	Teachers Supporting Students Learning [CK]

Previous and Ongoing Strategies	Watching Educational Videos to Learn Better [MK]

Three participants responded to question six by discussing previous experiences (before college) in which they worked in group settings, primarily with peers, to help resolve confusion. For instance, Ashley responded that she hadn’t any experiences where she figured out things on her own because she usually worked with peers or a teacher. When asked to explain how working with a friend helped her, Ashley stated, “I think it would be the two of us talking back and forth because again me, coming up with one question could be completely different from a question that my friend had. So, like if we both put our heads together, we tackle the problem at different angles.” This response, while not clear from a metacognitive standpoint, shows an understanding that multiple people speaking/working on a problem can think about that problem in multiple ways, which can help determine a solution.

Additionally, in the latter part of a response to question six, Dalisay stated, “I tend to work with other people to help me figure out because, I don't know, for some reason I feel more comfortable reaching out to students than my own teachers.” This response indicates a comfort level of reaching out to peers to help when confused, rather than a cognitive assessment of why speaking with peers supports understanding. Correspondingly, responses, coded as “Communication in Groups Helps with Challenging Ideas [CK]” generally did not allude to how experiences working with others (i.e., groups) supported the participants thinking or learning; thus, they were not coded as being metacognitive.

Three participants also explained, in response to question 6, that they watched educational videos, particularly Khan Academy videos, as a strategy to help learn confusing academic material. For instance, Dalisay stated, “I personally go to Khan Academy and some YouTube professors or teachers online, not professors, but AP Calculus YouTube videos…

because they give you practice problems after the short videos. And you can look back in the videos, and if you do get it wrong, they'll show you what you did wrong and explain to you why you got it wrong, so you would understand." Additionally, Daniel stated that he actively sought out videos to learn material that might not be as easy to grasp, such as in math, "I like to seek out more resources. I think having the Internet available to me has been a real big help… because I've always been able to just YouTube. By going to YouTube or I can just search for the concept and keep looking until I find someone (that) has an explanation that I can help break down for myself." The three participants, coded for the theme "Watching Educational Videos to Learn Better [MK]" explained how videos helped their understanding in some facet, which indicates metacognitive knowledge (MK). For instance, the term "break down for myself" in Daniel's previous response, indicates that Daniel uses educational videos to break down bigger ideas into smaller concepts to help him understand the whole process. For Dalisay, watching videos helps her correct her thinking (i.e., know what she did wrong) so she can understand or better understand the calculus problem.

Class Participants' Themes Related to Research Question #3a**.** Twenty-one of 25 available students responded to journal entry number 6 (JE6). Some responses were hand-written and later transcribed and others were typed. JE6 was the last journal entry assigned in the learning and thinking block and was completed after all the classes in the learning and thinking block had been completed. Themes that emerged from JE6 and structured within the category PEwL were based off reflective statements to question one, that asked about previous challenges students encountered in high school. Prompt #1 of JE6 asked, "What are some challenges that you faced in the past (like in high school) when learning?" Participants were not compelled to answer in a specific way. Class participants' responses were captured among three themes that categorically related to previous experiences with learning (PEwL). These themes are listed in Table 13 below.

Table 13

Themes that Emerged in JE6, Placed under the Category "PEwL"

Category	Themes
Previous Experiences with Learning	Did Not Know How to Study (7/21) [MK]
	Did Not Study Regularly in High School (4/21) [MK]
	Previous Education not Challenging (4/21) [CK]

Note. Numbers in parenthesis represent the number of students who were coded for the theme (on the left) out of the total number of students who responded to that specific question (on the right). Again, bracketed acronyms represent provisional codes based on metacognitive criteria found in the literature.

Did Not Know How to Study. Seven participants mentioned that they didn't know and/or learn how to study prior to college. This was a prominent theme in the PEwL category and an insightful theme in the study overall. Most students related 'not knowing how to study' to negative impacts on learning or performance in high school; however, Ana related not knowing how to study to negative impacts on academic performance during her short time in college. Ana stated, "Some challenges I faced in the past in high school were mostly taking exams. We never really learned proper ways to study which is majorly affecting my grades in college." The "Did Not Know How to Study" theme was provisionally coded as being metacognitive, as many students referred to studying in terms of what it couldn't provide to their cognition, (e.g., retention) or the knowledge they didn't have for study strategies. Other prominent quotes for this theme are listed in table 14 below.

Table 14

Prominent Quotes for "Did Not Know How to Study" Theme.

Participants	Prominent Quotes
Eli	"If I am being honest, I faced quite a few challenges in high school, I was in college level classes my freshman year and didn't know how to study really or be successful. Coming from a home where no one in my family had been to college, I knew it was going to be hard because I didn't have anyone I could ask for help."
Lucía	"I never knew how to study, and this became a problem, because when tests came, I never prepared for them, I hoped for the best."
Cathleen	"I have always loved taking nice, neat notes, but I could never figure out what I really needed to write down, and I struggled with remembering what I wrote down and would always find myself super frustrated."
Valeria	"Throughout high school, I struggled with obtaining good study habits that would actually help me retain the information that I was learning."
Miguel	"When I attempted to study, I never knew how so I ended up just looking over notes really quickly and pretty much procrastinating for the rest of the time."

Did Not Study Regularly in High School. Four class participants indicated that they did not study regularly for their classes in high school. Two participants mentioned periodically looking over notes quickly, possibly for the purpose of test-taking, and one student mentioned not studying for tests at all. Lack of motivation was interpreted as an implied obstacle for all participants coded for this theme. Prominent quotes for this theme are listed in Table 15.

Table 15

Prominent Quotes for "Did Not Study Regularly in High School" Theme.

Participants	Prominent Quotes
Renzo	"Outside of class one of the hardest things for me was just simply starting the learning process. I would struggle so much to force myself into my desk every day after school, and now in college it's even worse when I have only myself keeping track of myself."
Valeria	"My study habits consisted of memorizing as much information as possible the night before a test so that it is fresh in my memory when actually taking the test."
María	"A problem I had in high school was that I would never study for test. Memorizing things for tests was never really my thing and I would go into my exams blind. I would take the tests with what I had learned from in class and nothing else."

Previous Education not Challenging. Four participants also indicated in response to the first prompt of JE6, that their high school education was not challenging. For instance, one of the focal participants' Daniel stated, "I don't think I experienced a challenge in learning until college." Additionally, two class participants Ana and Valentina, related 'not being challenged in high school' to negative results in college. For instance, Valentina stated, "In high school it felt like I really had to try to fail but here I really have to try in order to get a decent passing grade and it can be really frustrating at times."

Summary of Research Question 3a**.** In summary, five out of six focal participants affirmed that they had few or no experiences where a teacher or counselor had helped them with their learning and/or thinking. This coincides with themes that emerged in JE6 for the class participants, most notably that several did not know (or never learned) how to study and/or they did not study regularly. If students were never taught about learning and/or learning strategies, it follows that they would mention not knowing how to study properly, and potentially have limited interest in studying consistently. It should be noted that toward the end of the learning and thinking block, when JE6 was assigned, many students were applying and/or integrating various learning strategies of their choosing. The application/integration of new learning strategies and learnings from those strategies may have compelled some class participants to focus on study habits when asked about previous challenges in high school.

Focal participants were also asked about how they cleared up confusion on their own before college. Participants primarily discussed either experiences working with others, particularly peers to figure out challenging ideas, or they mentioned watching educational videos to help their learning. Regarding the former theme, focal participants often did not clearly discuss how experiences working with others supported their learning, notably how language might support their thinking or learning. Regarding the latter theme, focal participants clearly acknowledged that videos supported their understanding. Interestingly, each individual had unique reasons as to why videos supported their understanding. For instance, watching educational videos allowed Abby to pause and rewind to gain access to more content; while videos helped Lilly see step-by-step processes, and helped Daniel gain access to more content so that he could then break down ideas into smaller chunks. Notably, no metacognitive strategies or visual-motor strategies (e.g., drawing, writing down ideas) were discussed in response to question 6 of the pre-assessment.

Research Question 3b

What do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course? In RQ3b, the researcher sought to understand how focal participants, in their first five weeks of college, thought about 1) learning in general, 2) thought about their own learning in general, and 3) thought about new ideas in primarily visual and auditory environments. Prominent themes emerged in response to question two, question three, and the Awareness of Cognition (AoC) section (questions seven through nine) of the pre-assessment. Themes that emerged from each question and the AoC section will be reported, followed by a synthesis of focal participants' responses (across all sections of the pre-assessment) to succinctly answer the research question. Themes emerged as a result of 1st cycle, provisional, and pattern coding methods (Saldaña, 2021).

Mid-Range Understanding of Learning (Rating). Question two asked focal participants, "how would you rate how well you understand your learning? On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best?" Participants were asked to rate understanding of their learning at the beginning and end of both the pre- and post-assessment. Responses helped track students' metacognitive confidence at various stages of the research to find if the interview itself acted as an intervention and if meta-learning in the context of the ASC helped change metacognitive confidence.

Four participants rated themselves between a five and seven, which the researcher subjectively labeled as “mid-range.” One, focal participant Abby, rated themselves high, between an “eight, nine” and Lilly rated themselves low, at a “four and a half.” At the end of the pre-assessment, all six participants again rated their understanding of learning. Four participants rated themselves the same as the beginning of the interview and therefore, had no change in their understanding of learning rating. Two participants, Lilly and Daniel, gave themselves a higher score at the end of the interview than the beginning. Notably, Lilly’s score jumped from a “four and a half” at the beginning of the interview to an “eight” at the end of the interview. The boost in metacognitive confidence could indicate that the interview itself acted as an intervention. Conceivably, after reflecting on their learning, for approximately 60 minutes Lilly and Daniel felt more confident they had either answered the interview questions well and/or learned something about their learning. The boost in metacognitive confidence could also indicate that the understanding of learning (rating) is prone to volatility in specific circumstances. Though, participants’ understanding of learning rating was not volatile (i.e., prone to major shifts) over the course of this study.

Still Figure out What Works Best for My Learning. After focal participants rated their understanding of learning in question two, some participants elaborated on their reasoning. If participants did not elaborate, the researcher asked the follow-up, “why do you think you placed yourself at that point?” Four focal participants indicated that they were unsure of specific aspects of their learning. Because participants also signaled a willingness to learn the researcher coded these responses as “still figuring out what works best for my learning.” Lilly for instance, explained, “…*some methods work for me, but it doesn't work for me in every subject*. For example, in science like drawing pictures and more visual learning tools are very helpful to me, but then at the same time, for Math that wouldn't be helpful for me. It would just depend on the subject and *I'm still trying to figure out what works best for me*."

Another participant, Coreen, contrasted her current feelings about learning with how she learned in high school, "I don't feel very confident in how I learn. I never really had to try in high school or middle school for that matter. I would take the notes and take the test and boom, there's an A. It was just really the only study strategy I had was pay attention in class. *Now that I'm in college, I'm realizing-- I already knew going into this…that wasn't going to be enough*." Two participants also indicated in response to the follow-up that they were sometimes unsure of the best way to learn academic ideas. For instance, Ashley stated, "I think I placed myself there because sometimes I know I learn a certain way. Like I'm a visual learner, but at other times, I'm like, "Oh, I need someone to walk me through step-by-step" instead of just showing me one way through. *So, sometimes I get confused on what's the best way for me to understand something*." Themes that emerged in response to the question two follow-up were structured within the category, "Knowledge of Self as a Learner" (KoS) and are listed in Table 16 below.

Table 16

Themes that Emerged in the Pre-assessment, Placed under Category KoS for Question 2

Category	Themes
Knowledge of Self as a Learner	Still Figuring Out What Works Best for My Learning [CK | MK]
	Sometimes Unsure of Best Way to Learn Ideas [MK]

The KoS category represents declarative statements that participants made about themselves as learners. Themes structured within the KoS category in Table 16 align with themes discussed in RQ3a that relate to having few experiences learning how to learn - notably, “Few to No Experiences that an Adult Helped Me with Learning,” “Experiences with Learning/Thinking Lacking,” and “Did Not Know How to Study”.

Knowledge of Self and Others as Visual Learners. Question three asks for students’ thoughts/beliefs about what helps learners in general. This question was intended to facilitate students thinking about learning by asking them about their thoughts/beliefs. Question three asked, “As a student, looking at other students, what have you noticed about how other students in general, learn best?” Primary themes that emerged from question three are listed in Table 17.

Table 17

Themes that Emerged in the Pre-assessment for Question 3

Category	Themes
Knowledge of Self as a Learner	I am a Visual Learner [MK, VP]
Attention to Components of Learning and Thinking	Most Peers are Visual Learners [ToM]

Two focal participants, Ashley and Abby, mentioned they believed that most of their peers were visual learners. Ashley referred to the challenges of visual learners in virtual classrooms during the pandemic, “I think lately, *everybody's been more of a visual learner* because when we went on Zoom and stuff, we found that learning just by listening wasn't the best option. Then going back into in-person, you see everybody like just *trying so hard to get that visual side of learning. I think most of us are all visual learners*.” Ashley and Abby both indicated their peers needed visual stimuli in the learning environment, e.g., being led by example or having diagrams/graphs available in the learning environment. Based on a priori criteria, these responses indicated theory of mind (ToM), as participants ascribe a way of learning to other people.

In a follow-up to question three, the researcher asked focal participants to *explain how they think they learn best*. Three focal participants, including Abby and Ashley, labeled themselves as visual learners. Focal participants primarily related this label to needing visual examples (i.e., materials) to understand the ideas presented to them in a classroom. For instance, Abby stated, "…*I'm also a visual learner, we like to learn by example*. So, for example, we would ask questions to clarify, we'd like clarification." Shortly thereafter Abby stated, "So yeah, we like to *see other people do it to know and to assure ourselves* that we're doing what's right."

Additionally, Ashley stated, "I think I learned best visually, I would say, yeah." The researcher then asked, "what can somebody do in class to help you?" Ashley responded, "For example, in math, instead of just saying, "Oh, this is the formula, try it out," if (teachers) could just go through it once, and then go through it again with us following what they're doing to make it make more sense…".

Coreen was also coded for the theme "I am a Visual Learner" but not in response to question 3. The researcher asked Coreen in a follow-up to question 8, "In general, is there anything that you know about yourself and your own thinking that helps you understand other people when they're talking?" Coreen responded, "I know that I do not learn auditorily. I've always accepted that for the longest time. She stated shortly after, "If I'm hearing them talk, I turn and I look at them if I can. I need to." This response indicates that Coreen needs visual stimuli, (e.g., to see the person's movements) to be able to understand the (auditory) words that people are saying. The way Coreen processes ideas, will be discussed more in the section to follow. Finally, Lilly indicated she was a visual learner, equating the way she represented ideas (on paper), thought, and communicated with being "visual". For instance, Lilly stated, "Like I had said before, I'm very visual, just the way I communicate in general. When I communicate, even with my friends, like I'll draw pictures, or I show them videos or pictures to better explain myself." Lilly attributed aspects of her communication with peers and family members to her thinking and learning overall. In other words, she was aware of how she thought about ideas, and how others might think of those ideas, and as a result she used/created visual examples (e.g., videos, drawings) to help others understand her best. In the same response, Lilly continued to support the "visual" label, by discussing how she color coded notes to help separate and identify ideas (mentally).

In summation, three focal participants labeled themselves as being "visual" or being a "visual learner," in response to question three. Another participant, Coreen, indicated that she needed visual stimuli as opposed to auditory stimuli to understand ideas, so she was also included in the theme "I am a Visual Learner". All participants coded for this theme discuss needing to see or create visual stimuli in the learning environment to better understand or 'know' academic ideas. Two of those participants, Abby and Ashley, believe that most of their peers are visual learners and that they also need visual stimuli (i.e., perceivable visual elements) in the learning environment to better understand academic material. Thus far, a pattern has emerged in the first two research questions that indicates many FYFG students believe themselves and most of their peers to be visual learners, but indicate not knowing how to learn, in some contexts. As reported in RQ3a, many class participants have not learned how to utilize effective study strategies and it's apparent from the pre-assessment that focal participants have not learned strategies (from educators) that take advantage of being a visual thinker/learner. Thus, a contributing factor to participants' 'not knowing how to learn in some contexts' is conceivably that they haven't learned how to take advantage of their thinking and learning through application of research-based strategies for learning.

Awareness of Cognition Primary Themes. Three questions in the pre-assessment, (questions seven through nine) labeled the Awareness of Cognition section, explores participants' thought processes, particularly how they make sense of ideas (i.e., how they mentally construct meaning) within a learning task or situation. Questions in the AoC section are layered with visual thinking prompts. The researcher asked participants to mentally place themselves into casual settings where learning might occur (e.g., watching a video in your room), before asking the question. The AoC section helped determine 1) whether participants were metacognitively aware and/or in control of their thinking in a learning task, 2) how participants understood (or assigned meaning to their thinking and learning, 3) and what participants did to help them understand new ideas better.

Feeling of Knowing. Question seven explores what participants might do mentally in a learning situation when the primary external stimulus is visual, i.e., text or video. Question seven asked focal participants to think about a time last semester when they were watching a video or reading something in a place where they felt comfortable. The researcher then asked participants if they had the event in their mind. Once participants confirmed, the researcher asked, "so you're reading or watching a video in this place; and then you think you know something well, as in something makes perfect sense, what occurs inside your mind?"

Three participants indicated having a "feeling of knowing," which is a sense of conviction that one possesses certain information (see Chapter 2). In this case, the 'feeling' was reported when confronted with how ideas make sense to the participant, e.g., what occurs mentally when watching a video. For instance, Dalisay explained, "Basically, once when I watch something and I know of it, if I know what I'm watching, that goes behind my mind because *I feel like, "Okay, I get that*…".

Another participant, Ashley, needed additional information to answer question seven. The researcher then asked the follow-up question, “So, when you're reading the book and the light bulb goes off, it's like something just really makes sense. How does it make sense to you? Is it a feeling? Is it a thought? What occurs?” Ashley explained, “*It's usually a feeling* and then I kind of do -- you know those bubble graphs where each line connects to more things, *that goes off in my mind as the aha moment.*” These responses indicate that participants placed themselves in a learning moment mentally and explained the conscious feeling/s they might have in that moment. Feelings during a cognitive enterprise are referred to in the literature as metacognitive experiences (Flavell, 1979).

Focusing on Visual Movements of Speaker to Understand. Question eight explores what participants do mentally in a learning situation when the primary external stimulus is auditory, i.e., spoken words. Question number eight asked focal participants, to pick out a friend, family member or someone they are close to, and place them in their mind. The researcher then asked the participant if they had the event in their mind. Once participants confirmed, the researcher asked, “Okay, let’s say you’re both at lunch, and you’re outside and safely distanced, so no face masks. That person is telling you a story. Can you see this person telling you a story? As they are speaking how is it that you understand them best? So, what do you do, if anything, that helps you understand what they’re saying?” Four participants indicated they look at and/or focus on the visual movements of the speaker to understand the words they are saying. The visual movements that participants reported looking at and/or focusing on are listed in Table 18 below.

Table 18

Themes that Emerged in the Pre-assessment in the AoC section for Question 8

Category	Themes
Mental Strategies for Learning	Focusing on Visual Movements of Speaker to Understand Their Words (4/6) [MR (Control), VP]
	Focusing on Lip Movements (3/6) [MR (Control)]
	Transitioned from Reading Lips to Body Language (2/6) [MR (Control)]

Note. "Focusing on Lip Movements" and "Transition from Reading Lips to Body Language" are parallel coded with subthemes - "Focusing on Visual Movement of Speaker to Understand Their Words." Numbers in parenthesis represent the number of students who were coded for the theme (on the left) out of the total number of students who responded to that specific question (on the right). Bracketed acronyms represent provisional codes based on metacognitive criteria found in the literature.

Three of the four participants coded for the "focusing on visual movements…," theme indicated focusing on lips (i.e., mouth movements) to understand people when they are speaking. For instance, Coreen responded, "I focus on their lips, which has become very difficult in quarantine and stuff." Correspondingly, Ashley stated "Also, I like to look at lips, just see the words coming out I guess that helps me process better." Additionally, two participants mention having to transition from reading lips to paying attention to body language (e.g., hand and body movements) to understand speakers, because people often wore face masks (due to Covid precautions) when speaking. Coreen explained, "…I've moved to looking more at their body language and not just their lips, but their hands, and their shoulders, and that's helped a little bit… (with) how to understand what they're saying, and I have to pay so much more attention than I used to…". Correspondingly, Abby stated, "Having people with face masks, it constrained me to look at other behaviors and aspects like body language and stuff like that. It forces me to be more aware of other things that normally, I would just pay attention to the face or facial expressions and stuff like that."

It's important to note that students were returning to in-person classes after a 1-year or more hiatus from in-person classes due to the pandemic. In the ASC, instructors and students wore face masks, so students were not able to focus on each other's lip movements. In summation, four out of six focal participants indicated directing their attention to the visual movements of the speaker to understand their words. These visual movements were primarily composed of lip movements but because face masks were regularly worn, two participants also mentioned transitioning to focusing on body movements.

Writing Ideas in My Own Words to Understand. Question nine explores what participants do mentally in an academic learning task when the primary external stimulus is visual, i.e., typed text. Question nine asked focal participants, to think about a place they've studied before and also feel comfortable in. The researcher then asked the participant if they had the event in their mind. Once participants confirmed, the researcher asked, "when you're in this place and you're reading a textbook for one of your classes; so, when reading the words on a page, how do you make sense of the words?" No themes emerged in response to question nine for at least half of focal participants. However, two participants mentioned that they tried to write ideas using their own words (i.e., use their own language). Focal participants mentioned this strategy (among others) helps with understanding the ideas they are trying to learn. For instance, Abby mentioned that she first re-reads the text to make sense of the words and then if it's still confusing, she will break down the text word-for-word, sometimes writing her own words on paper, "I like to break the text down word by word and write words that I do know in place of the words that I don't know, so that I would be able to grasp it fully."

As guest instructor in the ASC, the researcher taught that writing ideas in your own words, as opposed to copying the teachers' notes, is an effective strategy for learning. The strategy compels students to engage with academic material metacognitively to translate the concepts into their own language (i.e., own thinking). It's important to note, that the researcher discussed this strategy, as well as the importance of using natural language in the first class of the ‘learning and thinking block,’ which directly preceded the pre-assessment. While Abby, did not report this strategy as something she learned in the ASC, both Coreen and Dalisay reported that taking notes in their own words was a strategy they had just begun to apply because of what they learned in the ASC. Coreen explained in the latter part of her response to question nine, that "…a lot of these strategies are pretty recent, especially with trying to figure out how to care about (class material), and *also the putting things into my own words when I take notes*. It's just like, "This makes so much sense." It takes a lot of effort, but they're study strategies that I have been implementing and I'm seeing improvements. It's only been like two days though." Another focal participant, Dalisay mentioned toward the end of the interview, that she also was taking notes in her own words as a result of what she learned in the ASC. Thus, two focal participants independently began to apply a strategy they learned in the ASC at the outset of the study. Participants' utilization of this strategy will be discussed more in the next research question, as it applies more to the Strategy and Skills (S&S) section of the pre-assessment. Prominent themes discussed in the following sections emerged in response to the AoC section of the pre-assessment as a whole (i.e., all three questions) rather than an individual question.

Seeing with Mental Images and Visualizing Ideas. Four focal participants showed knowledge that they ‘see’ (or understand) ideas through mental images. This theme was coded in response to question seven, eight, and nine of the AoC section, as well as for question 11 of the S&S section. Other visual thinking themes that emerged primarily in response to the AoC section are listed in Table 19 below.

Table 19

Prominent Visual Thinking Themes that Emerged from the AoC Section - Listed by Category and Participant Involved

Category	Themes	Focal Participants Involved
Awareness of Cognition	Seeing (Understanding) with Mental Images (4/6) [MK, VT]	Daniel, Lilly, Dalisay, Ashley
Mental Strategies for Learning	Visualizing Ideas to Understand Speakers' Words (3/6) [MR (Control), VT, MetStrat, MetSkills]	Daniel, Lilly, Dalisay
	Creating Context through Visual Thinking (3/6) [MR (Control), VT, MetStrat, MetSkills]	Daniel, Lilly, Dalisay

Note. There was overlap among the responses that were coded for visual thinking. For example, in one statement a participant could show knowledge that they 'see' with mental images, discuss visualizing ideas, and mention how they create context in those visualizations. Thus, "Creating Context through Visual Thinking" is a subtheme of (and parallel coded with) "Visualizing Ideas to Understand Speakers' Words," as the behavior predominantly occurred in this context. Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills.

As Table 19 shows, the theme, "Seeing with Mental Images" (SwMI) was structured within the category, "Awareness of Cognition," as it represented participants' metacognitive awareness in a learning task. The SwMI theme, particularly represents metacognitive knowledge the participants had for their visual thinking, which is why it was provisionally coded as MK. As guest instructor in the ASC, the researcher discussed (several weeks after the pre-assessment) how mental images can be a source of thinking/understanding, so this theme has relevance to the ASC curriculum, and helps directly answer the research question. Prominent quotes for the SwMI theme are listed in Table 20 below.

Table 20

Prominent Quotes for the "Seeing with Mental Images" Theme.

Questions	Prominent Quotes

Question 7, follow-up: “So, when you're reading the book and the light bulb goes off, it's like something just really makes sense. How does it make sense to you? Is it a feeling? Is it a thought? What occurs?”	Ashley: …you know those bubble graphs where each line connects to more things, that goes off in my mind as the aha moment.
Question 7: “So, you're reading or watching a video and then something clicks as in you understand it, like the light bulb goes off. How do the ideas make sense to you?”	Daniel: But when I have like, when I understand all the parts of something I can visualize it in my head and that's when I would say, I like, that's the moment of understanding.
Question 8, follow up: **“**Okay, great. Can you explain, you say “visualization,” can you explain what that means to you?”	Daniel: Because that's true understanding, is when I can see it and then and I can just – like if I can first hear it, like everything described, and then take the parts that I’ve heard, and then put it all together into one little scene that I can visualize, that's where I think my understanding and learning is.
Question 8: “As they're speaking, how is it that you understand them best? So, what do you do, if anything, that helps you understand what they're saying?”	Lilly: Usually, if the story's being told well enough, I try to visualize the situation. Like, the person I'm thinking of is my mom. She and I are very similar. When we talk, we use a lot of hand gestures and just seeing her hand gestures, kind of listening to her tone to try to picture that story.
Question 11: “Follow-up: If (the teacher is) talking, how do you create meaning out of what they’re saying?”	Dalisay: So, I would picture myself as the scientist doing this, and doing that. Then, if I don’t see myself- or I don’t picture it, or I don’t understand what pouring the beaker is to this, that’s like, “Okay.” I got confused, my image is all cloudy and stuff.

In response to question seven in the AoC section, both Ashley and Daniel were metacognitively aware that they understood ideas through mental images (i.e., visualizations) when watching a video or reading. For Daniel, when he can ‘see’ all the parts in a scene, “that’s the moment of understanding.” Additionally, in response to question eight, both Lilly and Daniel were metacognitively aware that they understood speakers by ‘visualizing’ (i.e., visually thinking about) their spoken ideas. Dalisay's response in Table 20, also indicates that she understood spoken words, by 'picturing' ideas, and if she didn't 'picture' an image (i.e., concept), or if her image was "cloudy" it was a sign that she was confused.

In the same context, Lilly, Dalisay, and Daniel also discussed 'picturing' or 'visualizing' story-based contexts for ideas being spoken about. As Table 21 illustrates, the theme "Creating Context through Visual Thinking" represents a specific mental behavior that participants report primarily in the context of visualizing (i.e., visually thinking about) a speaker's words.

Table 21

Prominent Quotes for the "Creating Context Through Visual Thinking" Theme.

Questions	Prominent Quotes
Question 8: "As they are speaking, how is it that you understand them best? So, what do you do if anything that helps you understand what they're saying?"	Daniel: When they're talking to me, I like to take the story and I like trying to like place myself into that third person like view of their story and try to visualize every element. And then, because visualizing every element like I said earlier, for question seven, like once I understand all the parts of something I can truly just like understand the whole thing.
Question 8, Follow Up: "Okay. When you say picture, what do you mean by that?"	Lilly: Like, I have pet ducks and she'll [laughs] tell me funny stories about them and just having a basic understanding of them and understanding the way my mom is, I can visualize little things that my mom tells me.
Question 11, Follow Up: [Researcher asks about Dalisay's previous response – in which she pictures herself in various contexts to understand ideas.]	Dalisay: Yeah, if I could see it. If I can see me doing it, or if I can see me understanding it or talking about (a) history event, like the bombing of Pearl Harbor. If they're talking about that, I would picture myself in that situation and see for myself.

"Creating Context through Visual Thinking" represents a behavior that could be conducted without being aware and/or being deliberate, almost like daydreaming or imagining what people are talking about. But Daniel, Lilly, and Dalisay discuss ‘visualizations’ more deliberately, as if they control the behavior (to a degree) and use it to understand or create meaning for what others are saying. For instance, in reference to his quote in Table 21, the researcher asked Daniel if he could explain what he meant by ‘visualization’. Daniel explained - “Seeing the thing happen in my head. Like, if we're talking about a movie scene, once that scene is described to me, *I will try and visualize it in my head and watch it over*.” Daniel was aware that mentally “seeing” ideas (what he termed ‘visualizations’) was a source of his understanding and gave examples in which he actively visualized events to understand other people’s spoken thoughts. Daniel created story-based contexts for his visual thinking, explaining that he mentally places himself (or other ideas) into situations from different perspectives (e.g., third person) to create more meaning for the ideas he is thinking about. Furthermore, Dalisay’s quote in Table 21 suggests she places herself in various events, even historical contexts to create more meaning to understand spoken ideas. Lastly, Lilly’s quote depicts how she visualizes contexts that she’s familiar with, and likely have meaning to her. All three participants show knowledge in these responses that they 1) understand spoken ideas with visual-mental thoughts (or visualizations), 2) that they can mentally see events that have meaning to them (e.g., stories), and 3) that they create story-based situations (i.e., context) to help think about the ideas that are being spoken about.

In summation, four of six focal participants mentioned they make sense and/or understand ideas by picturing those ideas mentally. Participants’ responses about their visual thinking primarily converged in the AoC section but some responses were dispersed throughout the pre-assessment. Three focal participants, Daniel, Lilly, and Dalisay explained in depth how visualizing ideas helped them better understand ideas in learning situations, primarily those situations in which a person is speaking to them, i.e., when auditory words are the primary stimulus. Additionally, half the focal participants discussed using ‘visualizations’ deliberately to create context (more meaning) for their learning. This deliberate use of visual thinking indicates half of the focal participants had a degree of metacognitive control over elements of their visual thinking and could use it in a strategic way.

Re-reads Text to Make Sense of Words. Three participants mention that they re-read text to make sense of the words. This theme emerged in response to question seven and nine of the AoC section, which prompted participants to think about how they make sense of words when reading. Prominent quotes related to this theme are listed in Table 22 below.

Table 22

Prominent Quotes for the “Re-reads Text to Make Sense of Words” Theme

Focal Participants	Prominent Quotes
Coreen	Oftentimes, I have to look back in the book or I have to scroll back a little bit and just like, "They said that here, did they not? What does that mean for here?"
Coreen	Then I really speed through the next couple of minutes or the next couple of pages, and I'm just like, "Either I was wrong, or I was close to it, or I was right."
Abby	I would make sense of the words by usually reading it over and over again until something clicks.
Dalisay	Rereading it, but slower and more precise. Even if I have to go word for word, I would do so.
Dalisay	I'm a reader that would slow down, like understand word for word if I have to. Like, if I were to read a book, I can just read through it, but then once I know, I don't understand, I have to go back, and my speed goes down.
Dalisay	I'll be like, a sentence like “how do you understand those words best?” So, I read it fast, normally, but then if I don't, I'd be like “how do you understand (saying it very slow)?” Like I’ll have to go slow.

Dalisay	I'll be like, a sentence like "how do you understand those words best?" So, I read it fast, normally, but then if I don't, I'd be like "how do you understand (saying it very slow)?" Like I'll have to go slow.

As illustrated in Table 22, three focal participants explained they make sense of words in a text, often, by repetitively reading the text until ideas become clear in their mind. Dalisay, for instance, slowed down when re-reading, trying to connect every word auditorily until the words made sense. The re-reading theme indicated that focal participants had knowledge that they sometimes struggled to understand written text on a first pass, but repetitive reading as a strategy eventually helped ideas make sense or become recognizable to them. Thus, participants were metacognitively aware of what they 'did' to help their understanding when reading. Notably, participants did not connect their re-reading to their visual thinking (e.g., 'visualizations') or their use of language in general. It's worth noting that two of the three participants included in this theme, did not explicitly assign meaning to visual thinking in the pre-assessment. The following sections will list prominent quotes for each focal participant along with corresponding themes that best illustrates how each participant understands their learning. Sections of the case summaries will be included to add depth to participants' statements and verify the researcher's interpretations from the pre-assessment.

Ashley's Understanding of Learning. Prominent quotes and themes in Table 23 illustrate how Ashley assigned meaning to her thinking and learning during the pre-assessment.

Table 23

Corresponding Quotes and Themes that Explain How Ashley Understood Her Learning.

Questions	Relevant Themes	Prominent Quotes
Question 3, PK Section As a student looking at other students, what have you noticed about how other students, in general, learn best?	1) I am a Visual Learner [MK] 2) Access to More Input Supports Understanding [MK]	Ashley: I think I learned best visually, I would say, yeah. Chris: What can somebody do in class to help you? Ashley: For example, in math, instead of just saying, "Oh, this is the formula, try it out," if they could just go through it once, and then go through it again with us following what they're doing to make it make more sense…
Question 7, AoC Section So, when you're reading the book and the light bulb goes off, it's like something just really makes sense. How does it make sense to you?	1) Feeling of Knowing [ME] 2) Seeing (Understanding) with Mental Images [MK, VT]	It's usually a feeling and then I kind of do -- you know those bubble graphs where each line connects to more things, that goes off in my mind as the aha moment. But, yeah.
Question 8, AoC Section So, what do you do if anything that helps you understand what they are saying?	Focusing on Visual Movements of Speaker to Understand Their Words [MR (Control)]	I like to maintain eye contact as much as possible, and look at their body language, I guess. Also, I like to look at lips, just see the words coming out I guess that helps me process better. Yeah.

Question 13, UoL section, I'd really like to hear your thoughts about what participating in this interview is like.	Challenging to Answer Specific Questions [CK|MK]	It was also kind of confusing or hard because it's like, you don't really think about the ways you study and learn.
Question 13b, UoL section …rate yourself on that same scale (as the beginning of the interview).	Sometimes Unsure of Best Way to Learn Ideas [MK]	I would rate myself a 6, because I feel like I sort of understand my learning, but I do not understand why I need to learn or study the way that I do to get the most out of it.

Note: Notable codes for Ashley that did not become themes: Writing Down Ideas I Understand to Remember. Provisional Codes: MK = Metacognitive Knowledge, ME = Metacognitive Experiences, MR = Metacognitive Regulation, VT = Visual Thinking, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Ashley's case summary and further developed the document with Ashley in a member check on Nov. 12th, 2021, approximately six weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Ashley's responses and were confirmed with her as being accurate in the member check. Any direct statements are listed in quotation marks.

I am a Visual Learner. In the fifth week of her first semester in college Ashley saw herself and most other students as visual learners. Ashley came into the ASC with an understanding that learning by listening (primarily), particularly listening online was not the best for her learning. Question and interpretations related to Ashley being a visual learner were discussed with Ashley during the first member check and her responses are captured in Table 24.

Table 24

Conversation in Member Check Relevant to Pre-assessment Theme - "I am a Visual Learner"

Chris (Question/Interpretation)	Ashley (Answering)

When you say “visual leaner” what does that mean to you?	I learn through slides rather than the teacher talking. Being shown step-by-step how to solve a specific problem rather than being left with the problem to do on my own.
Chris: So, if a visual example, like a picture, doesn’t work, it helps when someone models the idea or behavior in a step-by-step fashion, so you have a better understanding of how the ideas come together?	Yes, pretty much. That’s a good description.
Is this with both visual and auditory elements?	A combination of both is important. Slides by themselves are more difficult to understand. Also, “I can’ t learn just by listening, I need visual aspects with it.”
Ashley is a visual learner. What that means is that you need visual examples to help you learn.	“That’s perfect.”

As illustrated in Table 24, Ashley understood that she learned best through visual examples and materials in the learning environment. Similar to the pre-assessment, Ashley shows metacognitive knowledge for how she processes information best, which supports her problem-solving. Auditory elements are mentioned as an important supplement to visual materials. Notably, Ashley does not relate being a visual learner to visual thinking nor using language to think conceptually.

Access to More Input Supports Understanding. Ashley was initially asked during the pre-assessment (question nine) how she makes sense of the words in a text. Ashley explained that she first scans a page, then goes in for a deeper read. If she still didn’t understand the words Ashley explained, “I would refer to my notes or slides from a teacher, so that I could read it from different perspectives, and then that's usually how I make sense of it.” Questions and interpretations related to this statement were discussed and confirmed with Ashley during the first member check. The section that relates to her accessing more visual input is captured in Table 25.

Table 25

Conversation in Member Check Relevant to Pre-assessment Theme - "Access to More Input Supports Understanding"

Chris (Question/Interpretation)	Ashley (Answering)
If Ashley doesn't understand something she is reading, she will try to gain further clarification by reading notes, looking at the teachers slides to make sense of the ideas, or look at the ideas from various perspectives.	"Yes (that's accurate)."
Everything below (in your transcript) sounded like a visual document that you use to understand something better, is that correct?	Yes, that gives me visual access to understand something better.

As illustrated in Table 25, Ashley understood that she needed access to more visual materials if she struggled to understand what she was reading. This theme coincides with her understanding of herself as a visual learner. Overall the theme, "Access to More Input Supports Understanding," incorporates several different ways that students explain how gaining access to more input (meaning) helps their learning, but for Ashley it's specific to visual materials.

Seeing (Understanding) with Mental Images. Ashley was asked in the pre-assessment about how ideas make sense to her when reading or watching a video, as in the "light bulb (going) off." Ashley responded by expressing a feeling - an "aha moment," when a visual representation, like "bubble graphs where each line connects to more things… goes off" in her mind. Thus, Ashley briefly captured (metacognitively) how ideas make sense to her in a visual-mental capacity. Ashley is using a metaphor to describe her thinking process, which is a metacognitive statement about her visual thinking. Questions and interpretations of this statement were discussed and confirmed with Ashley during the first member check. The section that relates to her seeing with mental images is captured in Table 26.

Table 26

Conversation in Member Check Relevant to Pre-assessment Theme - "Seeing with Mental Images"

Chris (Question/Interpretation)	Ashley (Answering)
In school when an idea "goes off" in your mind, you typically write it down. Is this in-class and out-of-class?	Yes, in-class and out-of-class. Even sometimes randomly outside of the context of education, to help me remember.
What would you write down?	First thing that pops in my head about that idea. Usually, a real-world connection to the idea – as in something relatable to me.
So occasionally, you will connect ideas but usually writing things out as real-world connections. You would also make connections from previous classes. For instance, if you remembered something from a previous class, you would write out those ideas as well.	Ashley: [Non-verbal Confirmation].

As depicted in Table 26, Ashley makes a reference to her thinking, but not directly to mental images, when asked about what she would write down, "First thing that pops in my head about that idea. Usually a real-world connection to the idea – as in something relatable to me…". Mental imagery is based on concepts that people are learning or have learned, so if Ashley is picturing ideas that relate to her, those are previously learned concepts and/or events. This statement indicates that Ashley has a degree of metacognitive knowledge for what she thinks about (e.g., real world connections), but because she doesn't make explicit that these are 'pictures' the connection to visual thinking in the member check is unclear. However, it is clear that Ashley understood that writing down ideas she was thinking about helped her thinking. Ashley thus, explained a strategy that connects her metacognitive thoughts to her visual-motor movements (i.e., writing) to understand ideas better.

Focusing on Visual Movements of Speaker to Understand. In response to a question that asked Ashley what helps her understand people when they are speaking, Ashley discussed how she focuses on the visual movements of a person to understand them when they are speaking. Questions and interpretations from the pre-assessment that relate to Ashley focusing on speakers' movements were presented to Ashley during the first member check and her responses are captured in Table 27.

Table 27

Conversation in Member Check Relevant to Pre-assessment Theme - "Focusing on Visual Movements of Speaker to Understand Their Words"

Chris (Question/Interpretation)	Ashley (Answering)
When you say, you look at lips when people are speaking - I interpret that as you watched other people's lip movements to understand the meaning behind what they are speaking about. Is that correct?	"Yes."
And then you also try to assess a person's body language when they are communicating to you. Did you do both things (watching lips and body language) in casual conversation and in-class?	Yes, I do that in both settings. I do it more so in casual conversation, but I do try to do it in class as well, to be more attentive. Especially with face masks, it can be more difficult to follow somebody, so I consciously try to focus on body language.

Ashley's last statement in Table 27 about transitioning to reading body language because of the difficulty of understanding people with face masks, refers to the previously mentioned theme, "Transitioned from Reading Lips to Body Language," which Ashley was not originally coded for. Ashley mentioned in the pre-assessment that learning by listening was not as beneficial to her learning, which corresponds with Ashley supporting her visual processing (and attention) by focusing on body language.

Sometimes Unsure of Best Way to Learn Ideas. In response to question two and 13b in the pre-assessment which referenced the participants' meta-learning, Ashley indicated she doesn't always understand the best way to learn or study to get the most out of her learning (e.g., memorization for tests). Interpretations from the pre-assessment that relate to this theme, were confirmed with Ashley during the first member check. The sections that relate to Ashley not always knowing the best way to learn are captured in Table 28.

Table 28

Conversation in Member Check Relevant to Pre-assessment Theme - "Sometimes Unsure of Best Way to Learn Ideas"

Chris (Interpretation)	Ashley (Answering)
Ashley hadn't thought a lot about her own learning, thinking, and studying in the context of education before the (ASC) (and this interview). In her life educators didn't bring attention to those topics often. Learning, thinking, and studying are things that Ashley does, and she has strategies that suit her learning, but these things are not regularly reflected on.	"Yes, that's very accurate."
Sometimes Ashley doesn't know what's the best way for her to understand something (i.e., academic material). So, she needs to have somebody use a visual, step-by-step example, e.g., the teacher modeling a specific formula on a white board.	Yes, it is (as in the statement is accurate)."

Summary of Ashley's Understanding of Learning. Ashley showed some metacognitive knowledge for herself and others as visual learners. Specifically, Ashley understood she needed visual stimuli (cues) in a learning situation, e.g., mouth movements, body language, step-by-step examples, etc., to help her process ideas and think through problems. Ashley assigned meaning to her visual thinking in one pre-assessment question, related to reading/watching a video, and explained in the member check that she occasionally wrote down the connections she made to those ideas to help her understand the ideas she was learning better. It's not fully apparent if Ashley understood those connections as visual mental connections (i.e., mental pictures). To understand people when they are speaking Ashley focused on their visual movements, which also acted as a cue to help her pay attention. Though, Ashley is aware that she processes visual information best, and has some awareness that her visual-mental thoughts (i.e., mental images) can be a source of understanding, she does not always understand how to learn/study at her best.

Abby's Understanding of Learning. Prominent quotes and themes in Table 29 illustrate how Abby assigned meaning to her thinking and learning during the pre-assessment.

Table 29

Corresponding Quotes and Themes that Explain How Abby Understood Her Learning.

Questions	Relevant Themes	Prominent Quotes
Question 3, follow-up, PK section Can you explain how you think you learn best?	1) I am a Visual Learner [MK] 2) Visual Shapes Support Understanding [MK] 3) Hand-written Ideas Support My Understanding [MK]	Along with visual learning, I'm also a very hands-on learner. So, I tend to write things out rather than have it digitally. I feel like if I write things out, it's ingrained in my head, and I have a set format especially if it's on paper or something that I can see, that helps guide my thinking and my learning.
Question 3, follow-up, PK section When you say digitally, do you tend to write things out or you tend to type things out or do a little bit of both?	1) Creating (Meaningful) Visual Formats for Learning [MK|MR (Control)] 2) Hand-written Ideas Support My Understanding [MK]	I like to outline the processes of thinking or of an assignment or steps that I would have to go through in order to complete something. Generally, outlines and to-do lists. Mostly, on paper with pen because it helps repeat better, but occasionally on digital platforms as well.

Question 7, follow-up, AoC Section You're reading or watching a video, and something clicks, as in you understand it. Like the light bulb goes off. How do the ideas make sense to you?	Relating Prior Knowledge/Experiences to What I'm Learning [MR (Control), MetStrat | MK]	I would apply those ideas to my personal experiences. For example, I would be reading a book, [unintelligible] that talks about the journey and self-realization and stuff like that. I would relate it to me based off of personal experiences that are similar to the ones in the book. I'd like to compare, and contrast based on what I already know or what I've already been through. That helps a lot with my understanding.
Question 8, AoC section What do you do, if anything, that helps you understand what they're saying?	1) Focusing on Visual Movements of Speaker to Understand Their Words. [MR (Control)] 2) Focusing on Lip Movements [MR (Control)]	I like to look at their facial expressions. Facial expressions play a big part, especially when it's someone talking directly to me. I like to make eye contact. I make contact with the movement of their mouth when they form the words they're speaking and just giving them my attention.

Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, ML = Meta-learning, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Abby's case summary and further developed the document with Abby in a member check on Nov. 7th, 2021, approximately six weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Abby's responses and were confirmed with her as being accurate in the member check. Any direct statements are listed in quotation marks.

I am a Visual Learner. Abby was the only student in the pre-assessment to report she had "more than a few experiences" in which a teacher or counselor helped her learn about learning. Correspondingly, Abby was the only student to rate their understanding of learning as high, an "8,9" at the beginning of the pre-assessment. Potentially, as a result of these previous experiences and the metacognitive confidence she reported, Abby made several statements about who she was as a learner, e.g., a "visual learner," a "hands-on learner," and an "independent thinker." Only statements referring to herself as a visual learner contributed to a pre-assessment theme. Questions and interpretations from the pre-assessment that related to Abby being a visual learner, were presented to Abby during the first member check and her responses are captured in Table 30.

Table 30

Conversation in Member Check Relevant to Pre-assessment Theme - "I am a Visual Learner"

Chris (Interpretations/Questions)	Abby (Answering)
Abby is a visual learner - meaning, her experiences have led to a belief that she learns best visually. This means that Abby learns well by seeing others perform examples. Seeing other people do something (like in a class) helps to create understanding. This also means that Abby likes to write out notes and see the words on the page. Writing the words helps create understanding. Seeing the words helps guide Abby's thinking and learning. How so? My initial interpretation is that seeing the notes helps guide the process of learning and thinking (like a working system) and seeing the words can help with understanding? Is this accurate?	[Abby read through the interpretations on Zoom and confirmed them, and then answered the question.] Yes, the "working system" is accurate, for sure. Also, seeing the words helps me engage with the learning process and with learning (understanding) in general.
In this context, when you said you are a "hands-on learner," does that mean that you like to write things out, so you can see the words written out in your own writing? Anything else?	As long as I am doing something - like writing things out, typing things out, developing visual flowcharts, annotating a book (underline and highlight). As long as I'm using my hands and engaging with the concepts then I feel like I'm retaining the information better.

In the pre-assessment, Abby stated she was a visual learner and related that to preferring to learn by example and asking for clarification, without making a clear connection to how learning by example related to visual learning. In the member check, the researcher and Abby were able to further develop how Abby understood her learning from a visual perspective. Abby confirmed that she learned best through visual examples and that physical movements, e.g., writing, drawing, highlighting, etc., while seeing the words (ideas) helped her engage in the learning process and retain information better.

During the pre-assessment Abby referred to herself as a "hands-on learner" and discussed how writing ideas out on paper, physically rather than typing, helped her understanding. Ashley may have been referring to a kinesthetic learning style, which is a preference for learning associated with getting hands-on experience. It’s likely based on the literature from Chapter 2 and Abby’s rationale, that Abby utilizes visual-motor processing to think and learn, and her statement in the member check (see Table 30) that *using her hands and engaging with the concepts helps her retain information better,* is a further indication that Abby needs visual-motor access to help process information effectively. Therefore, Abby’s explanation of being a hands-on learner is likely to coincide with being a visual learner who needs visual-motor (multi-sensory) access to create semantic connections to ideas. For example, Abby confirmed that she has a “working system” for notetaking. In this system, Abby created meaningful *formats* for her notes through writing, highlighting, drawing concepts maps, and using headers, bullet points, etc. “Formats” in this sense references a meaningful way to organize/arrange ideas. Creating formats in such a manner, would require primarily visual and motor systems working in tandem to achieve mental tasks. Cumulatively, Abby reported that the ways she captured (or formatted) ideas (primarily) on paper helped her to categorize, connect, remember, learn, and think with ideas better.

Additionally, Abby stated she liked to "outline the processes of thinking… or steps that I would have to go through in order to complete something." She later explained in the member check that outlining helps her to feel more organized, "especially with being able to visually see the concepts and group them (like under header or sub-header)." Therefore, it seems clear that Abby understood that both visual and motor or "hands on" techniques helped her process information more effectively, though they were discussed separately. It's possible that seeing the ideas laid out in a meaningful way could also help somebody feel more organized but that's unclear. Themes in the pre-assessment that relate to Abby creating a system for notetaking or other meaningful visual formats include, "Creating (Meaningful) Visual Formats for Learning," "Hand-written Ideas Support My Understanding," "Visual Shapes Support Understanding," and "Breaking Down Ideas on Paper to Understand." More about what Abby does, in terms of strategies, as a visual learner will be discussed in the next research question.

Relating Prior Knowledge/Experiences to What I'm Learning. In response to a question that asked Abby how she understood ideas, when reading or watching a video, "like the light bulb going off (effect)," Ashley indicated that she related the ideas she was learning with previous experiences/knowledge. While this was a prominent theme for Abby, it was not prominent for the group of focal participants. Questions and interpretations from the pre-assessment that related to Abby mentally relating ideas were presented to Abby during the first member check and her responses are captured in Table 31.

Table 31

Conversation in Member Check Relevant to Pre-assessment Theme - "Relating Prior Knowledge/Experiences to What I'm Learning"

Chris (Interpretations/Questions)	Abby (Answering)
Abby likes to use prior knowledge and relate it to new concepts for most subjects.	If it's relatable or it's something that is important to know. (cont'd)
How? My initial interpretation is this may be something you do in your notes by replacing words you don't know with words you do know. Any other ways?	It's replacing words I don't know and replacing it with words I'm more familiar with, that creates an easier explanation that's understandable. If there's learning by example, I would try to relate it to past experiences, or draw from experience; this is more on the mental side. I sometimes use note-taking strategies to do this as well.

In the pre-assessment Abby mentioned the strategy of mentally relating ideas to past experiences, when referencing 1) learning in general, 2) listening to a teacher speak in class, and 3) learning situations outside of class (e.g., watching a video or reading). Abby mentioned that she engaged in this strategy to understand new ideas better. However, Abby's references to relating ideas to previous experiences/knowledge did not capture much situational or procedural knowledge. In other words, it was hard for the researcher to understand what this strategy entailed in specific situations. The researcher and Abby briefly discussed this mental behavior in the member check. Notably, there were no explicitly assigned meanings to visual thinking in the pre-assessment nor the member checkup in this specific exchange; so, it's unclear if Abby engaged in this strategy through utilization of visual-mental images.

Originally the researcher thought that perhaps relating ideas to past experiences and writing ideas in her own words were a connected strategy that Abby captured on paper, but in the member check, Abby explained them as two separate (mental) strategies, captured as the following pre-assessment themes: “Relating Prior Knowledge/Experiences to What I'm Learning” and “Writing Ideas in My Own Words to Understand.” Abby’s reference in Table 31 that she used notetaking strategies to relate ideas to previous experiences could mean that she occasionally captured the mental relations on paper.

Additionally, Abby explained in the member check that she replaced words from class with her own words (ideas) to create a better explanation. The utilization of one’s own words (i.e., natural language) was discussed in the ASC prior to the pre-assessment and throughout the learning and thinking block. Thus, Abby was metacognitively aware that she engaged in more than one mental strategy to create more meaning for her thinking, which helped her understand new ideas. This indicates both metacognitive knowledge and regulation for at least two mental strategies, though it’s unclear how developed or refined these mental strategies were in practice.

Focusing on Visual Movements of Speaker to Understand Their Words. In response to a question that asked Abby what helps her understand people when they are speaking, Abby reported that she actively focused on people's lip/mouth movements to understand their spoken words (ideas). Questions and interpretations from the pre-assessment that relate to Abby focusing on speakers’ movements were presented to Abby during the first member check and her responses are captured in Table 32.

Table 32

Conversation in Member Check Relevant to "Focusing on Visual Movements of Speaker to Understand Their Words"

Chris (Interpretations)	Abby (Answering)
Abby likes to look at facial expressions, gestures (e.g., bodily movement), and people's mouth moving to understand what people are communicating when speaking.	Yes, that's accurate.
Face masks have impaired being able to look at facial queues or mouth movements, so Abby tries much harder to engage with what people are saying, generally in an educational context.	Yes.

Abby confirmed in the member check that she actively focused on people's mouth movements and body language to understand their words (ideas). Additionally, Abby mentioned in the pre-assessment that because of facial coverings, due to the Covid pandemic, she paid more attention to the physical movements (cues) of a speaker, e.g., body language. Abby doesn't explain in the pre-assessment why following others mouth movements or body language helped her understanding, stating "I know more about what I wouldn't understand…". However, Abby did knowingly and actively focus on visual movements, which shows Abby had metacognitive knowledge for how she effectively processed information in listening situations. Furthermore, Abby was aware that her understanding struggled when speakers wore face masks and tried to resolve that issue by focusing on other visual cues.

Summary of Abby's Understanding of Learning. Abby indicated that the pre-assessment interview helped her "to realize that there are probably more effective ways of learning that could be more helpful and that I am bias to my understanding of learning." This statement suggests Abby learned something about herself as a learner while in the interview setting that may be helpful going forward but also stated she was "very comfortable" with where she was at. Abby understood in the pre-assessment that she was both a visual and hands-on learner, in terms of needing to see things explained/laid out and using her hands to create formats on paper to develop understanding. As previously stated, being a visual and hands-on learner, coincides with literature that would suggest Abby uses visual and motor systems to process information to understand ideas more effectively.

The previously listed themes in Table 29, align with how Abby understood herself as a visual and hands on learner, "Focusing on Visual Movements of Speaker to Understand Their Words," "Visual Shapes Support Understanding," "Hand-written Ideas Support My Understanding" and "Creating (Meaningful) Visual Formats for Learning." Thus, Abby understood that she needed to see visual examples and other visual cues (e.g., speakers' movements), as well as create hand-written, visual formats to help make ideas understandable. Additionally, Abby understood that she created understanding by relating academic material to previously learned and/or experienced ideas. Provisional coding indicated Abby had a degree of metacognitive control for mentally relating ideas to previous knowledge. Abby did not assign meaning to visual thinking in the context of learning in the pre-assessment nor in the member check excerpts previously listed, though she does assign meaning to visual thinking when discussing the theme "breaking down ideas on paper to understand," which will be discussed in the next research question.

Coreen's Understanding of Learning. Prominent quotes and themes in Table 33 illustrate how Coreen assigned meaning to her learning during the pre-assessment.

Table 33

Corresponding Quotes and Themes that Explain How Coreen Understood Her Learning.

Questions	Relevant Themes	Prominent Quotes
Question 2, UoL section Can you tell me why you placed yourself at that point (in your understanding of learning)?	Still Figuring Out What Works Best for My Learning [CK | MK]	…I'm learning how my brain best likes to repeat this information. It's steadily increased as I'm learning more about myself and trial and error, unfortunately, lots of errors so far, and just what works for me to understand.
Question 3, PK section As a student, looking at other students, what have you noticed about how other students in general, learn best?	Communication in Groups Helps with Challenging Ideas [CK]	…I realize that group study sessions, they're not usually one person teaching the group, they're everybody bouncing ideas off of each other to help everyone understand, which is never how I did it because I was always that teacher in the group helping other people understand. That's the whole point of me looking at others as being like, "I don't know how to study. How do you guys do it?"
Question 8, AoC Section Okay, as they are speaking, how is it that you understand them best? What do you do if anything that helps you understand what they're saying?	Focusing on Visual Movements of Speaker to Understand Their Words [MR (Control)]	… I've moved to looking more at their body language and not just their lips, but their hands, and their shoulders, and that's helped a little bit. … (cont'd) and I have to pay so much more attention than I used to, with just lips because seeing the physicalness of them moving helps me understand what I am hearing.
Question 8, follow-up, AoC Section: …is there anything that you know about yourself and your own thinking that helps you understand other people when they're talking?	Visual Shapes Support Understanding [MK]	I know that I do not learn auditorily. I've always accepted that for the longest time. Like subtitles on a TV show, no matter how loud it is, so I've known that I can't just listen to someone. If I'm hearing them talk, I turn and I look at them if I can. I need to.

Question 9, AoC section When reading a textbook for one of your classes, so when reading the words on a page, how do you make sense of the words?	Motivational to See Mental Images [MK, ME, VT]	…getting my mind engaged, it's such a difficult process. Especially in history textbooks, I have to make a movie in my brain to get me guessing to what comes next, so I actually care about reading further because if I'm just reading this to read it, I'm not going to care enough to comprehend it…

Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, ME = Metacognitive Experiences, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Coreen's case summary and further developed the document with Coreen in a member check on Nov. 9, 2021, approximately six weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Coreen's responses and were confirmed with her as being accurate in the member check. Any direct statements are listed in quotation marks.

Still Figuring Out What Works Best for My Learning. In responses to questions two, five, ten, eleven, and twelve of the pre-assessment the theme, "Still Figure Out What Works Best for my Learning" emerged from Coreen's interview transcript. At the beginning of the pre-assessment Coreen rated her understanding of learning at a six, though she said if you would have asked her in high school "I would have been at like a two." Coreen explained she would receive good grades in high school simply by taking notes and paying attention in class, "I would take the notes and take the test and boom, there's an A." After entering college, she said, "I don't feel very confident in how I learn." There was an awareness that the strategies she once applied would not be enough in college. Coreen stated in the pre-assessment she recently started to reflect more on her own learning, and what learning strategies worked best, "every week, I see a difference in my notes from week one…, I'm learning how my brain best likes to repeat this information." Questions and interpretations related to Coreen figuring out what worked best for her learning were discussed with Coreen during the first member check and her responses are captured in Table 34.

Table 34

Conversation in Member Check Relevant to Pre-assessment Theme - "Still Figuring Out What Work Best for My Learning"

Chris (Interpretations/Questions)	Coreen (Answering)
When you said, "how (your) brain likes to repeat this information," what did you mean?	"How do I know what needs to be important" is what I was thinking then. 'How to study the material and organize my thoughts.' 'What thoughts come to my mind first,' for a particular subject – making sure what is written (in terms of my notes) is important in relation to what's important for performance on a test.
So the "repeat this information" comment was in relation to finding what's meaningful in the context of the course and making sure that's what's important will also be on the test.	[Non-verbal confirmation]
Coreen's first reflections of her own thinking, learning, and understanding started with the (ASC) class, so this was all very new.	[Non-verbal confirmation]
The failed grade in the bio exam (beginning of first college semester) sparked something in Coreen to start asking questions about her own learning.	[Non-verbal confirmation]
What spurred this change over the last two years?	The failure in the Bio exam spurred the changes.
Academic material was not engaging nor meaningful for much of the time in K-12, except when Coreen was struggling.	"I like a challenge."

That's why Coreen chose Nursing - she wanted something challenging, that would push her, and she knew she would struggle in the field of Nursing.	"It's a purposeful thing to struggle." I wanted to struggle and actively sought that in her first few weeks of college.

Note. For clarity, the pre-assessment interview occurred after a one-week period in which Coreen failed a Biology exam and engaged in the first 'learning and thinking block' class. This first class explored how learning works neurobiologically, and recommended strategies students could apply to get more out of their learning.

As illustrated in Table 34, the underwhelming performance on the Biology exam, coincided with the ASC class, and contributed to changes to Coreen's approach to learning. In reference to question twelve, which asked how Coreen went about learning confusing ideas, Coreen stated:

> I can't think of any experience I've had where I've tried to combat that other than like this week after I didn't do too well on my bio exam and like realizing I need to work harder and then really struggling (with the teacher's) lectures this week. As much as I am making these improvements, I still don't understand much of it. It's a very new experience for me."

Coreen didn't apply many learning strategies in high school, and she had been successful, so it was difficult for her to think about what do when presented with challenging topics. Additionally, Coreen struggled to engage with academic topics. When the researcher discussed in the ASC, how it can be difficult for people to learn concepts that they aren't interested in, because they can struggle to create semantic relationships, Coreen began to reflect on how she could make the subject matter interesting, "…and it made me self-reflect a lot when you made your presentation and it was just like, "Yes, I'm reading." But…that makes sense why I don't comprehend because I don't care." Coreen also thought about ways to slow down her reading to comprehend the material better, "…especially with history textbooks, I find myself having a really hard time comprehending it because my eyes and my brain move really fast, and then it's like, "I don't remember any of that." Therefore, Coreen was learning more about what worked best for her when she didn’t fully understand academic material and when engaging in academic material during the first seven weeks of the semester. It’s also important to note that Coreen reported in the member check, that she wanted to struggle, and the struggling pushed her to try harder and learn more about herself.

Communication in Groups Helps with Challenging Ideas. In responses to question three, five, six, and twelve of the pre-assessment, the theme “Communication in Groups Helps with Challenging Ideas” emerged from Coreen’s interview transcript. Coreen explained she often taught academic material to other students in high school. She also explained that she noticed how other students bounced ideas off each other, which helped them learn, though those were not her experiences. Questions and interpretations related to learning in groups settings were discussed with Coreen during the first member check and her responses are captured in Table 34.

Table 35

Conversation in Member Check Relevant to Pre-assessment Theme - “Communication in Groups Helps with Challenging Ideas”

Chris (Interpretations/Questions)	Coreen (Answering)
Coreen was often the teacher. So, are these strategies (e.g., teaching the material) something you consciously engaged in while in high school or unconsciously participated in or observed?	“I was aware of my role as a teacher.” I did this to help others but was aware that it helped her (peers’) understanding as well. [This comment was made in reference to Coreen’s performance on the bio exam in her first 7 weeks of college.] There was an understanding that there was some struggle with college academics and the (ASC) gave me a direction and helped guide reflection about learning/thinking and strategies to use in relation to learning.

Did these strategies recently make sense because of our class, or did they layer on your understanding, or were you always aware of how people might be learning best and how you could also use these strategies to learn best?	I started to understand new strategies and ideas for thinking and learning (as in how they made sense in my previous experiences and uses of them) because of the (ASC) itself.

Using language to communicate ideas and teach the material within a group, was a prominent theme that emerged in Coreen's pre-assessment. Coreen referenced in the pre-assessment that the language strategies presented in the ASC, prior to the pre-assessment "made sense" to her. In the member check (see Table 35), Coreen explained that the ASC helped guide reflection about learning and learning strategies to apply. Thus, Coreen had already begun learning about her learning when the pre-assessment occurred. By the member check, approximately six weeks later, Coreen stated that she understood new strategies and why they could be helpful. More about the strategies that Coreen and others began to apply will be discussed in the following two research questions.

Focusing on Visual Movements of Speaker to Understand Their Words. In response to question eight, which asked what helps you understand people when they are speaking, Coreen reported that she focused on people's lip/mouth movements to understand their spoken words (ideas). A question that related to Coreen's focus on speakers' movements was confirmed with Coreen during the first member check and her responses are captured in Table 36.

Table 36

Conversation in Member Check Relevant to Pre-assessment Theme - "Focusing on Visual Movements of Speaker to Understand Their Words"

Chris (Interpretations)	Coreen (Answering)
So, you watch lips as a way to understand, as well as body language (when there are no face masks?)	Lips give me something to focus on - it provides extra meaning - keeps me engaged and listening to the conversation or discussion.

In the pre-assessment, Coreen explained why focusing on lip/mouth movements helped her effectively processes information when others were speaking, stating that "seeing the physicalness of them moving helps me understand what I am hearing." Coreen added more depth for her original response in the member check (see Table 36) saying her focus on lip movements provided extra meaning for her, and the act of focusing on lip movements helped her stay engaged in conversations. Coreen's responses indicate metacognitive awareness of how she created meaning when others were speaking as well as metacognitive control over her focus.

Other Visual Themes. Coreen was coded for several themes that related to aspects of being a visual learner, such as "Visual Shapes Support Understanding," "I am a Visual Learner" and "Motivational to see Mental Images." For clarity and brevity these themes are discussed collectively in this section. Questions and interpretations related to Coreen's visual thinking and learning were presented to Coreen during the first member check and her responses are captured in Table 37.

Table 37

Conversation in Member Check Relevant to Themes - "Visual Shapes Support Understanding," "I am a Visual Learner," and "Motivational to See Mental Images"

Chris (Interpretations)	Coreen (Answering)
You do not learn well through auditory information.	"No. I need visuals."
Coreen learns best through: - Communicating ideas to peers and to a lesser extent to instructors. - Visual input, like subtitles, reading lips, body language, and seeing things broken down into steps.	[Non-verbal confirmation]
Coreen might create a movie in her mind to engage in the ideas being presented – but this is done unconsciously. This occurs in subjects that lend themselves to a storytelling context. Is this done to engage, or does it just naturally happen?	This is automatically how I process information for all subjects. But I did this unconsciously. "I learn by having movies in my head." This was something I naturally did with information – (she said she 'needs a visual'). I had no idea it was a strategy for understanding or learning.

Coreen was metacognitively aware in the pre-assessment that she did not process auditory information well and instead needed to see visual shapes/movements (e.g., subtitles, mouth movements, body language) to understand information effectively. Coreen also confirmed that she needed visual input to learn well in the member check (see Table 36).

Additionally, in the pre-assessment Coreen explained that creating *movies in her head* motivated her to engage with the challenging topics she was reading about. However, Coreen's statement in the member check, "I learn by having movies in my head," is more in line with the theme, "Seeing (Understanding) with Mental Images" than with "Motivational to See Mental

Images." This is a strong indication that Coreen developed metacognitive knowledge for her visual thinking over the course of the of the ASC. Coreen realized that she learned through the movies she saw in her mind, although she was mostly unaware this was happening in her education prior to college.

Summary of Coreen's Understanding of Learning. The prominent theme that emerged from Coreen's pre-assessment was "Still Figuring Out What Works Best for My Learning," meaning Coreen was aware and actively trying to improve her learning. Specifically, Coreen realized she struggled with what to do when presented with challenging topics. The poor performance on her Biology exam was an impetus for change and the ASC helped to guide her meta-learning. Shortly thereafter, Coreen began to reflect more on ways she learned (e.g., reading, notetaking) and apply new strategies to support her thinking and learning. Coreen reported that the pre-assessment itself helped her to think about her learning, "…it's really making me self-reflect and I can use this. This is…extremely important to what I've been trying to do for the past week and what I've thought about for months now."

During the pre-assessment, Coreen explained that reading subtitles (for tv shows) and focusing on lip movements helped her to understand people when they were speaking. This shows Coreen was aware she relied on visual input in casual situations to support her understanding, e.g., watching the motion of lips move to process the ideas as movement/shapes. Additionally, Coreen stated she doesn't learn well from auditory information, thus the connection to being a visual learner is evident.

Lastly, Coreen did not assign meaning to visual thinking in the pre-assessment, in terms of supporting her thinking/understanding. However, Coreen did discuss seeing mental movies helped her stay engaged when reading challenging texts. In this case, visual thinking (i.e., mental movies) may have had a motivational effect and perhaps indirectly supported Coreen's learning. In the member check, there's a noticeable change. Coreen does not mention the motivational element but rather focuses on mental movies as the source of her processing and learning. Coreen is also aware that her (mental) movies occur for topics that are story-based (i.e., more meaningful). This response from the member check indicates a change in metacognitive knowledge that aligns with Coreen's visual thinking and learning and corresponds with her meta-learning at the outset of the study.

Daniel's Understanding of Learning. Prominent quotes and themes in Table 38 illustrate how Daniel assigned meaning to his thinking and learning during the pre-assessment.

Table 38

Corresponding Quotes and Themes that Explain How Daniel Understood His Learning

Questions	Relevant Themes	Prominent Quotes
Question 2, follow-up, UoL Section Okay, great yeah that makes perfect sense. Can you explain the 50% of the time when it does work and, like what recording yourself what that provides you?	1) Using Dialogue to Support Thinking/Learning [MK|MR (Control, MetStrat, MetSkills], 2) Using My Own Words Supports Thinking [MK]	I know that I like to record myself saying the material and then listen to myself saying the materials so that way I know I understand it. (cont'd) …but then at the point where I thought oh my explanation here wasn't -- my spoken explanation wasn't clear enough, and then I can delve more into that.
Question 7, AoC Section So, you're reading or watching a video and then something clicks as in you understand it, like the light bulb goes off. How do the ideas make sense to you?	Seeing (Understanding) with Mental Images [MK, VT]	…when I understand all the parts of something I can visualize it in my head and that's when I would say, I like, that's the moment of understanding.

Question 8, AoC Section As they are speaking, how is it that you understand them best? So, what do you do if anything that helps you understand what they're saying?	1) Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills] 2) Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills] 3) Seeing (Understanding) with Mental Images [MK, VT]	When they're talking to me, I like to take the story and I like trying to like place myself into that third person like view of their story and try to visualize every element. (Cont'd)… if I can first hear it, like everything described, and then take the parts that I've heard, and then put it all together into one little scene that I can visualize, that's where I think my understanding and learning is.
Question 9, AoC Section So, when reading a textbook for one of your classes in this place, so when reading the words on the page, how do you make sense of the words?	1) Seeing (Understanding) with Mental Images [MK, VT] 2) Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat, MetSkills]	I just see the words in my head is what I would say. And then if there's ever any diagrams those will pop up in my head too. But I will try and take the words from the paper or the image from the paper and just put it in my head, into like a mental scape where I can see it.

Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, MetSkills = Metacognitive Skills, MetStrat = Metacognitive Strategies, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Daniel's case summary and further developed the document with Daniel in a member check on Nov. 15, 2021, approximately seven weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Daniel's responses and were confirmed with him as being accurate in the member check. Any direct statements are listed in quotation marks.

Using Dialogue to Support Thinking/Learning. In response to question two of the pre-assessment, which asked how do you think you learn best, Daniel reported that he liked to record himself speaking about academic material, and that hearing his voice back helped him to recognize what he understood and parts of his explanation that were still unclear. A question about using dialogue in this manner was presented to Daniel during the first member check and his responses are captured in Table 39.

Table 39

Conversation in Member Check Relevant to Pre-assessment Themes - "Using Dialogue to Support Thinking/Learning" and "Using My Own Words Supports Thinking"

Chris (Questions/Interpretations)	Daniel (Answering)
Did you engage in these learning strategies (e.g., breaking down explanation) when you understood something in class or is it only when you don't understand the material as well?	- I have done this for every class since Freshman year of high school. This strategy is an active and ongoing strategy that works very well for me. - Listening to a recording of myself helps outline a specific logic and make it clear what ideas aren't connecting to the other ideas, and maybe which ideas aren't being discussed more fully. - This strategy helps to create a more revamped explanation – more clarified, logical explanation.

As illustrated in Table 39, Daniel understood that use of his own language (words) could help him develop clearer logic for academic concepts. By engaging in a dialogue and monitoring his own language (upon playback), he could find areas of his explanation that needed refinement (e.g., what ideas weren't connecting). Daniel reported in the pre-assessment this strategy was primarily used for subject matter where language-based logic was important, such as history or English (e.g., not math). Additionally, Daniel confirmed in the member check this strategy only works about 50% of the time for concepts Daniel already understands. The other 50% of the time Daniel was still searching for what worked best for his learning.

Seeing with Mental Images. In response to question seven, eight, and nine of the pre-assessment, the theme "Seeing (Understanding) with Mental Images," emerged as being prominent from Daniel's transcript. This theme suggests that Daniel was metacognitively aware that he understood ideas/concepts through mental images. Other visual thinking themes that were provisionally coded as metacognitive regulation (MR) also emerged (see Table 38), the most prominent being, "Creating Context through Visual Thinking". Most questions and interpretations related to Daniel's visual thinking were presented to Daniel during the first member check and his responses are captured in Table 40.

Table 40

Conversation in Member Check Relevant to "Seeing with Mental Images," and Other Visual Thinking/Visualizing Themes from Table 38.

Chris (Questions/Interpretations)	Daniel (Answering)
Do you jump in and out of the other persons perspective and your own perspective? How often did you do this?	I do this every time I listen to somebody, I care about speaking. Or when somebody is saying something interesting and engaging. [So, this is a mental activity that Daniel does on an active basis.] I'm primarily trying to put myself in another person's shoes and what they're thinking and feeling.
What specifically does this mental activity help with when reading (i.e., visualizing words coming off page)? It sounds like it helps with retaining and categorizing information. Is that correct? Anything else?	It helps with retaining and categorizing information.

In the member check, Daniel explained that when somebody is speaking to him, and he is engaged, he will listen to what they are saying and try to "visualize" (i.e., visually think about) the ideas from the speakers' perspective, which gives him context to understand the speakers' words. Daniel also confirmed in the member check, that when he understands something well – as in all the parts of an idea - he can visualize (see) it clearly.

When presented with a question about how Daniel made sense of ideas when reading, Daniel stated he pulled words off the page, which "isolated (them) from all the clutter," and helped him to see the ideas clearly. Daniel confirmed in the member check (see Table 40) that he engaged in this mental activity to better categorize and retain information. Daniel explained what this mental process looked like in the pre-assessment:

> …it's almost like sitting in my own room in my mind and just having the words decorate that room. And the most important (words) might be decorating that room in different colors to…make my brain retain them. And that probably helps with the fact that when I'm reading, I will usually highlight my textbooks…in different colors and so when they appear -- as I have them pop up in my brain, have them appear in those different colors to help signify that.

Although Daniel often saw *words* in his mind, he explained that he also thought of *pictures* if the concept related to something he's seen or learned before (e.g., a statue of Socrates). But for ideas he hadn't seen pictures of, he might only see words in his mind (e.g., the word "empiricism"). Seeing pictures both physically and mentally, may correspond with Daniel's preference to see ideas connected in visual structures (e.g., diagrams, flowcharts, arrows, and concept maps.)

> "I like flow charts like, seeing the flow of ideas. I like it when things are broken down into steps, otherwise I think sometimes diagrams can be really tricky to navigate through, because they can often be cluttered with like lots of different aspects that can just get in the way of the learning process."

Daniel confirmed in the member check he usually doesn't create these structures but viewing them helps him understand the material he is trying to learn better. Daniel connected his visual thinking to his highlighting strategy previously so there seems to be a connection between what he does on paper to what he sees in his mind, but the extent to that is not discussed further and is therefore, unclear.

Summary of Daniel's Understanding of Learning. Daniel was the only focal participant to assign meaning to his visual thinking (in terms of how he made sense of ideas) in both casual listening and reading situations in the pre-assessment. Daniel understood that his "visualizations" were the source of his understanding, and provisional coding indicated metacognitive control and strategic use of his visual thinking, e.g., visualizing contexts from another's perspective to understand ideas clearly. Daniel was also aware that he could better think with ideas that were captured through visual structures on paper or a screen (e.g., diagrams) but it's unclear if this relates to his ability to mentally 'see' those ideas.

Daniel also used his language, as a source of his thinking, particularly for subjects that were literacy-based (e.g., English). He engaged in an unconventional strategy, where he recorded himself and listened to his own explanation to identify where his thinking needed support. While language and visual thinking were discussed as sources of Daniel's thinking, the two were not mentioned together. Therefore, awareness for an interdependent visual thinking and learning process was not evident at this stage.

Dalisay's Understanding of Learning. Prominent quotes and themes in Table 41 illustrate how Dalisay (an ESL student) assigned meaning to her thinking and learning during the pre-assessment.

Table 41

Corresponding Quotes and Themes that Explain How Dalisay Understood Her Learning.

Questions	Relevant Themes	Prominent Quotes
Question 6, PK Section Can you tell me about a time in school when you were confused about something, and you were able to figure it out on your own?	Communication in Groups Helps with Challenging Ideas [CK]	I tend to work with other people to like help me figure out because, I don't know, for some reason I feel more comfortable reaching out to students than my own teachers. Because I feel like I can trust them or they will understand me more, empathize with me more than my teachers.
Question 7, AoC Section You're reading or watching a video and then something clicks as in you understand it, like the light bulb goes off. How do the ideas make sense to you?	Feeling of Knowing [ME]	So, based on how (I) understand is when I can relate to it. For example, I would watch a video how to start a streetwear company…and I know that I'm already interested but once I watch the video, like the steps, if I know I could do it, then I don't have to watch the video again.
Question 8, follow-up, AoC Section … (what) helps you understand other people when they are talking?	Using Dialogue to Support Thinking/Learning [MK|MR (Control, MetStrat, MetSkills]	Okay, I have like this voice in my head that…when I'm not talking, it's talking out loud in my head so it's like a conversation. And sometimes I talk to that person in my head…but when I have something in mind that I don't want to say out loud, I have that conversation with that person in my head.
Question 11, follow-up, S&S Section If they're talking, how do you create meaning out of what they're saying?	1) Seeing with Mental Images [MK, VT] 2) Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills] 3) Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills]	…talking about like (a) history event like the bombing of Pearl Harbor, if they're talking about that, I would picture myself in that situation and see for myself. And if I could understand that then I know what's happening.

Question 13, follow up, S&S Section …imagine that you leave here, and a friend asked you, "What happened in that interview? What was it about?" How might you answer that?	Learned About Myself as a Learner [MK, ML]	I would say I got to learn about myself as a learner. I will probably share my insight on, like, "I didn't know that I think about my learning this way. I didn't even know that I have conversations with myself in my head.

Note. Important to note, because of scheduling conflicts the pre-assessment interview occurred with Dalisay two weeks after the first learning and thinking block class, whereas for the other five focal participants it occurred one week after the first learning and thinking block class. Another Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, ME = Metacognitive Experiences, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Dalisay's case summary and further developed the document with Dalisay in a member check on Nov. 17, 2021, approximately six weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Dalisay's responses and were confirmed with her as being accurate in the member check. Any direct statements are listed in quotation marks.

Communication in Groups Helps with Challenging Ideas. In response to question six and twelve, the theme "Communication in Groups Helps with Challenging Ideas," emerged from Dalisay's pre-assessment transcript. Dalisay explained that she worked with peers to help her understand ideas when she was confused. Dalisay also discussed several affective elements in groups such as empathy and comfortability, which supported learning. Many of these 'affective' elements were structured in the "dispositions toward learning" (DTL) category, however, they did not translate to prominent themes in the study. Because these responses are integral in how Dalisay understood her learning, particularly when working with others, they are outlined in Table 42.

Table 42

Conversation in Member Check Relevant to Dispositions Toward Learning, Particularly in Relation to Group Settings

Chris (Questions/Interpretations)	Dalisay (Answering)
Empathy is intricately linked to learning for Dalisay.	"Yes."
This (empathy) is one reason why Dalisay likes to work with other students more than teachers, because she feels that students understand more about her and understand what she's going through.	"Definitely."
Dalisay feels she learns best when she is comfortable with the people around her, which allows for open conversations, and an environment where she can learn from others.	"Oh, yes."
So, you think students learn best when there is a more *personal* (e.g., building positive relationships, empathy) and *personalized* (e.g., face-to-face interaction, and visual input) experience in the classroom environment. Is that correct?	"Yes. That is very accurate." The students in (place of origin) need reassurance, so they find comfort when the teacher understands where they are coming from. When the teacher can meet the students where they are at, and help them understand the material, in that positive supporting role. For students to ask questions they need to feel comfortable sharing.
Dalisay felt like she needed to learn things on her own. If that didn't work, she would enlist the help of friends. Rarely would she reach out to the teacher for help.	"That's true."

As illustrated in Table 42, Dalisay was aware of several affective elements related to how she and her peers learned best (e.g., empathy, comfortability, personal attention). While these affective elements were not prominent themes in this study, they are integral to how Dalisay understood her learning and to her meta-learning in the context of the ASC.

Using Dialogue to Support Thinking/Learning. In response to question eight and twelve of the pre-assessment, the theme "Using Dialogue to Support Thinking/Learning," emerged from Dalisay's transcript. This theme indicated that Dalisay used dialogue internally and externally so support her thinking. In response to being asked about what helps her to understand when other people are talking, Dalisay's explained that she used inner (mental) dialogue to support her thinking when other people told stories. She specifically referenced a discussion with a family member, and how she carried on an internal conversation to help think about (and develop a response for) the family member's potential problem. Later in the pre-assessment, when the researcher Dalisay about the interview experience she stated that she learned about her own learning, specifically she realized that she had conversations in her head. A question related to Dalisay's use of internal dialogue was presented to Dalisay during the first member check and her responses are captured in Table 43.

Table 43

Conversation in Member Check Relevant to Pre-assessment Theme - "Using Dialogue to Support Thinking/Learning"

Chris (Questions/Interpretations)	Dalisay (Answering)
Did these multiple conversations (in your head) help you understand or help make sense of what somebody was saying -OR- do they help you more for figuring out how to respond to the person you are communicating with?	When I have conversations in my head, I'm going to try to give you a good answer to what you have said – like a good response back. When someone shares something with me, I want to make sure that I put effort into thinking about that – as in processing what they're saying and reflecting on it. Having multiple conversations (in my mind) also helps me make sense of what another person is saying. When a teacher is speaking, I'm actively having a conversation in my mind about what the teacher is speaking about - reflecting on whether I understand that well, and if it's confusing, I try to connect it to things that I know. So, I'm continually trying to ask myself if I understand something a teacher is

	speaking about. Sometimes I don't get all the information the teacher is saying, because I'm stuck in my head trying to make sense of things. When I do, I might miss other information.

Dalisay explained in the member check see (Table 43) that internal dialogue (conversations) helped her to reflect, understand, and develop an appropriate response in a discussion-based situation. Dalisay also mentioned that she used internal dialogue to relate ideas to previous knowledge and monitor her learning (e.g., asking questions of her understanding). Those mental strategies were not discussed in relation to internal dialogue in the pre-assessment. Dalisay is also metacognitively aware of a challenge when engaging in this mental activity - that she can get "stuck" in her own mind," and miss information from class. Such complexity in the member check indicates a change (i.e., development) in metacognitive knowledge for utilization of internal dialogue for thinking in learning situations. Again, Dalisay reported becoming aware that she used internal conversations, some six weeks prior in the context of the pre-assessment interview. As, will be discussed in subsequent research questions, Dalisay's use of internal dialogue corresponded with more strategic use of her own natural language as the semester progressed.

Feeling of Knowing. In response to question seven of the pre-assessment, the theme "Feeling of Knowing," was coded for Dalisay's transcript. Dalisay stated that she made sense of ideas when reading by being able to "relate to it." However, there was no indication how relating ideas was carried out or what the relationship was; thus, the researcher interpreted these responses as a feeling that Dalisay experienced when she made a connection between what she was learning and her own experiences. For context, Dalisay explained what relating is like when watching a movie:

Maybe like a movie, you can watch the movie one time and understand all the plotline is because you can understand it, like you can relate to it, versus learning, watching a math video, I don't know how to relate myself with numbers. So, it takes me more time to try to find a place to relate with numbers than watching a how-to video or an instructional video basically, so, yes.

Dalisay's feeling of knowing may be dependent on how Dalisay makes relations/connections when thinking but it's not explicitly stated in the pre-assessment. Questions and interpretations related to Dalisay relating ideas were presented to Dalisay during the first member check and her responses are captured in Table 44.

Table 44

Conversation in Member Check Relevant to Pre-assessment Theme - "Feeling of Knowing"

Chris (Questions/Interpretations)	Dalisay (Answering)
Dalisay *feels* she is learning something well when she can relate to it – meaning whether it's applicable or relevant to her own life and whether it's interesting and something that could be applied to her life in the future.	"Yes. All the above."
Your understanding and/or learning is connected to whether you can relate to the material being presented. As in, whether you can make a connection from what you did know to what you are learning.	That is second nature for me to do. Anytime I'm presented information that feels like it's too much to comprehend, I have a fear that I may not understand it, so my mind instantly begins to make connections with what I'm being taught to what I already know – and this helps me better understand what I'm being taught.]
Is that usually something that is conscious in your mind, or did you do this unconsciously? Were you actively trying to make connections with what you know to what you are learning to learn the material better?	My mind kind of does this automatically. It can be based on fear. I instantly make connections to help me understand. I try to comprehend by connecting the ideas to what I know. So, there's a bit of an anxiety like 'I need to learn this' so I'm going to connect it with something I know.

Dalisay explained in the member check (see Table 44) that she automatically made connections between new ideas and previous knowledge. These "connections" may correspond to Dalisay's use of internal dialogue to create relationships between ideas, as she discussed in the member check - *I'm actively having a conversation in my mind about what the teacher is speaking about - reflecting on whether I understand that well, and if it's confusing, I try to connect it to things that I know.* However, it's difficult to determine whether Dalisay uses or is aware she uses internal dialogue (conversations) to drive this mental connecting behavior and whether this is done automatically, as she described the connecting behavior in Table 44. The researcher interprets Dalisay's explanation for how she understands ideas when reading/watching videos as connections (integrations) between what she's learned and what she's learning. This leads to a feeling she understand something well. How the connections are made are not overtly clear, but it is plausible that she connects them through internal dialogue and/or visual-mental images.

Seeing with Mental Images. In response to Question 11, of the pre-assessment, which asked what you do to create meaning based on what the teacher is saying, the theme "Seeing with Mental Images," emerged for Dalisay's transcript. Dalisay explained she understood a speaker's words by "picturing" herself in context of situation-based events.

> For example, if they're talking about the scientific process, like the procedures of an experiment while they're talking about that, I visualize what they're talking about to make me understand. So, I would picture myself as the scientist doing this, and doing that.

Visual thinking themes that were provisionally coded as metacognitive regulation (MR) also emerged (see Table 41), the most prominent being, "Creating Context through Visual Thinking".

This theme relates to Dalisay's explanation that she pictured herself experiencing specific events/contexts being spoken about. Shortly thereafter, the researcher asked, "When you're thinking about those things, are you always in your own picture." Dalisay stated "Yes. I am. I am. Oh my gosh, I am. Yeah, I am in my own – yeah. Yes." Dalisay realized in that moment, that she placed herself in her own thinking when picturing various contexts. Additional questions and interpretations related to Dalisay's visual thinking were presented to Dalisay during the first member check and her responses are captured in Table 45.

Table 45

Conversation in Member Check Relevant to "Seeing with Mental Images," and Other Visual Thinking/Visualizing Themes from Table 41

Chris (Questions/Interpretations)	Dalisay (Answering)
Near the top - Was there some type of realization there? Where you said "I am. I am. Oh my gosh, I am, Yeah, I am in my own – yeah. Yes."	"That was a realization because I had never stopped to think that I incorporate myself in all my thoughts."
If Dalisay can visualize an idea – as in see it in her mind - she feels she has a firm understanding of that idea or ideas.	"Definitely."
You feel this can occur best when there's a storytelling element involved, which has enough context that allows you to create a clearer picture.	"Yes." Realizing what I have about visualization, that came from the last interview, it helps me understand that mental behavior and how I can learn something better.
So, you picture things in your mind not only to learn and understand, but because there's a belief you can manifest certain things into occurring?	"Yes, I'm a huge believe in manifestations, like speaking things into existence." It's a form of motivation that I could teach myself anything and understand it.
Sometimes this (picturing things in your mind) is done actively and sometimes it's something you do without thinking about it? But when you really want to understand something or	"Oh definitely." I definitely engage in manifesting things. If I can put myself into that situation, it helps put me in that mindset that I could understand things.

maybe manifest something this might be a behavior that you've engaged in?	Yes, I actively engage in visualization to understand and learn new ideas and to help manifest certain things, so they become a reality.

Dalisay confirmed and further explained in the member check, that she visualized ideas to understand new concepts and to manifest events into existence. The latter rationale is based on a belief held by Dalisay and perhaps an affective element of her learning, that while important for her, does not relate to other themes in the study. Additionally, Dalisay mentioned twice in the member check (see Table 45) that she learned something about her own visual thinking in the course of the interview, which affirms the interview can be an intervention for meta-learning.

Summary of Dalisay's Understanding of Learning. In the pre-assessment and member check Dalisay explained/confirmed that she was driven to understand more about herself and improve aspects of herself to succeed in education and life. Dalisay explicitly stated, "I got to learn about myself as a learner" in the context to the interview and mentioned three situations in the pre-assessment and member check that meta-learning occurred. Dalisay learned that she 1) placed herself in her own picture which helped her understand new concepts/events, 2) that she had conversations in her mind to understand new ideas, and 3) that she learned better when more visual input was presented in the learning environment. For example, during the member check Dalisay stated, "Yes. I learned based on our last interview that I'm more of a visual learner than an auditory learner." This means that Dalisay used visual input (e.g., watching videos, and using video-based practice problems) to learn more substantially than auditory input but she reported both were important to her learning. It should be noted that Dalisay was the only focal participant to take two classes in the ASC, before taking the pre-assessment (other focal participants took one class). Taking two classes may have given Dalisay an advantage in terms of how she thought about the pre-assessment questions. Dalisay was able to make at least one connection to ideas discussed in the curriculum (e.g., using language to support thinking (metacognition).

As Dalisay's pre-assessment interview progressed she seemed to learn how she best thought about new ideas in various situations. In the PK section, she focused on how she learned best when encountering affective elements that supported her learning, particularly in groups. She later discussed what she did to support her thinking when confused, such as watching videos. Toward the latter half of the interview (follow-up to question eight and on) she became more exploratory in a metacognitive sense with some of her responses, discussing how she read to makes sense of ideas, internal "conversations" with herself, and visually "picturing" events to understand new ideas/events (see Table 41 for themes). The rationale for these themes, particularly metacognitive knowledge was more fully developed during the member check, six weeks after the pre-assessment. It was evident that Dalisay had thought more about why she engaged in internal dialogue and mentally picturing events, as she assigned more meaning that provided clarity for these themes. She also mentioned two mental behaviors that were supported by using internal dialogue, e.g., relating ideas to previous knowledge and monitoring learning. Notably, these mental behaviors sync with behavior-based themes that emerged in Dalisay's post-assessment transcript.

Thus, Dalisay came to understand in the pre-assessment that she pictured ideas/events and used internal conversations to help herself understand spoken ideas. It's possible these mental behaviors are how Dalisay made connections/relations to other ideas, leading to a feeling of knowing, but this is unclear. Additionally, Dalisay is aware of a number of affective elements that need to be established in the learning environment (e.g., empathy, comfortability, personalization) to support mental/affective states conducive to thinking/learning.

Lilly's Understanding of Learning. Prominent quotes and themes in Table 46 illustrate how Lilly assigned meaning to her thinking and learning during the pre-assessment.

Table 46

Corresponding Quotes and Themes that Explain How Lilly Understood Her Learning

Questions	Relevant Themes	Prominent Quotes
Question 3, follow-up, PK Section Can you explain how you think you learn best?	1) I am a Visual Learner [MK] 2) Color-coding Notes to Organize Ideas [MK|MR (Control)] 3) Creating (Meaningful) Visual Formats for Learning [MK|MR (Control), VP]	Like I had said before, I'm very visual, just the way I communicate in general. When I communicate, even with my friends, like I'll draw pictures, or I show them videos or pictures to better explain myself. So, like what I tried doing is I'll color code my notes. So, I can just try to separate the ideas. For example, my biology class, every day of lecture I change the color of the pens I use, so I can separate those ideas.
Question 7, AoC Section So you're reading or watching a video and then something clicks, as in you understand it, like the light bulb goes off, how do the ideas make sense to you?	1) Watching Educational Videos to Learn Better [MK] 2) Using Dialogue to Support Thinking/Learning [MK|MR (Control, MetStrat, MetSkills]	And then even after I watch it, I try to explain it to myself, "Okay, this is what the video is explaining." And I kind of put the knowledge I had, and then the video that filled in the holes, I'll try to put them together."
Question 8, AoC Section So, what do you do, if anything, that helps you understand what they're saying?	1) Seeing (Understanding) with Mental Images [MK, VT] 2) Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills] 3) Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills]	Usually, if the story's being told well enough, I try to visualize the situation. Like, the person I'm thinking of is my mom. She and I are very similar. When we talk, we use a lot of hand gestures and just seeing her hand gestures, kind of listening to her tone to try to picture that story.

Question 10, S&S Section When studying here, do you have strategies that you use to learn something new or learn something better?	1) Using Dialogue to Support Thinking/Learning [MK|MR (Control, MetStrat, MetSkills] 2) Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat, MetSkills]	… I just stare out into what's in front of me and try to process everything. (cont'd) I'll try to brain dump and try to explain what I know especially if I'm working independently. Just trying to visualize it because for me I'm taking a lot more science classes. That tends to be the most interesting for me because there is more visual aspects to it. I try to explain things visually.

Note: Provisional Codes: Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, ME = Metacognitive Experiences, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

The researcher drafted Lilly's case summary and further developed the document with Lilly in a member check on Nov. 5, 2021, approximately five weeks after the pre-assessment. Relevant excerpts from the case summary are included in the sections to follow. All paraphrased statements were developed from Lilly's responses and were confirmed with her as being accurate in the member check. Any direct statements are listed in quotation marks.

I am a Visual Learner. In responses to question two and three of the pre-assessment Lilly mentioned that she was a visual person and that "visual learning tools" were helpful. Throughout the pre-assessment, Lilly added depth to those statements discussing how she thought, learned, and communicated as a visual learner. Interestingly, Lilly rated her understanding of learning at a "four and a half" at the beginning of the pre-assessment interview and an "eight" at the end of the interview. It's possible, the ways in which Lilly captured her thinking and learning contributed to the boost in metacognitive confidence. Questions and interpretations from the pre-assessment that related to Lilly's visual learning were discussed with her during the first member check and her responses are captured in Table 47.

Table 47

Conversation in Member Check Relevant to Pre-assessment Theme - "I am a Visual Learner"

Chris (Questions/Interpretations)	Lilly (Answering)
You learn best visually – What that means for you, is that creating a visual system for yourself where you can organize, and associate ideas visually helps you understand the material better.	"Yeah, that's pretty accurate." "I would definitely consider myself a visual learner."
Seeing things happen helps you understand more than when somebody verbally explains something.	Modeling something, as in showing me how to do something, helps me to replicate (pretty closely) and understand that process more clearly.
Color coding helps you to 'see' (or visualize) what groups of ideas belong to each other. As in how processes or aspects of processes occur.	"Yes. Usually I highlight a new definition or a new concept… and use a colored pen to elaborate on new terms and ideas. This shows up in my notes a lot."

Lilly confirmed in the member check that she utilized visual materials for learning more often than other forms, mentioning "kinesthetic" and "auditory", which are types of learning styles. Lilly specifically mentioned in the pre-assessment, that materials such as 3d videos/models that show various processes, help her separate steps and/or ideas, so that she can 'see' what the ideas look like on their own. Over time and with practice she can bring those ideas together to see how they are connected.

Lilly not only sought visual materials to process ideas better, but she also created a system for notetaking (specifically for Biology), composed of visual formats, e.g., drawings (e.g., icons) and color-coded notes/flashcards. Lilly highlighted key terms and used a colored pen to elaborate on and/or (mentally) distinguish between ideas. Without the ideas being color-coded Lilly reported it in the pre-assessment it was hard for her to identify scientific-based ideas in her notes.

> Yeah, so it just helps me. It is very helpful organizationally, especially when I go back to those notes because if I were to look at notes that were black and white, had no color, I wouldn't be able to find what I was looking for.

Color-coded notes helped Lilly to connect ideas and see them more clearly in her mind. Lilly offered in the pre-assessment that she had been diagnosed with attention deficit hyperactivity disorder (ADHD), and that she didn't "take the medications anymore." She explained that some of the things she does to pay attention or focus on academic material, such as doodling in her notes and fidgeting, are a result of having symptoms related to ADHD. In the pre-assessment, in response to question nine, which asked about how she makes sense of ideas when reading Lilly stated, "For me when I look at a page and it's just from top to bottom text, the words just for me at least merge into a bunch of-- where I get confused very easily." The researcher asked Lilly about this challenge in the member check and her responses are captured in Table 48.

Table 48

Conversation in Member Check Relevant to Lilly's Reading

Do the words get visually or mentally jumbled? Is it difficult to take the ideas off the page?	Visually it gets jumbled and "I lose my place very easily". I usually don't have the attention span to read long paragraphs. "I can't in one sitting, read the page from top to bottom." As a result, Lilly has to do a lot of re-reading, "which isn't the best use of my time." If I'm able to focus on the big idea long enough I'm able to understand. Lilly can skim a page (a strategy she learned in high school) where she pulls meaning from the page without reading the page in its entirety. She reads the first and last sentence of the paragraph and if it still doesn't make sense she'll go back through and read the entire page or paragraph.

Lilly explained in the member check (see Table 48) that she had trouble reading long pieces of text, and that re-reading wasn't always the best utilization of her time, so she engaged in mental processes, such as scanning and *focusing on the big idea* to pull meaning from the page. Lilly thus, engaged in strategies when reading and taking notes to help her organize, identify, and connect ideas mentally. It's not clear whether reading and note-taking strategies are connected to the challenge of words getting visually jumbled. Lilly however, confirmed in the member check that seeing ideas in her mind, and how they connect helps her to understand academic material.

Seeing with Mental Images and Using Dialogue to Support Thinking/Learning. In response to question eight of the pre-assessment, which asked how you understand what others are saying when telling you a story, Lilly explained that she visualized the situation, specifically referencing her Mom telling her a story about their pet ducks, "and just having a basic understanding of them and understanding the way my mom is, I can visualize little things that my mom tells me." Additionally, in response to question 10, which asked about Lilly's study strategies, Lilly stated that she had moments of reflection in which she looked out the window, staring at nothing in particular, and explained ideas to herself while picturing those ideas mentally. Lilly's visual thinking and language (i.e., dialogue) at times in the pre-assessment, are connected and are thus, discussed in this section jointly. Questions and interpretations from the pre-assessment that related to Lilly's visual thinking and language were discussed with her during the first member check and her responses are captured in Table 49.

Table 49

Conversation in Member Check Relevant to Pre-assessment Themes – "Using Dialogue to Support Thinking/Learning," "Seeing with Mental Images," and other Visual Thinking Themes

Chris (Questions/Interpretations)	Lilly (Answering)
You explain ideas to yourself in your head (and sometimes out loud when studying in a room alone), to deepen your understanding of the ideas. You can see the ideas that you are explaining in your mind (visualizing).	Sometimes if things are confusing, and studying alone, by talking the process out loud, as I visualize it, sometimes it helps me process things a little better. Like, reading essays out loud, helps me to visualize if the words make sense together. And that helps when something doesn't sound right - as in the words don't go together grammatically or when the ideas don't go together, and also when the logic is not aligned or doesn't quite make sense. This all also happens in my mind. In my own internal voice.
[When telling the story of the ducks with friends] are you telling the story with visual descriptions?	Yes. "I do use visual descriptions to tell stories. I try to give as much visual detail." If I explain it visually it's easier to visualize something so that it makes sense to me, and so I can explain it to others well.

Note. Some of the pronouns were changed from third person to first person in this conversation to accommodate the meaning in the conversation.

Lilly explained in the member check, (see Table 49), that she used language internally (and sometimes vocally) which supported her ability to create mental pictures and develop logic (e.g., connect ideas/words to make sense of what she was trying to learn). In other words, Lilly, explained new ideas to herself verbally, which supported her ability to 'see' those ideas mentally, and better think/learn with those ideas. Additionally, Lilly communicated *visually*, using vivid descriptions, sharing videos, and creating drawings, because it helped her understand the ideas better, which helped her express what she wanted to convey, and she believed helped others understand what she was explaining. Lilly confirmed in the member check that visualizing ideas (i.e., utilizing mental imagery) helped to ground her, to help her find meaning.

Summary of Lilly's Understanding of Learning. Lilly stated she was a visual learner in the member check, meaning she sought visual materials to process ideas better when confused. Lilly also saw herself as being "visual" in terms of how she communicated and thought. Lilly developed a visual system for her notes composed of conceptual drawings and color-coded words. She confirmed in the member check that the visual system for her notes, specifically the color-coding, helped her to see ideas in her mind more clearly, while the color-coded writing helped her to elaborate on ideas. Specific examples (artifacts) of Lilly's notes are shown in the next research question.

Lilly was aware she used dialogue (explanations) both internally and externally to better process and think with new ideas. In specific instances in the pre-assessment and member check, Lilly showed awareness of her visual thinking as well as strategic utilization of visual thinking ("visualization") with internal dialogue to reflect on and learn new ideas. Cumulatively, Lilly showed a depth of metacognitive knowledge for visual thinking, explaining how she 1) understood spoken ideas, 2) reflected on new ideas when studying 3) stayed focused, by looking at non-dynamic objects - "I look at the tree, but I don't focus on the tree."

Summary of Research Question 3b. All pre-assessment themes were structurally coded into four overarching categories in the pre-assessment template - "Knowledge-Based Themes as a Learner," "Physical Strategies for Learning," "Mental Strategies for Learning," and "Judgements of One's Learning" (see Appendix M). The strategy-based categories incorporated themes that showed knowledge for *how/what participants did to support thinking and/or learning*, while the knowledge-based category incorporated themes that captured *what/why factors* or *attributes related to participants' thinking/learning*. The judgement category incorporated themes that captured participants' ratings of their understanding of learning (related to metacognitive confidence). See Appendix L for Codebook.

All students were unique in the way they understood their learning and how they supported their learning. While many themes emerged in the pre-assessment, there were elements of each students learning that were not captured in this chapter. Prominent themes related to how students assigned meaning to their thinking and learning in the pre-assessment are listed in Table 50.

Table 50

Prominent Metacognitive Themes from Pre-assessment that Relate to Participants' Learning/Thinking Process

Categories	Theme 1	Theme 2	Theme 3	Theme 4
Physical Strategies for Learning	Creating (Meaningful) Visual Formats for Learning	Breaking Down Ideas on Paper to Understand	Watching Educational Videos to Learn Better	--
Mental Strategies for Learning	Focusing on Visual Movements of Speaker to Understand Their Words	Visualizing Ideas to Understand Speakers Words	Creating Context through Visual Thinking	Using Dialogue to Support Thinking/Le arning
Attention to Components of Learning and Thinking	Visual Shapes Support Understanding	--	--	--
Knowledge of Self as a Learner	I am a Visual Learner	Still Figuring Out What Works Best for My Learning	--	--

Awareness of Cognition	Seeing (Understanding) with Mental Images	--	--	--

Note. There is overlap in these themes, particularly with Visualizing Ideas to Understand Speakers Words, Creating Context through Visual Thinking, and Seeing with Mental Images. This overlap can best be explained by the following summation: four focal participants used visual thinking or "visualizations" to understand spoken words, and three of those focal participants primarily visualized specific contexts. In these statements, focal participants referenced or implied that they understood spoken words by seeing ideas in their mind.

Overlap in participants' meanings, particularly those that related to learning were most prevalent for themes which indicated participants sought, focused on and/or created visual input to better understand new ideas. For instance, several focal participants explained that seeing ideas represented and/or broken down visually supported their understanding. Some participants did mention that auditory information or learning in a kinesthetic style was a factor in their learning, but these assigned meanings were mostly anecdotal.

Knowledge-based themes that related to visual input included, "Visual Shapes Support Understanding," and "Hand-written Ideas Support Understanding," and strategy based-themes that related to students creating/seeking visual input included, "Focusing on Visual Movements of Speaker to Understand Their Words," "Creating (Meaningful) Visual Formats for Learning," "Color-coding Notes to Organize Ideas," "Watching Educational Videos to Learn Better," and "Breaking Down Ideas on Paper to Understand." All themes listed above were provisionally coded as being metacognitive, in that participants referred to an element of their cognition (e.g., processing or understanding). These 'visual' themes aligned with focal participants' statements that they and their peers were visual learners. Table 51 shows alignment between the theme "I am a Visual Learner" and assigned meanings related to the visual learning process (as conceptualized by the NsLLT framework). The first column in table 51 relates to the 'visual' themes listed above (i.e., utilizing visual input in a meaningful way); the second column captures whether participants were aware of their visual thinking during the course of the pre-assessment;

the third column relates to students controlling aspects of their visual thinking, and the fourth column relates to participants' statements of being a visual learner or person.

Table 51

Aligning the Theme "I am a Visual Learner" with Themes Related to Visual Thinking/Learning

Participants	Sought/Created Visual Materials for Understanding	Metacognition for Visual Thinking	Using Visual Thinking (Strategically)	I am a Visual Learner
Ashley	Yes	*Briefly	*Briefly	Stated
Abby	Yes	**Not in pre-assessment	**Not in pre-assessment	Stated
Coreen	Yes	***More related to learning in member check	No	Implied but Not Stated
Dalisay	No	Yes	Yes	No
Daniel	Yes	Yes	Yes	No
Lilly	Yes	Yes	Yes	Stated

Note. *Ashley briefly mentioned her visual thinking, in terms of how she understood spoken words, though not directly by saying she pictured ideas. In another statement, Ashley mentioned picturing ideas from memory that she previously wrote down, which doesn't necessarily relate to understanding. **Abby did not assign meaning to visual thinking in the pre-assessment but did mention her visual thinking in terms of visualizing ideas when creating concept maps in the member check. ***Coreen mentioned visual thinking briefly in relation to staying engaged in the pre-assessment but in the member check referenced visual thinking as a source of her learning.

All six focal participants captured in Table 51 showed a degree of metacognitive knowledge for an aspect of their learning process. Several visual thinking themes were provisionally coded as metacognitive knowledge (MK) and metacognitive regulation (MR) suggesting at least half of focal participants were metacognitively aware of their visual thinking and controlled aspects of their visual thinking to support understanding. Specifically, three focal participants used "visualizations" to create context (meaning) for their thinking, sometimes from different people's perspectives, which helped them understand spoken words.

Five of six focal participants used their language to support their thinking/learning as represented by the themes "Using Dialogue to Support their Thinking/Learning" and "Writing Ideas in My Own Words to Understand." More about the participants' strategies from the pre-assessment will be discussed in the next research question. Participants referenced using their language in connection with other strategies or behaviors (e.g., taking notes), with a few exceptions. Notably, Lilly integrated language with visual thinking (in moments of reflection) to support her ability to connect ideas and develop logic.

These results show that more than half of focal participants, at the outset of their first semester in college, had a degree of metacognitive knowledge for their visual thinking. Most notable to this study, that they would 'see' or 'picture' images in learning situations, and their ability to 'see' or 'visualize' ideas was a source of understanding. Provisional coding criteria revealed that half of focal participants had a degree of metacognitive control over their ability to "visualize" context-based situations to support thinking about new ideas. It's important to note that references to visual thinking and language for each participant were intermittent, and sometimes required follow-up questions. Lastly, participants reported learning or having realizations about their thinking and learning during the interview, which suggests the pre-assessment (and the member check) were meta-learning interventions in themselves.

Research Question 3c

What do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course? The ASC curriculum focused on meta-learning within an NsLLT framework, including application of learning strategies. In RQ3c, the researcher sought to understand what strategies first-generation students reported upon entering college and why they engaged in those strategies. Prominent themes emerged primarily from the Strategies and Skills (S&S) section of the pre-assessment, which are reported along with notable themes that help answer the research question. Themes emerged as a result of 1st cycle, provisional, and pattern coding methods (Saldaña, 2021).

Using Dialogue to Support Thinking/Learning. Question ten of the S&S section asked focal participants to picture a place that they studied and then asked *do you have strategies that you use to learn something new or learning something better* (in this place). In response to question ten or follow-ups, three focal participants indicated they used inner (mental) or vocal dialogue to support their thinking/learning. This theme suggests that participants used their own words (i.e., natural language) to a degree, to support conceptual understanding of new ideas. Using one's natural language internally and externally was something that was taught in the ASC starting in week one of the learning and thinking block. Prominent quotes from this theme are listed in Table 52 below.

Table 52

Prominent Quotes from Pre-assessment Theme – "Using Dialogue to Support Thinking/Learning"

Participants	Prominent Quotes
Dalisay	Especially thinking about my friend, we're in our math class, we always work on math homework together. So, when I notice that when I'm saying things, she uses my thinking as her way to reflect and make up new thinking. That kind of helps us -- she's using what I'm saying as her way of learning things. And we just bounce back and forth with our random ideas and that helps us connect. Because there are things that I can't think of right there that she could, and so that helps both of us.
Daniel	…I can find a point, in my own words, and then help continue putting the concept in my own words and defining it for myself.

Lilly	I'll try to brain dump and try to explain what I know especially if I'm working independently.
Lilly	And then even after I watch it, I try to explain it to myself, "Okay, this is what the video is explaining." And I kind of put the knowledge I had, and then the video that filled in the holes, I'll try to put them together.

Note. "Using Dialogue to Support Thinking/Learning" was also coded in response to other questions (besides 10).

Questions and interpretations from the pre-assessment that related to participants using dialogue were discussed with them during the first member check, approximately five to seven weeks later, and their responses are captured in the following sections.

Dalisay. In the pre-assessment, Dalisay reported using dialogue internally and externally (vocally) to support her thinking. Table 53 captures the exchange in the member check related to Dalisay's use of dialogue (see Table 52).

Table 53

Conversation in Dalisay's Member Check Relevant to Pre-assessment Theme – "Using Dialogue to Support Thinking/Learning"

Chris (Questions/Interpretations)	Dalisay (Answering)
Speaking with friends about what she is learning helps Dalisay bounce ideas off (peers) and add to what each is saying, until she has a better understanding of the class material.	"Yes, I do that a lot, especially in Math."

Dalisay confirmed in the member check that speaking with friends helped to layer her thinking. Additionally, in the pre-assessment, when asked about what helped her to understand people when they were speaking Dalisay's explained that she used inner (mental) conversations to support her thinking when other people told stories. This behavior was confirmed in the member check and her response is captured in RQ3b.

Daniel. In the pre-assessment, Daniel reported using dialogue internally and externally (vocally) to support his thinking when trying to understand new ideas/ processes. Daniel engaged in a strategy where he recorded himself speaking and played back the audio to find areas in his language (thinking) that could use refinement. He also reported explaining ideas to himself in connection with breaking down ideas to figure out steps in a process. Table 53 captures the exchange in the member check related to Daniel's use of dialogue (see Table 52).

Table 54

Conversation in Daniel's Member Check Relevant to Pre-assessment Theme – "Using Dialogue to Support Thinking/Learning"

Chris (Questions/Interpretations)	Daniel (Answering)
Did you engage in these learning strategies (e.g., breaking down explanation) when you understood something in class or is it only when you don't understand the material?	It would also be when I don't understand the material. I'm trying to create simple terms to explain it to myself.
So, when confused in certain subjects that have more of a problem-solving nature, you might utilize online videos to break things down, to see how all the parts connect to the problem as a whole? Whereas, when confused in a subject that is more language or story-based, you tend to focus on repetition, and breaking things down by explaining it to yourself.	Both interpretations above are accurate.

Daniel explained in the pre-assessment and confirmed in the member check that he liked to "explain" new ideas to himself, which helped him think about (or recognize) what he understood well and the parts of his dialogue that were still not clear. Daniel primarily used dialogue for subject matter in which he had a cursory understanding. He also confirmed that he was still learning ways to learn effectively in subject matter that he did not have a cursory understanding.

Lilly. In the pre-assessment Lilly reported using dialogue internally and externally (vocally) to support her thinking (e.g., logic), specifically referencing this in connection with visualizations. Table 55 captures the exchange in the member check related to Lilly's use of dialogue (see Table 52).

Table 55

Conversation in Lilly's Member Check Relevant to Pre-assessment Theme – "Using Dialogue to Support Thinking/Learning"

Chris (Questions/Interpretations)	Lilly (Answering)
Do you explain ideas to yourself out loud or internally? What does that look like?	I explain it internally (mostly). Create that mental picture, to visualize what's happening as I explain it to myself. Putting terms to certain steps or trying to separate certain parts of the logic or processes (working from the group up). Going through the layers of ideas and how they connect (e.g., protein structure and how it builds off itself).

Lilly explained in the member check, that in moments of reflection she explained new ideas (mostly internally) which supported her ability to "visualize" ideas and develop logic (e.g., connect ideas/words to make sense of what she was trying to learn). In other words, Lilly, explained new ideas to herself through internal dialogue, which supported her ability to 'see' those ideas mentally, and better think/learn with those ideas. Lilly confirmed in the member check that visualizing ideas (i.e., utilizing mental imagery) helped to ground her, to help her find meaning.

Writing Ideas in My Own Words to Understand. Two focal participants indicated that they tried to write ideas in their own words (e.g., summarizing in natural language), as opposed to copying the teachers' words, which helped with understanding the ideas they were learning. For Coreen and Dalisay, this was a strategy they learned in the first 'learning and thinking block' class and had already begun to apply. For Abby, this was likely a strategy she had previously engaged in to support her thinking about new ideas, not necessarily related to what she learned in the ASC.

The utilization of one's own words (i.e., natural language) was discussed in the ASC prior to the pre-assessment and throughout the learning and thinking block. Using one's own words, rather than copying words (e.g., teachers' notes), takes advantage of students' natural language (i.e., thinking) to support mental engagement with academic ideas. Students must read or listen to the ideas, think of what those ideas mean, then think of how they can translate that to their own language to make more sense of the ideas. Prominent quotes of this theme are listed in Table 56 below.

Table 56

Prominent Quotes from Pre-assessment Theme – "Writing Ideas in My Own Words to Understand"

Participants	Prominent Quotes
Abby	I like to break the text down word by word and write words that I do know in place of the words that I don't know, so that I would be able to grasp it fully.
Coreen	This is something I've changed very recently, sometimes afternoon on Tuesday but not just copying down what they're saying, word for word but doing my best to summarize and the way I've done it is like trick my brain to mean like, "You can't plagiarize off of their

	words," and so I have to rewrite it but that's something I literally came up with today in biology.
Coreen	I write down what she says and then when she's like pausing to take a breath and drink of water, go to the next slide, I think about it in my head. If I think of a better way to say that makes sense to me, then I write it down.
Dalisay	Actually, ever since you talked about writing notes in your own words, I've been doing that ever since. (cont'd) …it forces me to really understand what I'm learning, because my goal now, is to try and write things in my own words. It pushes me to actually listen and understand, and then, think about it and then write it my own words, but yes. Chris: Are you integrating that into Cornell notes? Dalisay: Yes, I do.

Questions and interpretations from the pre-assessment that related to participants writing ideas in their own words were discussed with them during the first member check, approximately five to seven weeks later, and their responses are captured in the following sections.

Abby. In the member check, Abby explained that she mentally related the ideas the teacher was speaking about to ideas and/or events she already understood with the intent to think about and understand concepts and/or events being presented in class. In the member check, Abby stated that she wrote out ideas and reflected on them (e.g., relating ideas to previous knowledge), mostly outside of class because in class it could be difficult to mentally reflect when the teacher was speaking. Additionally, Abby mentioned that she replaced words from class with her own words (ideas) to create a better explanation for new ideas. For instance, in the pre-assessment, Abby stated, "Writing things down, writing certain phrases down, also help me map out what the text is trying to say." Cumulatively, Abby related ideas mentally and wrote new ideas in her own words, which helped create context (based on previous knowledge) for thinking about new ideas.

Coreen. In the pre-assessment, Coreen explained that she had recently begun to write in her own words, which "made sense" to her. In Table 56 she explained how she engaged in this strategy – writing down what the teacher said first and then trying to summarize those ideas in her own words when time permitted. These details were not discussed in the ASC. Coreen was discussing what she'd learned thus far from applying the strategy in class. Coreen, confirmed in the member check that because of what she was learning in the ASC she had begun to reflect on her learning more and understand new strategies for thinking and learning. Coreen had some struggles academically early on in the semester and the ASC helped to guide thinking about her own learning. Thus, Coreen was engaging in meta-learning - for writing ideas in her own words - when the study had begun.

Dalisay. At the end of the pre-assessment, just before it concluded, Dalisay mentioned she had begun to take notes using her own words as she had learned in the ASC. Dalisay reported that writing ideas in her own words forced her to mentally engage (i.e., listen and think about) the ideas she was learning. Writing ideas in her own words showed further utilization of language to support thinking/learning, as Dalisay also used inner dialogue to support her thinking when listening to other speak and vocal dialogue (with peers) to support her learning. Similar to Coreen, Dalisay applied this strategy and in the process of reflecting on what she'd learned, engaged in meta-learning at the outset of the study.

Asking for Clarification. Four focal participants explained they asked for clarification from a teacher or classmate if they didn't understand the academic material presented. This theme primarily emerged in response to the three questions in the S&S section but was also coded in response to other pre-assessment questions. Prominent quotes of this theme are listed in Table 57 below.

Table 57

Prominent Quotes from Pre-assessment Theme – "Asking for Clarification"

Participants	Prominent Quotes
Ashley	And I think the things I've done to understand the concepts would just be to ask a friend for a better example, because sometimes if I just hear other people rephrase the same concepts, I understand it depending on how they explain it.
Daniel	I like to ask for clarification. If I really don't understand something, I don't want to sit there and pretend like I do understand. I will speak up and I'll say, "what does that mean?" Or I'll ask for clarification in the story.
Daniel	And then if I know the teacher is going to eventually stop and ask for questions, I will just write down my questions within my margins of my notes to like signify that I need to ask this or… I won't be able to progress forward with learning the material, then I will stop, and I will raise my hand…and just ask the question that's coming to mind in order to help further my understanding.
Lilly	I just try to, like I'll ask my parents, I'll ask someone I know who is very knowledgeable in that subject…
Dalisay	But when I do want to learn something new, like if I'm struggling, I tend to call out another person or get another brain because I feel that more than one brain works better. (cont'd) Yes, it's just normally friends and colleagues, classmates, and then my last resort will be the teacher.

Three of the four focal participants (Ashley, Dalisay, Daniel) indicated that asking for clarification supported their thinking (e.g., understanding) when confronted with challenging ideas. This coincides with another prominent theme, "Communication in Groups Helps with

Challenging Ideas," which captures focal participants' recollections that they were able to learn better in peer groups before college. These 'language' themes indicate focal participants largely relied on language, particularly communication with peers/teachers to support their thinking and learning. The following section synthesizes students' explanations for strategies that encompassed the *creation of visual formats* when trying to learning.

Creating Visual Formats for Learning. Five focal participants created visual formats, generally on paper, to help them understand the academic ideas they were learning. "Formats," references a meaningful way to organize/arrange ideas in space. Visual formats were unique and thus, encompassed a variety of strategies including concept maps, writing out steps of problems/processes, breaking down ideas on paper, and color-coding notes. This is an overarching theme, composed of the sub-themes ,"Breaking Down Ideas on Paper to Understand" and "Color-coding Notes to Organize Ideas," as well as several 1st level codes. The through line between these strategies is that students developed visual formats, based on what made sense to them, and often referenced an ability to see the ideas, which supported their thinking. Students reported that such formats/structures supported their ability to identify, separate, organize, and/or connect ideas. This theme primarily emerged in response to the three questions in the S&S section and question three in the PK section. Prominent quotes of this theme are listed in Table 58 below.

Table 58

Prominent Quotes from Pre-assessment Theme – "Creating (Meaningful) Visual Formats for Learning"

Participants	Prominent Quotes
Abby	…and I have a set format especially if it's on paper or something that I can see, that helps guide my thinking and my learning. (cont'd)

Abby	I like to outline the processes of thinking or of an assignment or steps that I would have to go through in order to complete something. I like to emphasize concept maps and highlight formulas so that I know what's important and what's not, and how things relate to each other. (cont'd) Usually, it would start out with a general idea or concept. I just like to list under it or connect it to other concepts that are related that I would also need to know.
Ashley, Question 12	Also, I just go over a bunch of examples and write out each step, instead of trying to do some parts in my head and some parts on paper. If I do every single step on paper, I can see where I go wrong or where I go right, and then work from there.
Dalisay, Question 13 (after questions)	Each color is specific for a certain thing, and I kept it that way since middle school, and it helped me format my notes, and know what I'm looking for in my notes…
Daniel, Question 10	…if it wasn't working, I would stop, I would go back to what I was trying to break down and understand, and I would see where in regards to this specific problem is my understanding not working. And then just like, work it out.
Lilly, Question 10	… I wrote down every chemical formula…because we're going over amino acids and how to identify if it's hydrophobic, hydrophilic all of that stuff. Just writing it all out and just looking at it color coded, it helped me create that separation and the visualization which part to look at.
Lilly, Question 10	For example, we learned about proteins yesterday, so I did the chemical formula out on a flashcard because I had a hard time identifying it since it wasn't color-coded. And so actually writing that out and just looking at each one as I wrote it, that helped me understand it more.

Questions and interpretations from the pre-assessment that related to participants creating visual formats, including breaking down ideas on paper, were discussed with them during the first member check approximately five to seven weeks later. Responses that added more context are captured in the following sections.

Abby. In the pre-assessment, Abby stated she created concepts maps, which helped her relate/connect ideas. She explained that an "ideal" concept map would have certain terms attached to a concept followed by a description of the concept, including relationships to other ideas on the page. She mentioned concept maps help her, "…see a visual representation of how it all would connect." Table 59 captures the discussion in the member check related to the way Abby captured ideas on paper (see Table 52).

Table 59

Conversation in Abby's Member Check Relevant to Pre-assessment Theme – "Creating Visual Formats for Learning"

Chris (Questions/Interpretations)	Abby (Answering)
This is my interpretation, so please correct me if I'm wrong, you like to create a *concept* on paper by using a definition or term, and then connect that concept to other ideas (that you need to know)?	"That's pretty accurate." It's the same as seeing things connect, like in the last section. Grouping ideas that belong or relate to each other. Seeing that and visualizing that and visually memorizing it can help me remember the idea when taking a test.
That visual representation of the ideas connecting helps you understand the concept or concepts better?	Yes, that's right.
How had you adapted the Cornell notes? And why?	Outlining is another way of taking notes. The outline way of taking notes is still the way I take notes today. I like this better. I feel like outlining is applicable to all subjects. An outline is a title with subtitles, headers, sub-headers, and bullet point format. Having key points and key points under key points. This way feels better for me. I feel more organized this way, especially with being able to visually see the concepts and group them (like under header or sub-header). It's easier to categorize concepts and helps with visual learning. I'll remember key points that go under specific headers.

Abby has created a working system (e.g., highlighting, annotating, concept maps, written notes) for herself that helps her engage in the learning and thinking process. This system helps promote a feeling of being organized, which helps start and maintain the learning process once it's time to begin studying. This system also helps with creating understanding of the material whether in-class or out-of-class. This involves remembering the material, relating ideas to previous knowledge/experiences, and connecting ideas to other ideas. This is all primarily done in a visual manner, but with some affordances to verbal explanations like in class recordings.	"That's pretty accurate, yeah." "I'm also big on annotating and highlighting as well. That helps to have physical copies in front of me."

Note. Abby stated in the member check that concepts maps are in "mind map form".

Abby confirmed in the member check (see Table 59) that she created a working visual system for her notes, that helped her feel that everything was organized and also helped to understand academic material. When asked about the difference between outlining her notes and creating concept maps, Abby explained that she "learn(s) with the outline" and "memorize(s) the material through the concept maps."

Notably, Abby assigned meaning to her visual thinking, stating that "seeing" and "visually memorizing" the concept maps helped her "remember the idea" when taking the test. This was the first time Abby assigned meaning to her visual thinking despite discussing concept maps previously. Thus, a change in metacognitive knowledge (MK) occurred for using concepts maps in connection with visual thoughts. The ASC curriculum addressed conceptual drawing in connection with visual thinking as a strategy, so the change in MK for Abby coincides with the curriculum. Unfortunately, Abby's concept maps were never presented to the researcher as a strategy, so there are no artifact for readers to review.

Lilly. Lilly explained in the pre-assessment and confirmed in the member check that she created a system for notetaking (specifically for Biology), composed of visual formats, e.g., drawings (e.g., icons that represent ideas), and color-coded notes/flashcards. She explained in the member check that science is very "visual" for her, "you can see a cell, a protein under a microscope, so being able to label it (pictures with words), that helps my visualization." Lilly also highlighted key terms and used a colored pen to elaborate on and/or (mentally) distinguish between ideas. She stated in the member check that the color-coding strategy was specifically for science-based ideas. Lilly shared her Biology notes with the researcher in the pre-assessment, captured in Figure 5 below.

Figure 5

Lilly's Biology Notes Shown During the Pre-assessment

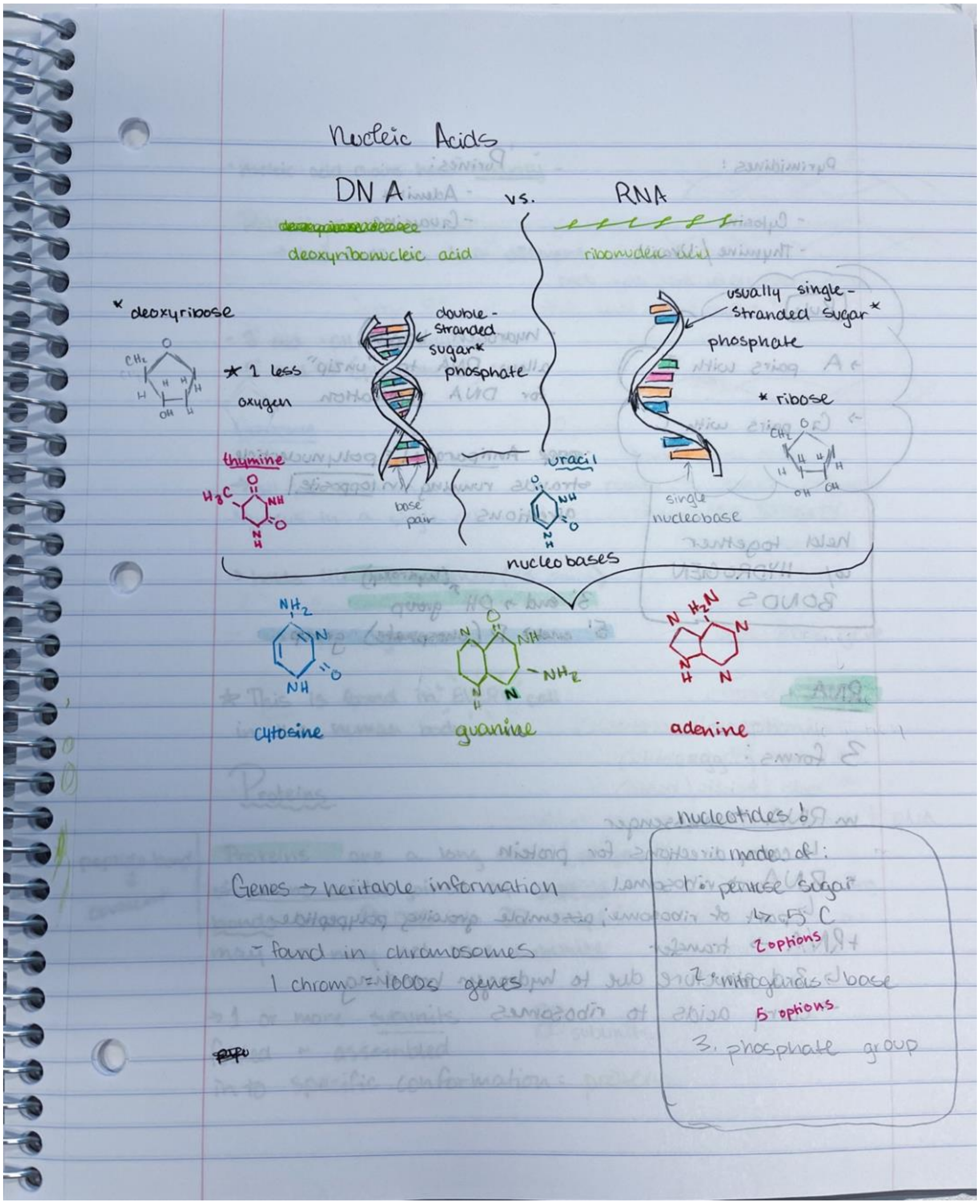
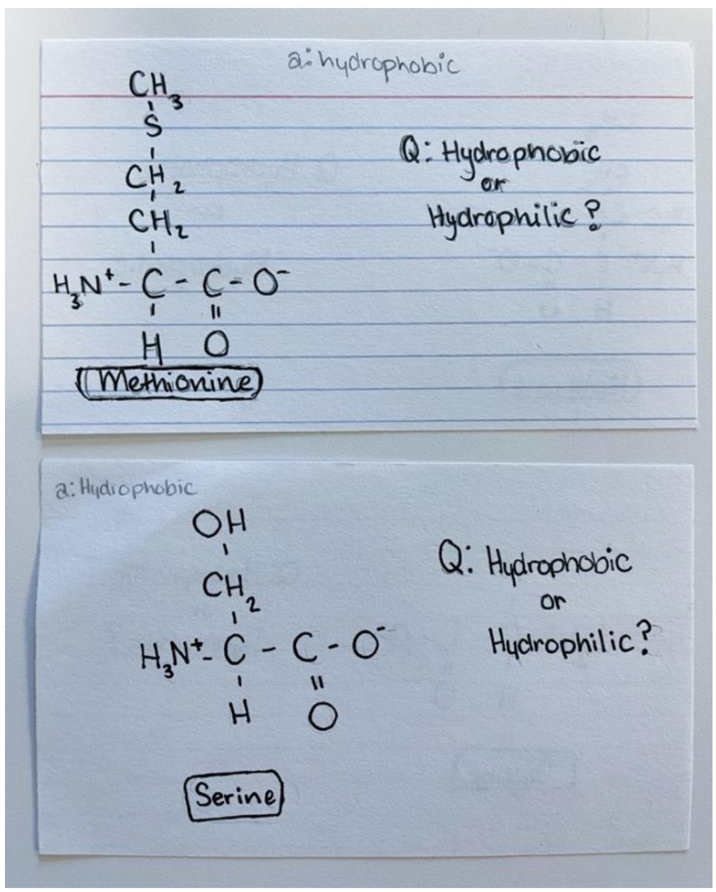


Figure 5 shows that Lilly drew and color-coded an RNA and DNA double helix. She also drew chemical formulas for several compounds and color-coded them based on her color-coding system. Lilly has labeled the drawings, including the compounds with words to help represent the ideas. She has also written words (some color-coded) in a table she outlined (bottom right corner of page) that describe the nucleotides which make-up DNA and RNA structures. Without the ideas being color-coded Lilly reported it in the pre-assessment it would be hard for her to identify scientific-based ideas when reviewing her notes. Lilly confirmed in the member check that color-coding notes helps her mentally organize (e.g., connect) ideas and see them more clearly in her mind. Lilly also shared her Biology flashcards with the researcher during the pre-assessment, captured in Figure 6 below.

Figure 6

Lilly's Flash Cards Shown During the Pre-assessment

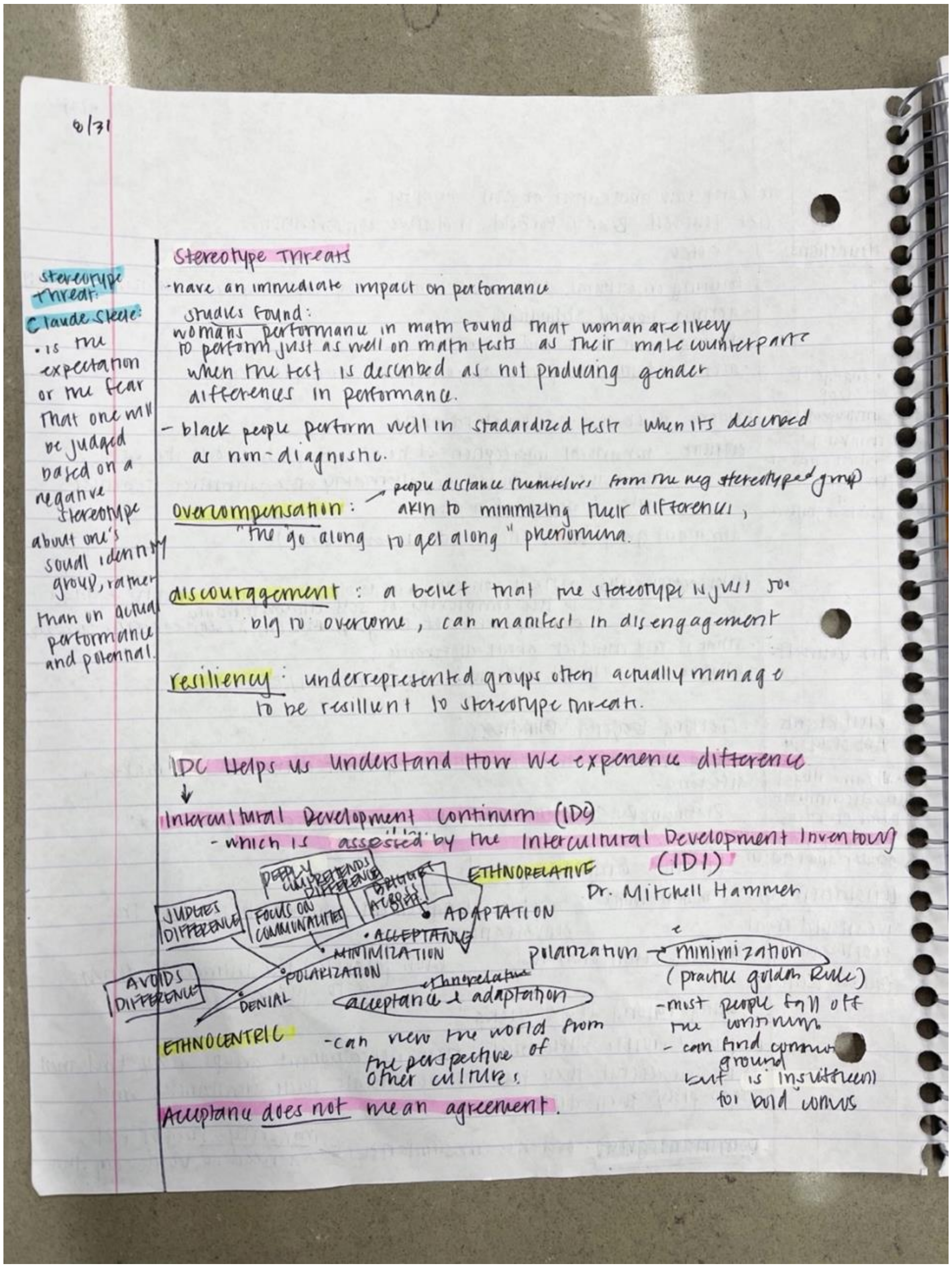


Lilly stated in the pre-assessment that she wrote down every chemical formula on a flashcard because she was having difficulty identifying the formulas because the Biology teacher hadn't color-coded them (like she usually did). Lilly stated that writing out the flash cards and "looking at each one as I wrote it" helped her understand it more. While Lilly created visual formats for science-based subjects that she linked to being "visual," she would engage in different strategies (e.g., using dialogue) to support thinking for more "verbal" subjects like English and Spanish.

Dalisay. At the end of the pre-assessment interview, after the researcher proposed that Dalisay could share documents of strategies she used to be included as artifacts, Dalisay briefly mentioned formatting her notes a specific way. Dalisay shared these notes with the researcher (see Figure 7 below).

Figure 7

Dalisay's Sociocultural Notes Shown During the Pre-assessment



Dalisay's formatting consisted of color-coding and an adaptation of the Cornell notes format (e.g., sections for keywords, summary, and questions). Figure 7 shows that Dalisay highlighted ideas in colors that held meaning to her. She stated, "Pink (are) the main topics," "orange (are) examples" and "yellow is key information that I need to know." The researcher is unsure what class these notes belong, but the ideas compose an examination of society and culture, specifically communications and relations between cultures (i.e., related to social psychology). Dalisay drew a large bubble arrow (at the bottom left of the page) and labeled it with various points with labels that shows a psychological process indicative of maturation, e.g., "Denial, Polarization, Minimalization, Acceptance, Adaptation." Dalisay drew simple arrows in various other areas to connect specific ideas and/or processes. She also wrote the results of specific studies toward the top of the page and listed several key ideas with corresponding meaning in the middle of the page. In addition, she created a left margin, with a line drawn vertically, and wrote a definition for "Stereotype Threat". Dalisay stated that she had begun to write some of the ideas captured in Figure 7 in her own words (i.e., natural language) as discussed in the ASC. "Actually, ever since you talked about writing notes in your own words, I've been doing that ever since." Figure 8 shows another page of notes for the same subject, though formatted with slight differences.

Figure 8

Dalisay's Sociocultural Notes Shown During the Pre-assessment

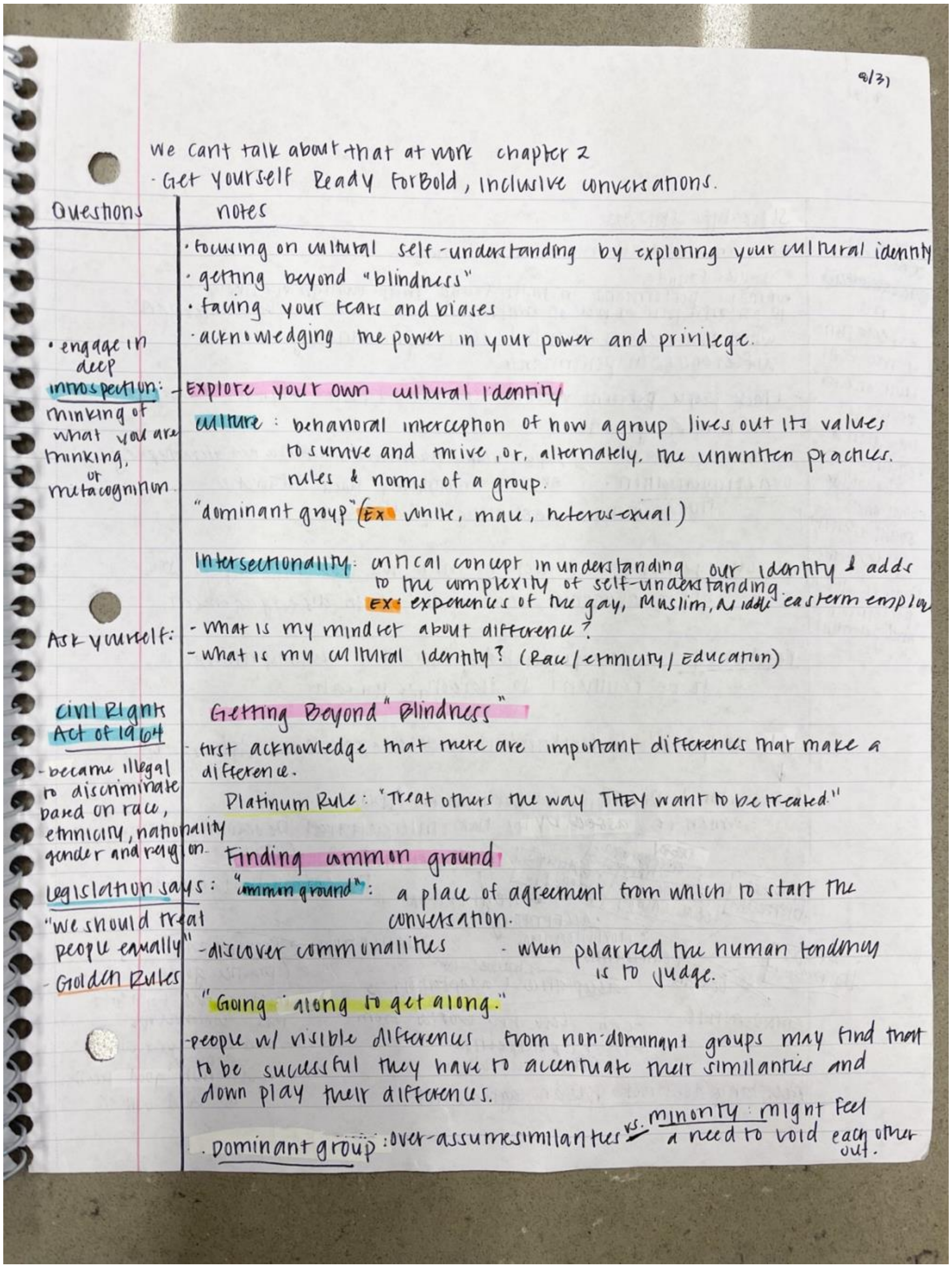


Figure 8 shows much of the same color-coding and formatting that was explained for Figure 4. The key differences in Figure 8, are there are no arrows on the page, and in the left margin Dalisay has written a "Questions" section with ideas to ask herself and reflect on.

Notably, there is no summary section as there is in a basic Cornell notes format, so Dalisay has modified the format. Cumulatively, Dalisay created visual formats, composed of arrows, signifiers (e.g., circles and underlined statements), color-coded ideas, and sections with specific information. The researchers' assumption is that formatting her notes in a way that meaningfully represented and connected ideas, helped Dalisay identify and make sense of the ideas on the page.

Ashley. In response to question 12 of the pre-assessment, which asked participants what they do to help them understand challenging ideas, Ashley stated she usually talks about mathematical concepts with friends, but that she will also try to write out mathematical steps on paper, so she can see where goes right or wrong (see Table 52). Ashley previously stated that her study strategies primarily consisted of taking notes, "All my study strategies are usually like writing notes so that I remember things better because sometimes I could picture the notes in my head. Like what I've written compared to typing." Table 61 captures a part of the discussion in the member check related to the way Ashley captured ideas in her notes (see Table 52).

Table 60

Conversation in Ashley's Member Check Relevant to Pre-assessment Themes – "Creating Visual Formats for Learning" and "Breaking Down Ideas on Paper to Understand"

Chris (Questions/Interpretations)	Ashley (Answering)
Writing out her notes on paper is Ashley's primary study strategy, which she feels helps her to remember things better – as in picture or 'see' the notes in her head.	I usually write things out on paper or use my iPad to write things out. I have a couple of Notes apps, that I use instead of typing. "I use an Apple pen."
And how does the iPad help?	It keeps things neater. And it also gives me more space to move things around and change the shape. Whereas, with paper I'd have to erase or restart. There's more flexibility and options to organize notes overall.

Writing out notes can also help Ashley understand material better, but this is dependent on the subject. She can write out a math formula in a step-by-step fashion, and see the ideas that do and don't connect, which helps her realize if she doesn't understand something well.	Yes, that's accurate.
Is this only for math?	"I think it's more of like any subject that makes me think critically. So, like science as well."
Can you tell me what it looks like when you wrote out each step? Is that all words?	It's mainly sentences, but sometimes I connect ideas. Connecting ideas (words) with arrows, not drawings.

As illustrated in the member check (see Table 61), Ashley's primary strategy was capturing ideas in her notes, which she took primarily on her iPad. The iPad provided the opportunity to modify the format of her notes easily. Ashley would sometimes write out problems in a step-by-step fashion in these notes to see how they connected.

Daniel. In response to question 10 of the pre-assessment, which asked if participants had strategies that they used to learn something new or learning something better, Daniel stated that he would break down ideas into smaller and smaller chunks until he had a conceptual understanding of the material. Table 62 captures a part of the discussion in the member check related to the way Daniel broke down ideas on paper (see Table 52).

Table 61

Conversation in Daniel's Member Check Relevant to Pre-assessment Themes – "Creating Visual Formats for Learning" and "Breaking Down Ideas on Paper to Understand"

Chris (Questions/Interpretations)	Daniel (Answering)
What's the primary way that you break ideas down to learn each part? Is it mental or on paper – what does it look like?	I need to have it on a piece of paper and see it – either on paper or screen – need to have a record of it, to go back to it – to see it, come back to it, and regularly study it and re-learn the concept or concepts.

	Some things are so simple you can mentally break them down. For something more complex those ideas need to be written down to be able to see the impact of each idea on the next and how those things connect.

Daniel explained in the member check that breaking down ideas supported his ability to see and identify how ideas (e.g., problems or processes) connected. Daniel also mentioned in the pre-assessment that he broke down ideas with his language. For example, in the pre-assessment, when the researcher asked Daniel how he thought about he learned best he stated, "… it's usually just explaining to myself and like breaking down that explanation until I have it in its key concepts and just understanding that." In another part of the pre-assessment, when The researcher asked him about breaking down concepts, he discussed breaking down the compound H2O (water), "And it's all right, what is oxygen? What is this? And then obviously that's a molecule that's from the periodic – that's from two elements of the periodic table and so, I just try and slowly break it down into more and more parts until there's nothing left, I can do to be like "oh, I understand this." In the member check, Daniel explained that he *broke down ideas on paper and supported those connections with (written) language*, which was not something he mentioned in connection to breaking down on paper previously. Thus, Daniel may have integrated the utilization of his language (in written form) with breaking down ideas on paper. Cumulatively, breaking down ideas (with language) on paper, in terms of segmenting ideas into smaller chunks to see how they connect, supports Daniel's ability to understand challenging ideas. The following section synthesizes students' explanations for the behavior, *monitoring learning.*

Monitoring Learning. Four participants indicated they (metacognitively) monitored their own thinking/understanding in the process of a learning task. This was a broader theme, that incorporated different types of monitoring behaviors in various learning tasks. This theme emerged primarily in response to the S&S section of the pre-assessment but was coded for other responses. Prominent quotes that comprise this theme are listed in Table 63 below.

Table 62

Prominent Quotes from Pre-assessment Theme – "Monitoring Learning"

Participants	Prominent Quotes
Coreen, Question 11	…and then when she's like pausing to take a breath and drink of water, go to the next slide, I think about it in my head. If I think of a better way to say that makes sense to me, then I write it down.
Abby, Question 12	I would go over it to see if I forgot to write anything down or if I got distracted, make sure I have everything, that I understood the concept, especially when my teacher is talking to me.
Daniel, Question 10	… if it wasn't working, I would stop, I would go back to what I was trying to break down and understand, and I would see where in regards to this specific problem is my understanding not working.
Daniel (not S&S)	…whereas after like recording an explanation, I can look at another I can find a point, in my own words, and then help continue putting the concept in my own words.
Dalisay (not S&S)	Basically, once…I watch something and I know of it, if I know what I'm watching, that goes behind my mind because I feel like, "Okay, I get that," but then I start to think about what I don't know after.

The through line among these responses (see Table 63) is that focal participants (metacognitively) monitored their understanding in various learning situations. This mental activity varied among focal participants, sometimes occurring in class - *when listening to a teacher*, and sometimes outside of class - *when watching a video* or *breaking down ideas on* *paper*. Thus, four focal participants assigned meaning to a monitoring behavior that supported their learning.

Online Tools Supports Confusion. All focal participants indicated that they searched for materials online, particularly when faced with challenging ideas. Participants discussed utilizing online tools in high school and also during their short time in college. The two prominent themes that related to online (internet) support were “Searching in Google for Help with Class Material,” and “Watching Educational Videos to Learn Better.”

Searching in Google for Help with Class Material. Five focal participants mentioned they searched for material in google primarily in response to the S&S section of the pre-assessment which asked about current strategies inside and outside of class. Prominent quotes related to students searching in google are listed in Table 64 below.

Table 63

Prominent Quotes from Pre-assessment Theme – “Searching in Google for Help with Class Material”

Participants	Prominent Quotes
Coreen, Question 10	I ask Google often and they don't usually help.
Ashley, Question 6	So, we would either refer back to our notes or refer to our book, and if that didn't help us for some reason, we would Google the formulas or whatever the process was.
Abby, Question 6	If it was confusing, I would Google. If Google doesn't help me out, then I would resort to the videos.
Daniel, Question 11	Or when I do – I’m very hyperactive with my Google searches, so if I get if we were learning about a topic, I will start searching for different aspects of things within the topic we're learning to see if I can find maybe like a subtopic or something that incorporates something that I would be interested in.
Dalisay, Question 9	

	And then if I don't get it, I'll just go straight to Google and-- **Chris:** Straight to what? **Dalisay:** Google. And just ask the computer itself, and then use that and put it back in (beat) like what I'm reading.

Focal participants primarily conducted google searches as a way to gather more information (input) to help them when confused or with challenging ideas (e.g., challenges in math were discussed prominently). Focal participants did not often offer how searching in Google supported their cognition (i.e., learning/thinking) and sometimes mentioned the strategy/behavior was not helpful or may not have helped.

Watching Educational Videos to Learn Better. Four focal participants explained they watched educational videos to learn academic material, in response to question six of the PK section, which asked participants about what they did in high school to learn when confused. Prominent quotes that comprised watching educational videos are listed in Table 65 below.

Table 64

Prominent Quotes from Pre-assessment Theme –"Watching Educational Videos to Learn Better"

Participants	Prominent Quotes
Abby	Khan Academy would mostly help math, but there would be more instances with biology and anatomy - Course Hero, Crash Hero, something like that, also on YouTube. (cont'd) I wouldn't go out of my way if I did understand it.
Dalisay	…but Khan Academy like gave me that chance to actually sit down and actually learn things. I think it's just the format and the multiple possibilities of practicing. They give you a lot of practice. It's very specific to their curriculum. Every step it shows you-- especially for math, it helps me understand where I went wrong and stuff.

Daniel	I like to seek out more resources. I think having the Internet available to me has been a real big help in helping me learn, because I've always been able to just YouTube. By going to YouTube or I can just search for the concept and like keep looking until I find someone like has an explanation that I can help break down for myself.
Lilly	One thing I like to do especially if I'm not understanding a topic is I go back and watch a video and I find it interesting sometimes I just needed to fill in those holes.

(cont'd)

Focal participants primarily sought educational videos to support their understanding of challenging ideas (see Table 65). Participants mentioned in the pre-assessment that they preferred the visual format and/or class whiteboard style of Khan Academy, and opportunities for repetition and practice, e.g., playing back videos (if confused) and practicing problems within the videos. The following section synthesizes students' explanations for their visual thinking.

"Visualizing" Ideas to Understand New Ideas. Four focal participants referenced their visual thinking as a source of their understanding (e.g., "Seeing Ideas with Mental Images") and those four also indicated (through provisional coding) they used their visual thinking or "visualizations" strategically. As discussed extensively in the previous research question, three focal participants (Daniel, Dalisay, and Lilly) used "visualizations" to create context (meaning) for their thinking, sometimes from different people's perspectives, which helped them understand spoken words. Three focal participants (Ashley, Daniel, and Lilly) also referenced visual thinking to understand or remember new ideas when engaged with visual input, e.g., writing notes and flashcards and when reading. "Visualizing Ideas in Visual Environments" primarily emerged in response to the S&S section of the pre-assessment. Themes that were provisionally coded as metacognitive control (MC) for visual thinking were structured into the

"Mental Strategies for Learning" category in the pre-assessment template and are captured in Table 66.

Table 65

Prominent Themes that Emerged in the Pre-assessment Related to Strategies for Visual Thinking

Category	Themes
Mental Strategies for Learning	4.7 Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills] 4.7.1 Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills] 4.8 Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat, MetSkills]

Note. Only prominent themes are mentioned in this table (i.e., coded for at least three participants).

Focal participants visualized ideas in learning situations where there was primarily auditory and visual input. However, participants assigned meaning more prominently and strategically in situations in which they were asked about understanding speakers' words. The next section summarizes the results of RQ3c.

Summary of Research Question 3c. Several prominent and notable themes emerged from the pre-assessment, which answer research question **3c** and provide results for the primary research question, RQ**3**. As intended, most themes that related to participants' strategies for thinking/learning emerged in response to the three questions in the S&S section. Those themes, as well as the categories they are structured are captured in Table 66.

Table 66

Prominent and Notable Themes that emerged from the S&S section of the Pre-assessment that Relates to Participants' Strategies for Thinking/Learning

Categories	Theme 1	Theme 2	Theme 3	Theme 4
Previous and Ongoing Physical Strategies	Creating (Meaningful) Visual Formats for Learning	Breaking Down Ideas on Paper to Understand	Asking for Clarification	Searching in Google for Help with Class Material
New and Ongoing Physical Strategies	Writing Ideas in My Own Words to Understand	--	--	--
Mental Strategies for Learning	Using Dialogue to Support Thinking/Learning	Monitoring Learning	Visualizing Ideas in Visual Environments	--

Note. See Appendix M for provisional codes. Additional note. The category "Previous and Ongoing Physical Strategies" incorporates themes in which participants mentioned something they used to do (for learning) but didn't rule out as something they continue to do. "New and Ongoing Strategies" incorporates a theme in which the strategy was new for two participants and 'ongoing' for another participant. The term "physical" alludes to the strategy needing physical movement to be effective, whereas mental strategies are primarily cognitive enterprises. Additional Note. The only theme above that was not provisionally coded as being metacognitive was "Searching in Google for Help with Class Material."

"Creating Visual Formats for Learning," was the primary theme that emerged from the pre-assessment, in terms of 1) number of quotes coded overall, 2) number of participants who reported a strategy that fell under this theme, and 3) depth of metacognitive knowledge, i.e., explanations for why participants engaged in strategies that fell under this theme. 'Creating visual formats' relates to the ways in which students captured/formatted ideas, primarily on paper but also digitally. This is an overarching theme which encompasses the sub-themes, "Color-coding Notes to Organize Ideas" and "Breaking Down Ideas on Paper to Understand."

Some focal participants also utilized their language to capture ideas and/or break down ideas on physical/digital pages. For instance, three participants, (Daniel, Abby, and Ashley) used elements of their own language to break down ideas (i.e., create smaller ideas) or write out steps to understand challenging ideas. Interview responses (from the pre-assessment and member check) and artifacts showed that five focal participants created meaningful visual formats (e.g., shapes, colors, and/or spaces), which reportedly helped to better identify, organize, and/or create relationships between ideas. Cumulatively, the theme "Creating Visual Formats for Learning" indicates some FYFG students, a) adapted their notetaking over time to include more visual formats, which varies based upon subject matter, and b) learned to break down ideas or write out steps to an idea/process on paper or digitally.

Next, five focal participants reported using language to support thinking/learning, represented by the themes "Using Dialogue to Support their Thinking/Learning" and "Writing Ideas in My Own Words to Understand." Dalisay and Coreen for instance, reported they had begun to write ideas in their own words (when taking notes), which had been effective thus far. Additionally, four focal participants indicated they *asked for clarification* to support their thinking (e.g., understanding) when confronted with challenging ideas. These 'language' themes correspond to the theme, "Communication in Groups Helps with Challenging Ideas," which relates to previous experiences (before college) focal participants reported in which they were able to better learn in peer groups. Pre-assessment themes that relate to utilization of language/communication indicate focal participants largely relied (before college) and continued to rely (early in college) on their language, particularly communication with peers, to support thinking and learning. Additionally, participants used their own words (i.e., natural language) to varying degrees when speaking, thinking, and writing (taking notes), to support their conceptual understanding of new and sometimes challenging ideas.

It's important to note that students engaged in other strategies, specifically "Visualizing Ideas to Understand Speakers' Words," "Creating Context through Visual Thinking," and "Watching Educational Videos to Learn Better." These strategies were not mentioned in Table

66 because they did not emerge in response to the S&S section but came in response to other sections in the pre-assessment. Provisional coding criteria revealed that more than half of focal participants, at the outset of their first semester in college, had a degree of metacognitive knowledge for their visual thinking and three participants had a degree of metacognitive control over their ability to "visualize" context-based situations to support thinking about new ideas. Three focal participants also showed (metacognitive) control over aspects of their visual thinking when engaged in primarily visual environments. In other words participants utilized visual thinking, in situations when they were working with primarily visual input, e.g., reading or writing notes/flashcards. References to visual thinking and language for each participant were intermittent, and sometimes required follow-up questions.

The researcher did not directly ask about focal participants skills (in relation to learning) nor were they mentioned by participants. Provisional coding did reveal that some participants utilized their visual thinking and language skillfully in terms of deliberate, strategic, and consistent use of strategies. Additionally, the extent to which participants controlled visual thinking in terms of how active or skillful they were at picturing events in various learning scenarios is unclear and is not the focus of this research. It's possible those aware of their visual thinking when engaged in learning tasks might explain their visual thinking in terms of control, but in actuality their mind automatically or unconsciously began to 'picture' ideas. See Codebook, Appendix L, for provisional criteria, and see the pre-assessment template, Appendix M, for themes that were provisionally coded as "metacognitive skills."

Research Question 3d

Research question 3d asks**,** *what meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students'* *visual thinking and learning?* In RQ3d, the researcher sought to understand what meta-learning themes became apparent at the end of the learning and thinking block that may have influenced changes to focal participants' visual thinking and learning during the semester. Specific class activities (LSA and JE6) were chosen that marked a mid-point in the ASC (from when the study began), which made it an ideal temporal marker to assess change. In RQ3d, various applied and/or integrated strategies are reported and meta-learnings that emerged for the class participant group (N = 25). Themes are reported as cumulative (LSA and JE6 together), as they were merged in the time ordered matrix to condense analysis. Class participants' responses are also reported to support the cumulative themes that emerged. Artifacts are used where relevant to provide contextualization of reported themes. The following section focuses on students' participation in class activities.

Participation in Class Activities. FYFG students participated in various class activities, including journal entries, out-of-class assignments, and in-class exercises. One journal entry, journal entry #6 (JE6) and one out-of-class assignment, the learning strategy assignment (LSA), were chosen to represent the mid-point of the study to better assess focal participants' changes. Twenty-five class participants (N = 25), including five of six focal participants agreed to their class activities being included as part of this study. Table 67 captures FYFG students interview and class participation in the study.

Table 67

FYFG Students' Participation in Class Activities

No.	Class Participants	Interviews (Focal Participants)	LSA	JE6
1	Abby	Yes	Yes	Yes
2	Alena	-	Yes	--
3	Ana	-	Yes	Yes
4	Ashley	Yes	Yes	Yes
5	Cathleen	-	Yes	Yes
6	Chea*	-	Yes	Yes
7	Coreen	Yes	Yes	Yes
8	Dalisay	Yes	Yes	Yes
9	Daniel	Yes	Yes	Yes
10	Eduardo	-	Yes	Yes
11	Efrain	-	Yes	Yes
12	Eli	-	Yes	Yes
13	Emanuel	-	Yes	Yes
14	Francisca	-	-	-
15	Kai	-	Yes	-
16	Kalani	-	Yes	Yes
17	Lilly*	Yes	-	-
18	Lucía	-	Yes	Yes
19	Luna	-	--	-
20	Makaio	-	Yes	Yes
21	María	-	Yes	Yes
22	Melia	-	-	Yes
23	Miguel	-	Yes	Yes
24	Renzo	-	Yes	Yes
25	Valentina	-	Yes	Yes
26	Valeria	-	-	Yes

Note. Horizontal dashes denote no participation. Additional Note. *Lilly consented to participating in interviews only, not the class portion of the study.

Two class participants, Luna and Francisca, did not complete the class activities that were chosen to represent this study. Four other class participants, Valeria, Melia, Kai, and Alena completed one of the two class activities chosen to represent the class activities portion of the study. Thus, 23 class participants (N = 23), including the five focal participants completed at least one of two class activities included in the study. Of those 23 class participants, 21 completed JE6, 21 completed the LSA, and 19 completed both class activities.

Class Activities. The LSA was assigned in week nine, class eight of the ASC. The instructors asked students to apply a strategy discussed in class and reflect on their application of the strategy. The LSA instructions read, "Try one or two visual, metacognitive, and/or language learning strategies this week that you think could be impactful. This can be visualization, drawing, note-taking in your own voice, teaching the material, etc. Try to use this strategy (or strategies) all week. Please do not use a strategy that we have not covered in class." FYFG students were asked to upload an example of the strategy they utilized to the university's learning management system. See Appendix J for full instructions and an infographic that supported this assignment.

JE6 was assigned in week 10, class nine of the ASC, at the conclusion of the learning and thinking block. JE6 consisted of five primary questions and two sub-questions designed to understand students' previous challenges with learning, as well as to assess dispositions related to meta-learning, and meta-learning overall. JE6's instructions read, "Take out a visual block of at least 20 mins and reflect on your experiences with learning and thinking for the past 6 weeks. Please answer all the prompts, minimum 350 words, for full credit." One question in JE6 asked class participants if they had "integrated" strategies they learned in the ASC into their lives and if so, why had they integrated them. Participants were also asked several questions related to their learning. See Appendix K for the full list of questions.

Themes that emerged from class participants' responses about applied and/or integrated strategies in class activities will be discussed, as well as the meta-learning themes that emerged primarily as a result (see Appendix N for full list of themes). Lastly, three notable meta-learning themes from JE6, that fell outside the utilization of strategies will be discussed.

Drawing as an Adapted Strategy for Learning. In response to questions in the LSA and JE6 related to what strategies students applied and integrated at the latter stages of the learning and thinking block, 16/23 class participants reported they applied and/or integrated drawing as a strategy for their learning. Eight of those 16 students reported they applied and integrated drawing as a strategy (in the LSA and JE6). FYFG students were taught about utilizing drawing when reading and taking notes to support conceptual learning. All students adapted the strategy based on what they had learned in the ASC and their own learning needs. Table 68 captures the themes within the class activities that make up the cumulative theme, "Drawing as an Adapted Strategy for Learning."

Table 68

Themes from Class Activities that Encompass the Cumulative Theme, "Drawing as an Adapted Strategy for Learning"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	Applied Strategies from ASC	Drawing as a Strategy for Learning (13/21) [CK | MK | MR (Control), MetSkills | ML]
Journal Entry #6	Integrated Strategies from ASC	Drawing to Represent Ideas (11/21) [CK | MK, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for and the second number represents the total number of students that theme could have been coded for. Another Note: Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

Themes listed in Table 68 are discussed next.

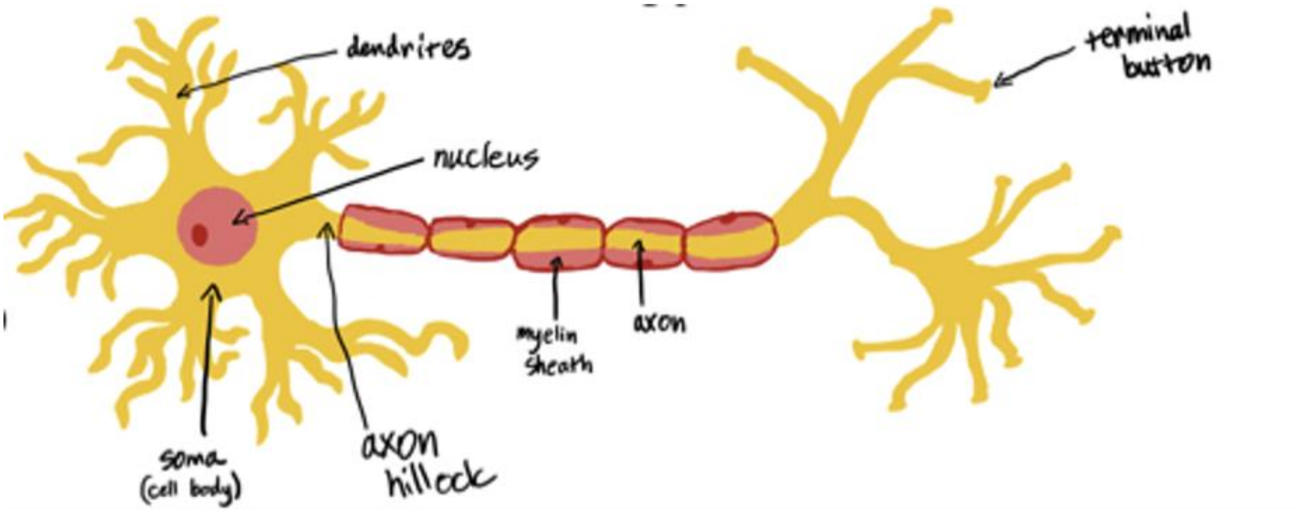
Drawing as a Strategy for Learning. Thirteen class participants mentioned they applied drawing as a strategy for their learning strategies assignment (LSA), similar to the drawing/flowcharting strategy discussed in the ASC. Instead of copying notes from a slide/presentation or from the teachers' lecture, students were taught to, 1) visually think about what the teacher presented, 2) draw the ideas that came to mind, 3) connect those ideas with arrows, and 4) use language to tag or label the drawings (ideas). Conceptual drawing can be a deeper thinking and metacognitive strategy for learning that capitalizes on students' visual-mental thinking as a source of learning. Class participants responded to the LSA by stating they've been drawing (ideas), primarily in their notes. Most students did not engage in drawing exactly as it was discussed in the ASC. Instead, they engaged in a form of drawing, adapted to the way they understood it or the way they thought drawing best suited them.

Eleven of the thirteen students who applied drawing discussed drawing in a metacognitive context, in that they discussed how they engaged in the strategy mentally or how it supported them mentally when learning. Of those 11 students, seven were provisionally coded as MK and four were provisionally coded as MR. Those coded as MR discussed procedural aspects of drawing, which indicated a degree of metacognitive control of the strategy they applied. These participants' artifacts aligned with what they discussed, and they adhered to some concepts for drawing that were discussed in the ASC. For instance, five participants who applied drawing knew to utilize visual thinking (i.e., imagination, visualization) with their drawing. Meaning students understood to connect the physical act of drawing (i.e., writing, sight) with their visual thoughts. This will be discussed more in the section, "Learned about Visual Thinking."

Five drawings were chosen by the researcher that well represented the diversity of drawings among class participants and could be explained in clear terms. Additionally, the researcher chose focal participants drawings as they are the subject of change in the study. A sample of drawings from the LSA are shown in figures six through ten below.

Figure 9

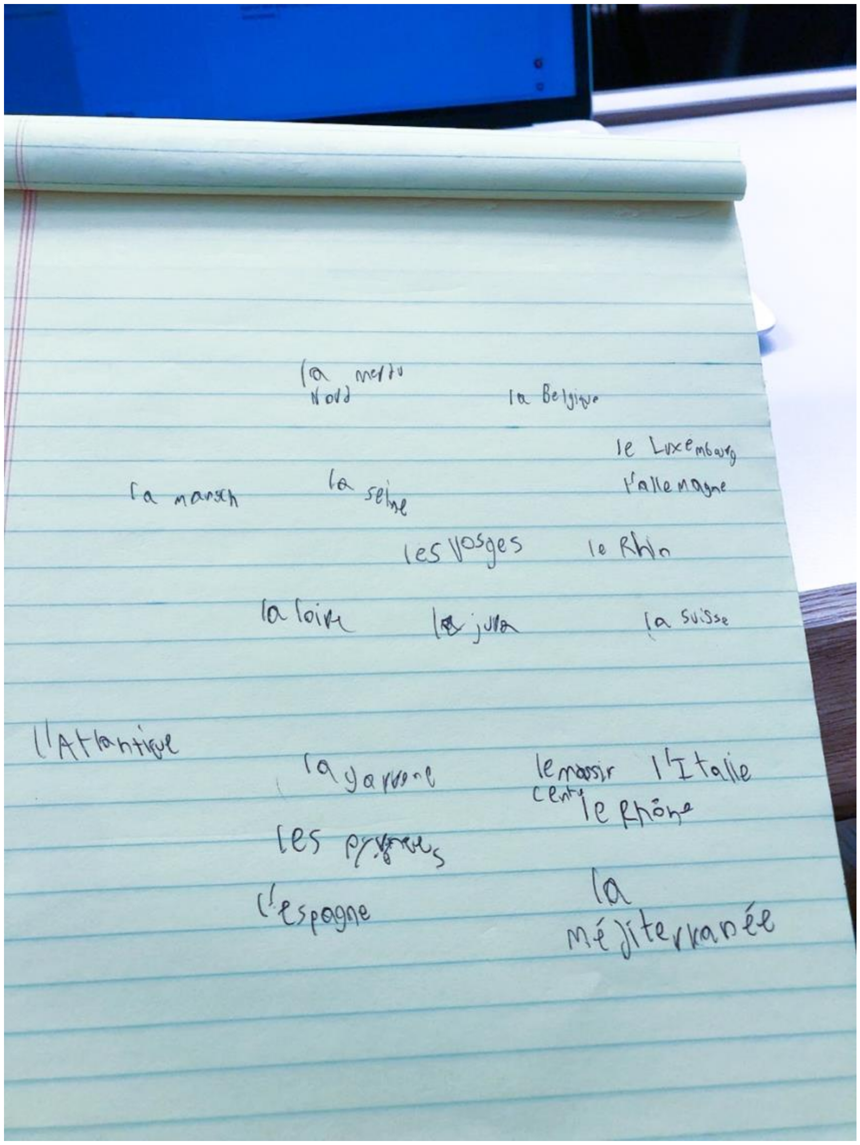
Ashley's Drawing from the LSA



In Figure 9, Ashley drew a picture of a neuron, colored specific sections based on the physiological make-up of a neuron, and labeled the different structures that make up a neuron, e.g., soma, axon hillock, dendrites, nucleus, myelin sheath, axon, and terminal button. Ashley stated that the drawing the neuron helped her to better understand "how signals travel through them." She did not indicate if the drawing was for a class or something she wanted to learn on her own. Daniel's drawing is shown in Figure 10 below.

Figure 10

Daniel's Drawing from the LSA



In Figure 10, Daniel wrote the regions of France on paper in the French language, e.g. la Loire, le Rhône, la Seine, etc., as well as some surrounding countries. Daniel explained he would usually try to study for something like a French map quiz by looking up the map online, but he was unable to do so in this instance.

> I had a quiz in French 201 on Friday last week after having an essay due Monday and a midterm on Wednesday. Due to the sheer pressure in that class last week, plus anything

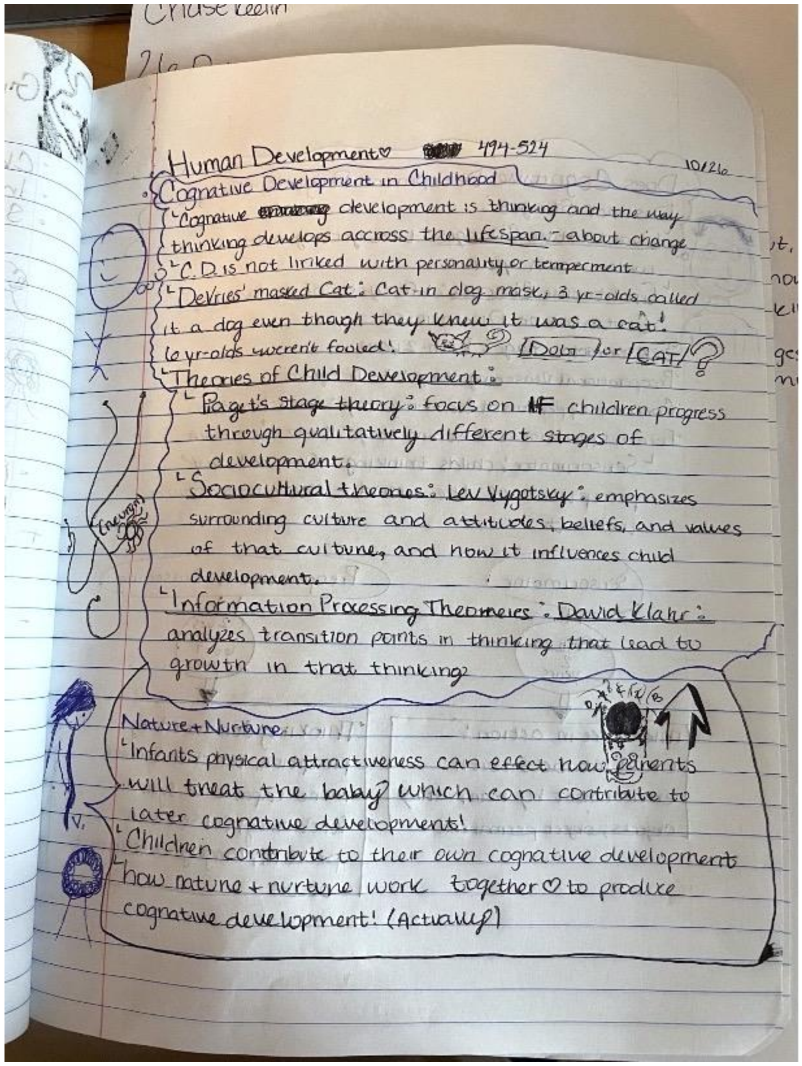
extraneous from my other classes, I could only start studying for the quiz on Thursday night. This was very tricky as the quiz would be on a map of France's mountain ranges, rivers, and parks, along with the countries surrounding it. Usually, for a map quiz, I would go online and look for a website where it contains a map test of placing a country's name on the country itself. I would do that for 25 minutes three times and I could have it made, but due to the varied nature of this map quiz, there was no website. I only had the one labeled worksheet from class and recognizing that I wouldn't be able to study effectively from it, I was lost. Until I saw that the map of France looks like a tilted hexagon.

Daniel found that he could visualize the *tilted hexagon* which composed regions listed in Figure 7. He stated, "From there I started repeatedly drawing out my titled hexagon and labeling points on or around the hexagon." Labeling the different regions and visualizing them within the hexagon helped him to remember the regions for a quiz in French class. Daniel later stated he "aced" the test. Although, it could be asserted Daniel's strategy relates more to visual thinking than it does conceptual drawing, Daniel thought of it as drawing, and drew the tilted hexagon (likely in other drawings), as well as labeling the structure with space in mind on paper, so the researcher included the strategy in this theme.

Renzo's drawing is shown in Figure 11 below.

Figure 11

Renzo's Drawing from the LSA

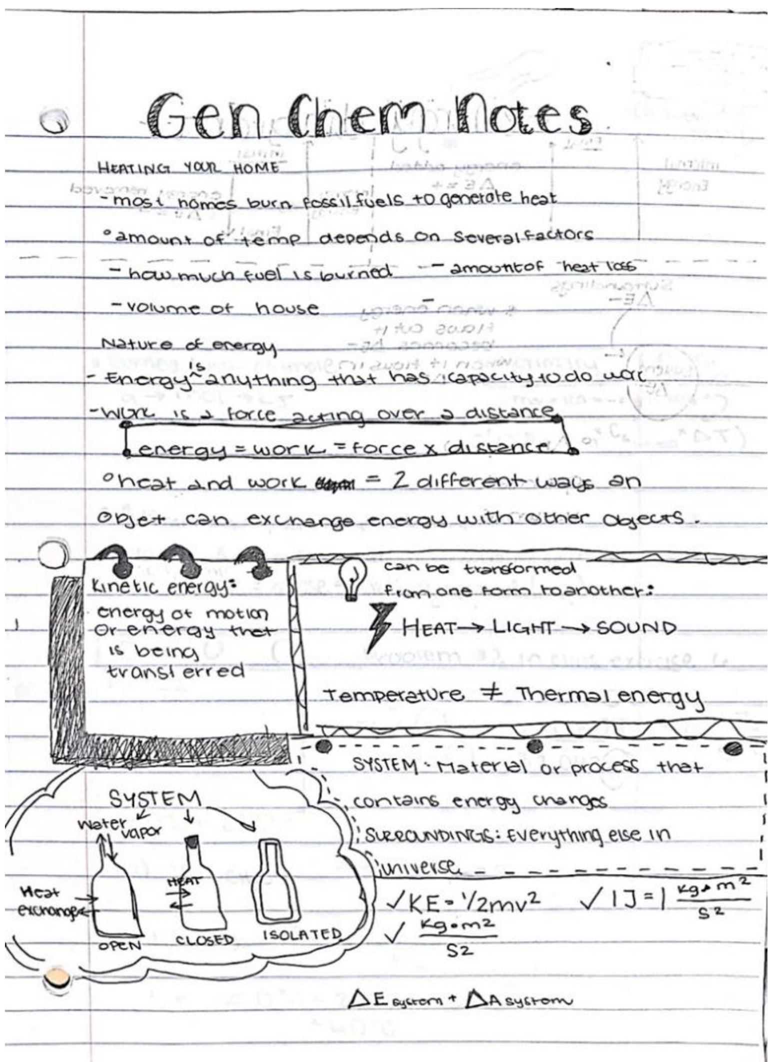


In Figure 11, Renzo created various visual formats in his notes, primarily composed of icon drawings that represented ideas. The notes are presumably for a psychology class, on the subject of "Human Development." Renzo drew icons in the left margin of his notes, such as a mother (possibly), and related that to the concept of "nurture". He also drew a tree to represent the concept of "nature". Renzo drew a stick figure person with a thought bubble that enclosed notes about psychological research on childhood development. He also drew a picture of a neuron, which looks to be related to three psychology-based theories on development, e.g.

Information Processing Theory, Sociocultural Theory, and Piaget's Stage Theory. These drawings related to three distinct sections that Renzo outlined on the page. He stated, "Along the margins of my pages would be cute, insightful doodles that would remind me of my own thoughts or redirect my busy brain when it started wandering." Renzo also stated that he used the drawings to "emphasize key points, to visualize the material, and to help me see my thoughts." Ana's drawing is shown in Figure 12 below.

Figure 12

Ana's Drawing from the LSA

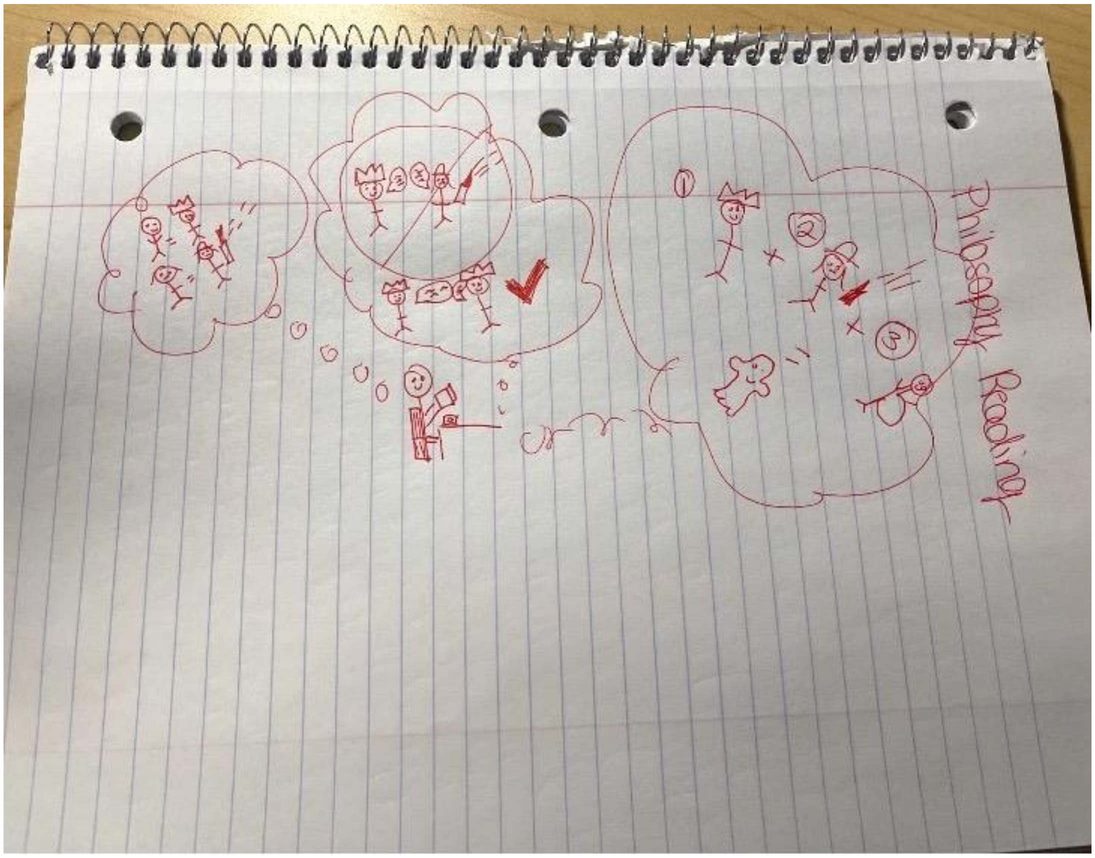


In Figure 12, Ana created visual formats (e.g., drawings) to arrange and represent ideas in her Chemistry notes. She drew icons such as a lightning bolt and light bulb presumably to represent types of energy, and cylinders that illustrated a process of heat/energy exchange. Ana also connected ideas with arrows, wrote ideas in her own words, and created areas on the page which stood out from the rest of the page, e.g., a drawing of a notebook with main ideas/processes listed in the notebook. Drawing ideas in the way that she "imagines them" helped Anna to understand what she was learning better.

Additionally, Ana stated that her favorite drawing was the three cylinders with the particles, "because the first cylinder has this little cap that isn't pressed all the way down, while the cylinder next to it has the cap pressed down a little harder and that's a great example of how the one with the cap pressed down hold(s) greater pressure since the particles are tightened up more than the one with the cap all the way up." Ana mentioned that she sometimes had difficulty understanding the lectures and the ideas presented in classes, so she liked to make diagrams and add notes in her own words to understand the ideas better. Ana was one of the five participants who applied drawing as a strategy and utilized visual thinking (e.g., imagination,) with their drawing. Eli's drawing is shown in Figure 13 below.

Figure 13

Eli's Drawing from the LSA



Eli utilized drawing for her Philosophy class, similar to the way flowcharting was discussed in the ASC, although without the language one should incorporate. She drew a picture of herself presumably, and the thought bubbles which encompassed her thoughts as she read the book "Plato's Republic." Students were taught to draw stick figures and keep drawings rudimentary (for speed and effective processing).

Eli stated she "sometimes struggle(d) to understand the topics in that class... and found "it hard to pay attention." Instead of handwriting notes from the book, Eli chose "...to draw out some ideas from the text to help me better understand the reading." She also mentioned that it was challenging to convert the big ideas into things she could draw, "Just because they're so broad and big it's hard to really define some of the concepts they are talking about."

The previous five artifacts represented the drawings received by class participants who engaged in the strategy for the LSA. Class participants integration of drawing as a strategy as reported in JE6 is discussed next.

Drawing to Represent Ideas. Eleven of 21 class participants responded to prompts in JE6 by stating that they've used or integrated drawing (ideas) in their notes as a strategy for learning. Again, most students adapted this strategy from the way it was discussed in the ASC, based on how they understood the strategy and/or based on what they needed.

Some students engaged in the strategy more accurately, in terms of how it was discussed in the ASC than others. For instance, three participants showed a knowledge (i.e., understanding) of the connection between drawing and visual-mental thoughts, meaning they were metacognitively aware that they should draw what they saw in their minds or what they drew supported visual thinking.

Five of eleven participants who *drew to represent ideas* were provisionally coded as MK. Six of 11 participants were provisionally coded as CK for this theme, meaning participants mentioned using drawing as a strategy, rather than mentioning the impact drawing had on their cognition or discussing how they utilized the strategy in connection with their thinking.

There is a steep learning curve with conceptual drawing, as the strategy tasks the learner with drawing what's in their mind when learning new ideas. Thus, the only way to utilize conceptual drawing well is to apply it regularly. With more than half of class participants reporting they integrated drawing into their learning, this would presumably begin or continue a process of meta-learning. Participants' meta-learning in relation to application/integration of drawing is discussed next.

Drawing Supports My Learning. In total, 10/23 class participants responded to prompts in the LSA and JE6 by mentioning that drawing supported an aspect of their learning and/or understanding. Because participants learned something about their own learning in the context of using drawing, they engaged in meta-learning. Themes provisionally coded for meta-learning from the LSA and JE6 and incorporated into the cumulative theme, "Drawing Supports My Learning," are captured in Table 69.

Table 69

Themes from Class Activities that Encompass the Cumulative Theme, "Drawing Supports My Learning"

Class Activity	Category	Meta-learning Themes
Learning Strategies Assignment (LSA)	What I Learned	Drawing Supports Aspects of My Learning (6/21) [MK, ML]
Journal Entry #6	What I Learned	Drawing Helps to Better Understand Material (4/21) [MK, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Another Note: Provisional Codes: MK = Metacognitive Knowledge, ML = Meta-learning.

Themes listed in Table 69 are discussed next.

Drawing Supports Aspects of My Learning. In response to prompts in the LSA, seven participants mentioned how drawing (as a strategy for learning) supported their retention, learning, and understanding - with "understanding" being the most cited. Class participants adapted drawing as it was discussed in class and in applying the strategy participants reported that the strategy supported aspects of their learning. Responses in Table 70 and some not listed were deductively coded for the theme "Drawing Supports Aspects of My Learning."

Table 70

Prominent Quotes for Meta-learning theme –"Drawing Supports Aspects of My Learning"

Class Participants	Prominent Quotes
Ashley	With this drawing I am able to have a better understanding of what a neuron looks like and how signals travel through them.
Renzo	Along the margins of my pages would be cute, insightful doodles that would remind me of my own thoughts or redirect my busy brain when it started wandering. I think the drawings were particularly helpful to me for this reason.
Ana	I used these strategies during my chemistry class because there's a lot of lectures but also a lot of visuals and sometimes the way it's drawn makes it more difficult for me to understand personally so I like to make diagrams/add more notes to the diagrams so I can understand better.
Chea	I think that drawing was super helpful for my learning. After I finished, I realized that adding drawing to imagination really helped me to understand the concept of the lesson...
Kai	But after using the drawing strategy, I was able to find a way to understand and create a positive trend in my grades.
Efrain	That is where this method shines, as I now remember clearly all the concepts that were taught in my philosophy class in which I used this method.

In Table 70, class participants shared meta-learnings from applying drawing as a strategy for learning. Responses in Table 70 and some not mentioned were deductively coded for the theme “Drawing Supports Aspects of My Learning.” The latter theme in Table 69 is discussed next.

Drawing Helps to Better Understand Material. In response to prompts in JE6, four participants reported that drawing, when used as a strategy for academics, supported an aspect of their learning, e.g., helping them to understand academic material. Responses in Table 71 and some not listed were deductively coded for the theme “Drawing Helps to Better Understand Material.”

Table 71

Prominent Quotes for Meta-learning theme –“Drawing Helps to Better Understand Material”

Class Participants	Prominent Quotes
Abby	However, I’ve definitely been integrating (concept maps) into my life a little more and I have noticed that I understand concepts more easily.
Eli	I chose to integrate that particular strategy into my learning because I thought it was a really cool idea and it actually helped me understand the reading material better.
Ana	...and learning the visual technique has helped me stay more focused and has made the content in class easier to understand.
María	Biology is a tough subject to learn, but when you add drawings and graphs it’s like ten times easier to understand.

Class participants’ responses in Table 70 and some not mentioned were deductively coded for the theme “Drawing Helps to Better Understand Material.” In applying and/or integrating drawing as a strategy, class participants also reported diverse learnings, which is discussed next.

Diverse Learnings from Drawing. In response to prompts in the LSA and JE6 about specific strategies class participants had utilized, 9/23 class participants reported unique learnings from drawings representing a diversity in responses. These learnings are captured by the themes listed in Table 72.

Table 72

Themes from Class Activities that Encompass the Cumulative Theme, "Diverse Learnings from Drawing"

Class Activity	Category	Meta-learning Themes
Learning Strategies Assignment (LSA)	What I Learned	Various Learnings from Applying Drawing (6/21) [MK, ML]
Journal Entry #6	What I Learned	Various Learnings from Drawing (6/21) [MK, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, ML = Meta-learning.

Themes listed in Table 72 are discussed next.

Various Learnings from Apply Drawing. Six class participants had unique learnings from applying drawing as a strategy. This theme is broad in context, as it's meant to illustrate the differences in experiences/knowledge as it applied to drawing. Prominent quotes from this theme are listed in Table 73.

Table 73

Prominent Quotes from Theme in the LSA – "Various Learnings from Apply Drawing"

Class Participants	Prominent Quotes
Ashley	(The drawings) may also (have) been less useful because they weren't thoroughly drawn or described which means I should think more carefully about what information is really important and which aren't.
Daniel	I also noticed that as I got more and more involved in trying to just see where the words should be, I stopped drawing the hexagon in order to just better view the placement of the words. You can't allow the placement of things in your drawing to get too cramped.
Renzo	If I paced myself and was conscious of not taking a terribly long-time drawing, this strategy had very little challenges of use or very little downside.
Eli	I think I can overcome the challenges by working more on the smaller concepts first and working up to the bigger ones just because I think it would be better to start small then work up.

In Table 73, class participants shared a unique meta-learning from their experiences applying drawing as a strategy for learning. Class participants' meta-learnings came in response to a question in the LSA which asked participants how they would overcome challenges to the strategy they utilized. It's logical that students would have unique experiences from engaging in drawing and as a result have dissimilarity in their knowledge (learnings). The theme, "Various Learning from Apply Drawing" was provisionally coded as metacognitive and meta-learning for all but one student, whose insights were based more on perceptions/opinions. The latter theme in Table 72 is discussed next.

Various Learnings from Drawing. Six class participants had unique learnings from utilizing drawing as a strategy. This is a broad theme meant to show that students who integrated and/or applied (i.e., used) drawings learned from their experiences, apart from its benefits in supporting understanding of material. Responses in Table 74 and some not listed were deductively coded for the theme "Various Learnings from Drawing."

Table 74

Prominent quotes from Theme in the LSA – "Various Learnings from Drawing"

Class Participants	Prominent Quotes
Abby	I have been choosing to implement these (concept maps) more because I realized that no one really sees my notes and that writing down all the words in my notes is a waste of time and unnecessary.
Abby	...writing less is a timesaver and it helps me be more effective in understanding the concepts and connections without writing an ample amount of material.
Daniel	It was a great strategy that I would want to try again, it just has such limited application.
Renzo	I found it was easier to stay focused when I could doodle or translate...information into my own thoughts.
Lucía	I've never used drawing in notes before, other than diagrams, but using them instead of words can be difficult to interpret.
Chea	In addition, after taking the class, I started to learn to integrate drawing ideas and concept maps by connecting them with diagrams and my own language.

Some class participants' learnings in Table 74 showed challenges and/or perceptions related to implementing drawing as a strategy. The theme "*Various Learnings from Drawing*," was provisionally coded as a metacognitive/meta-learning theme for all but one student, whose insights were based more on perceptions. A summary of class participants' utilization of drawing is discussed next.

Summary for Drawing in Class Activities. The drawing themes that emerged for each class participant based on their responses to the LSA and JE6 are captured in Table 75.

Table 75

Prominent Themes Between LSA and JE6 for Drawing, Listed for Each Class Participant

		Learning Strategies Assignment			Journal Entry #6		
No.	Name	Drawing as a Strategy for Learning	Drawing Supports Aspects of My Learning	Various Learnings from Applying Drawing	Drawing to Represent Ideas	Drawing Helps to Better Understand Material	Various Learnings from Drawing
1	Abby	-	-	-	X	X	X
2	Alena	-	-	-	-	-	-
3	Ana*	X	X	-	-	X	X
4	Ashley	X	X	X	X	-	-
5	Cathleen	-	-	-	-	-	-
6	Chea*	X	X	X	X	-	X
7	Coreen	-	-	-	-	-	-
8	Dalisay*	-	-	-	X	-	-
9	Daniel*	X	-	X	X	-	X
10	Eduardo	-	-	-	-	-	-
11	Efrain	X	X	-	-	-	-
12	Eli	X	-	X	X	X	-
13	Emanuel	X	-	-	X	-	-
14	Kai	X	X	X	-	-	-
15	Kalani*	X	X	-	-	-	-
16	Lucía*	-	-	-	X	-	X
17	Makaio	X	-	-	-	-	-
18	María*	X	-	-	X	X	-
19	Melia	-	-	-	-	-	-
20	Miguel	X	-	-	X	-	-
21	Renzo*	X	X	X	X	-	X
22	Valentina	-	-	-	-	-	-

23	Valeria	-	-	-	-	-	-

Note. *Students with an asterisk next to their name also mentioned knowledge of utilizing drawing in connection with their visual thinking. Additional Note. "X"'s denote the participant was coded for this theme. Dashes denotes the participant was not coded for this theme. Last Note.

The themes listed in Table 75 were merged into "cumulative" themes which represented an accumulation of themes between the LSA and JE6 with similar meanings, e.g., applied/integrated strategies, similar meta-learnings. Merged themes with corresponding cumulative themes are captured in Table 76.

Table 76

Cumulative Themes from Class Activities Related to Drawing

Themes Merged into Cumulative Theme	Merged Into Category	Cumulative Themes
1) Drawing as a Strategy for Learning (from LSA) 2) Drawing to Represent Ideas (from JE6)	Applied and/or Integrated Strategies	Drawing as a Strategy for Learning (16/23)
1) Drawing Supports Aspects of My Learning (from LSA) 2) Drawing Helps to Better Understand Material (from JE6)	Primary Meta-Learning Themes	Drawing Supports My Learning (10/23)
1) Various Learnings from Applying Drawing (from LSA) 2) Various Learnings from Drawing (from JE6)	Primary Meta-Learning Themes	Diverse Learnings from Drawing (9/23)

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for.

As illustrated in Tables 75 and 76, between the LSA and JE6, 16/23 class participants applied and/or integrated drawing as a strategy for learning - represented by the cumulative theme, “Drawing as a Strategy for Learning.” Eight of those 16 students reported applying (in the LSA) and integrating (in JE6) drawing as a strategy for learning. All students adapted drawing based on what they had learned in the ASC and/or their own learning needs.

Between the LSA and JE6, 10/23 class participants reported that drawing supported an aspect of their learning - represented by the cumulative theme, “Drawing Supports My Learning.” Only one class participant, Ana, mentioned that drawing supported an aspect of learning in response to prompts in the LSA and JE6.

Nine of 23 class participants mentioned something unique they learned from applying/using drawing as a strategy - represented by the cumulative theme, “Diverse Learnings from Drawing.” Three participants, Chea, Daniel, and Renzo, mentioned a unique meta-learning in response to prompts in both the LSA and JE6.

Between the latter two cumulative themes, 12/23 participants reported knowledge they had attained (in most cases, meta-learnings) from utilizing drawing as a strategy for learning. Commonly mentioned challenges to drawing were that it was time consuming and that it was difficult to think about what to draw. See Appendix N to view the full list of themes from the class activities.

Lastly, eight class participants marked by an asterisk in Table 75, understood to connect the physical act of drawing (i.e., writing, sight) with their visual-mental thoughts. Engaging in drawing by using one’s visual thoughts to draw the ideas that come to mind was something specifically taught in the ASC prior to the LSA assignment. This knowledge is incorporated in the theme, “Learned about Visual Thinking,” but it overlaps with the application of drawing, so it's mentioned here. Visualization as a strategy and learning about visual thinking is discussed next.

Using Visualization to Support Self in Academics. In response to questions in the LSA and JE6 related to what strategies students applied and integrated at the latter stages of the learning and thinking block, 7/23 class participants indicated applying and/or integrating visualization as a strategy to support themselves in academics and/or to support their learning. Additionally, three of those seven participants indicated applying and integrating visualization as a strategy for their learning (between the LSA and JE6). Table 76 captures the themes within the class activities that make up the cumulative theme, "Using Visualization to Support Self in Academics."

Table 77

Themes from Class Activities that Encompass the Cumulative Theme, "Using Visualization to Support Self in Academics"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	Applied Strategies from ASC	Using Visualization for Academics (5/21) [MR (Control), ML, VT]
Journal Entry #6	Integrated Strategies from ASC	Using Visualization as a Strategy to Support Learning (5/21) [CK | MK, ML, VT]

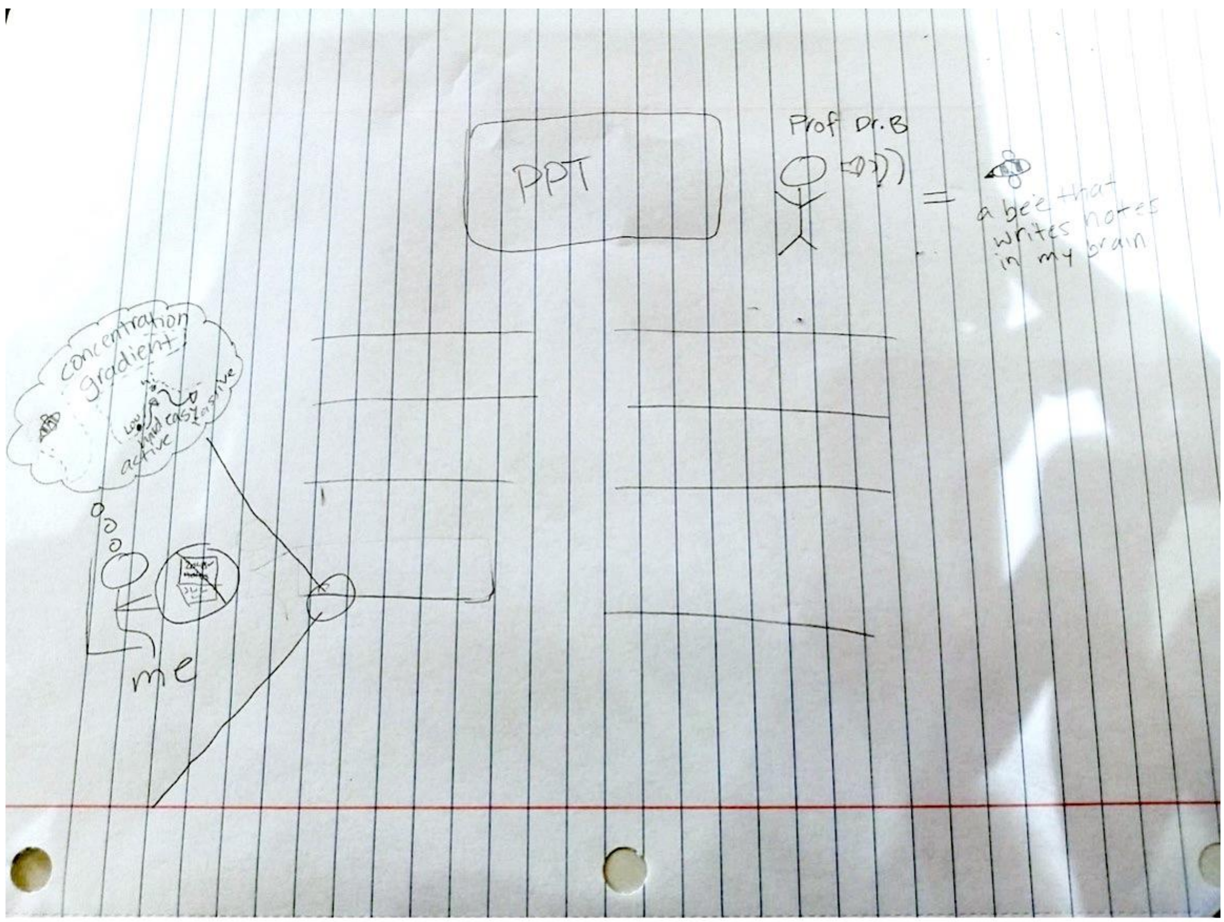
Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

Themes listed in Table 77 are discussed next.

Using Visualization for Academics. In response to the LSA, five class participants applied "visualization" as a strategy or incorporated elements of visual thinking into other strategies (e.g., drawing) to support academics in general (not necessarily learning). This theme was provisionally coded as “MR” and “ML” for all respondents as they used visual thinking (e.g., imagination and visualization) to support their learning and/or academic performance based on what was discussed in the ASC. Two participants, Coreen and Chea indicated using visualization to learn/retain information and another, Miguel, used visualization to manage anxiousness when taking tests. Miguel stated, “I usually get really anxious and nervous before big moments in my life such as big games or big tests, so I try to use this technique to my advantage and picture myself performing well, having the situation under control, or receiving a good grade.” Miguel mentioned he used visualization for sports in high school and in the last year he started using it for academics. Obviously, visualization is not a strategy that can be shown, but it is something that can be explained metacognitively as Miguel does in the quote above. Two artifacts that class participants provided were chosen to better support class participants explanations of using their visual thinking. Coreen and Chea’s artifacts are shown in figures 14 and 15 below.

Figure 14

Coreen's Drawing from the LSA on How She Uses Visualization



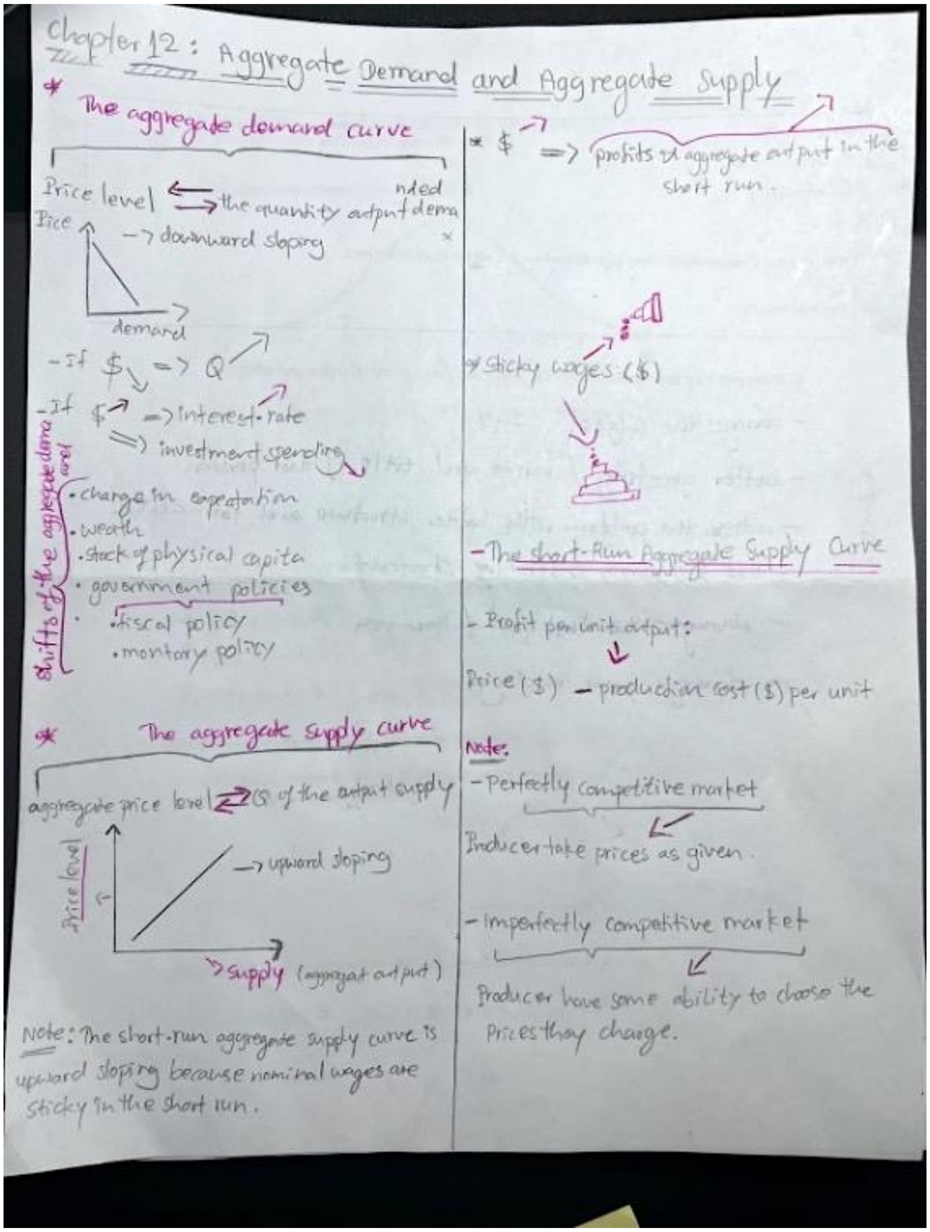
Coreen drew the visualization strategy she engaged in for the LSA assignment. As illustrated in Figure 14, Coreen drew a stick figure of herself sitting at a desk in her Biology class. A thought bubble stemming from her head, contains a thought process for the biological process - "concentration gradient." There are two columns and four rows of lines that are presumably meant to represent other students and their desks inside the Biology class. At the front of the class, a stick figure of her Biology teacher lecturing from a PowerPoint has been drawn, along with a bee and the words "a bee that writes notes in my brain." Coreen explained that she used visualization to spatially organize mental images of her own words in her mind based on what the teacher was saying, which helped make sense of the ideas.

> The strategies I have used to improve my learning in biology class are a mix of visualization and taking notes in my own voice. Despite diligent note-taking, I was struggling to perform well on exams 1 and 2. So for exam 3, I've decided to try something different and instead of taking notes, just to listen. While I listen to what my professor says I am using visualization to organize her words into meaningful notes in my own words in my head. I believe that keeping this process in my brain instead of frantically typing it as fast as I can allows the process to become more complete. It seems to provide a better initial understanding and also requires me to be more engaged in the class. Interestingly enough I also seem to have the same amount of recall when asked a question as I did when I took notes diligently.

Coreen's explanation shows an understanding (based on meta-learning) that the "process" of thinking becomes more complete when she organizes ideas in her mind. It should be noted that this type of mental behavior was not discussed in the ASC. Instead of drawing herself in a seat with a thought bubble and drawing the ideas that come into her mind when listening to the teacher, Coreen is doing much of what would be done on paper in her mind. Therefore, Coreen is combining elements of visual thinking, drawing, and writing in her own words, based off what she believes will work for her learning. Next, Chea's artifact and use of visualization will be discussed.

Figure 15

Chea's Drawing from the LSA on How She Uses Visualization



In Figure 15, Chea created various visual formats (e.g., diagrams) in her notes for Macroeconomics. In these notes, Chea stated that she "...combined the use of imagination, my own language with concept maps and diagrams." She explained her process as follows, "At first, I read the important concept in the text, then I processed the information in my mind and tried to understand what it really meant. Next, I drew the idea with my own words using arrow diagrams to connect them. I did the same things on other parts of the lesson that I tried to understand." Chea further stated that she thought using drawings along with her "imagination" helped her to "understand" the lesson in Macroeconomics and possibly "remember" ideas longer, compared to solely trying to memorize the information. Class participants use of visualization as reported in JE6 is discussed next.

Using Visualization as a Strategy to Support Learning. In response to prompts in JE6, five class participants mentioned that they integrated and/or are using visualization (i.e., mental imagery) as a strategy to support their learning. In two cases, participants detailed how they used mental imagery and how it supported their learning. For instance, Kalani explained that visualizing a test environment helped her deal with anxiety when taking tests. Such responses were provisionally coded as "MK" and for showing meta-learning, "ML". Three other participants mentioned they integrated visualization as strategy but did not elaborate. Such responses were provisionally coded as "CK." Responses in Table 78 and some not listed were deductively coded for the theme "Using Visualization as a Strategy to Support Learning."

Table 78

Prominent Quotes from Theme in LSA – "Using Visualization as a Strategy to Support Learning"

Class Participants	Prominent Quotes
Kalani	Before school, if there's any tests or quizzes happening that day, I would try to imagine myself physically there and to be at a peaceful state. I had this one exam for math, and I went through every step. We had a study guide for the exam, which was helpful, so I went through every problem with my calculator on my side and took deep breathing and was at a relaxed state.

Chea	As a learner, I use mental images and imagination, and reflection a lot. I realized I always like to imagine pictures when people are talking about any story or concept.
Valeria	I also learned how to use mental imagery, which I have applied when studying for my nursing exam last week.

Themes that emerged as a result of participants' meta-learning in relation to the application of drawing and visualization as strategies are discussed next.

Learned about Visual Thinking. In response to prompts in the LSA and JE6, 11 of 23 class participants were coded for a meta-learning theme that related to utilization of their visual thinking in the learning process (i.e., metacognitive knowledge of visual thinking when learning). Class participants assigned meaning to their own visual thinking predominantly in the context of drawing or using visualization as an applied and/or integrated strategy. These responses were coded into three visual thinking themes listed in Table 79, which were later merged into the cumulative theme "Learned about Visual Thinking."

Table 79

Themes from Class Activities that Encompass the Cumulative Theme, "Learned about Visual Thinking"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	Drawing as a Strategy for Learning	Drawing and Seeing Thoughts (5/21) [MK, ML, VT]
Journal Entry #6	What I Learned	Mental Imagery Supports My Thinking/Learning (5/21) [MK, ML, VT]

Journal Entry #6	What I Learned	Connection Between Drawing and Mental Images (3/21) [MK, ML, VT]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, VT = Visual Thinking, ML = Meta-learning.

Themes listed in Table 79 are discussed next.

Drawing and Seeing Thoughts. Five of the 13 participants who applied drawing as a strategy for learning (in the LSA) also knew to utilize visual thinking (i.e., imagination, visualization) with their drawing - represented by the theme "Drawing and Seeing Thoughts." This theme illustrates a connection between the physical act of drawing and metacognitive awareness/control for one's visual thoughts. Because utilization of visual thinking was taught in this manner in the ASC, this theme was provisionally coded for meta-learning, "ML." Prominent quotes for this theme are listed in Table 80.

Table 80

Prominent quotes from theme in LSA – "Drawing and Seeing Thoughts"

Class Participants	Prominent Quotes
Daniel	From there I started repeatedly drawing out my titled hexagon and labeling points on or around the hexagon. This was insanely helpful for studying for the test, as I was able to visualize my hexagon on top of the map of France, allowing me to fill out the quiz.
Renzo	I used drawing to emphasize key points, to visualize the material, and to help me see my thoughts.
Renzo	I gained a much richer picture of what I was learning, and the ideas became much more clear and concrete in my mind.

Renzo	I found it all too easy to spend just more than enough time scribbling down an image in my mind.
Ana	I think drawing things in ways I imagine them helps me understand them better because then I can imagine it in my head when a question asking that on the test or the homework comes up which is super helpful in terms of remembering how one thing affects the other etc.
Kalani	Putting everyone's names that are also part of my team helped since I was able to imagine us all together and actually physically handing our payments to whoever is above us.
Chea	After I finished, I realized that adding drawing to imagination really helped me to really understand the concept of the lesson...

Class participants' responses in Table 80 overlap with the application of drawing, meaning students, 1) began to learn to use visual thinking in connection with drawing, and 2) understood that doing so, could support their thinking/learning. Some class participants' also assigned meaning to mental imagery in connection with drawing in JE6, which is discussed next.

Connection between Drawing and Mental Images. In response to questions in JE6, three class participants showed knowledge (i.e., understanding) of the connection between drawing and visual-mental thoughts. This means that students were metacognitively aware that they should draw what they saw in their minds or what they drew supported visual thinking. The connection between drawing and visual-mental thoughts was discussed in the ASC, and some students mentioned learning about mental imagery within the context of applying the strategy.

Therefore, this is considered a meta-learning, "ML" theme. Responses in Table 81 and some not listed were deductively coded for the theme "Connection Between Drawing and Mental Images."

Table 81

Prominent quotes from theme in JE6 – "Connection between Drawing and Mental Images"

Class Participants	Prominent Quotes
Dalisay	Drawing visual concepts when note taking is another strategy Chris has shared which I personally would like to try incorporating in my learning strategy. That way I can "see" what my brain is thinking through pictures and dialogues to help me better understand what I am learning. It is kind of like the phrase, "thinking out loud."
Dalisay	I integrated these strategies in my learning because I've learned that I am a visual learner and I work best as a student when I can "see" what I am thinking.
Lucía	It's sort of like creating a new language, you have to use specific pictures and visualizations that pop into your head when hearing or learning the information.
María	The main strategy that I've implemented in my life is visual note taking. I've been doing it for a while, and it really *helps me visualize what I'm learning.* Biology is a tough subject to learn, but when you add drawings and graphs it's like ten times easier to understand.

As illustrated in Table 81, three participants in JE6, understood that they should draw what they saw in their minds. Dalisay, specifically mentioned that she learned that she was a visual learner and connected that statement to needing to see pictures and "dialogues" in her mind. Lucía similarly alludes to drawings and visual thoughts being like a form of language (thinking), which is how it is discussed by Arwood (2009), e.g., “a language of pictures.” Class participants’ responses to prompts in JE6 related to mental imagery are discussed next.

Mental Imagery Supports My Thinking/Learning. In response to prompts in JE6, five participants reported that their mental imagery when used as a strategy (e.g., visualization) supported an aspect of their learning. Because students learned something about their own thinking/learning by using a metacognitive strategy, this theme was provisionally coded as “ML.” Interestingly, none of the focal participants were captured for this theme. Responses in Table 82 and some not listed were deductively coded for the theme “Mental Imagery Supports My Thinking/Learning.”

Table 82

Prominent quotes from theme in JE6 – “Mental Imagery Supports My Thinking/Learning”

Class Participants	Prominent Quotes
Eli	I think I learn best with hands-on learning because I always remember stuff better when I am actually seeing it or picturing it in my head or doing it.
Kalani	Using (visualization) at school and work can improve my performance and build more skills. This will help me be more productive as well since everytime I try to do something, I am usually overwhelmed and think about how much other stuff I have to do also so taking a few minutes to visualize everything is vital to completing tasks. (cont’d) I learn best when it comes to visualizing since it does help me with my anxiety.
Chea	The similar way would go when I read; I like to imagine pictures and stories in my head as I consume academic ideas.

Melia	To me being able to picture and imagine the information I'm taking helps me open up to seeing all aspects and the bigger picture, showing me stuff I could've missed or things I didn't understand before
Valeria	...because the information that we are learning is very application-based. Mental imagery allowed me to picture myself as a nurse in the scenarios that I was given. That made it easier to truly think about what the right actions would be in those situations
Valeria	Additionally, when it comes to application-based information, such as my nursing course, I learn best through mental imagery.

Participants assigned meanings in Table 82 specifically relate to mental imagery apart from drawing, and in several cases relates to using visual thinking (e.g., "visualization") in learning scenarios. A summary of class participants' assigned meanings for visual thinking in the LSA and JE6 is discussed next.

Summary for Visual Thinking in Class Activities. The visual thinking themes that emerged for each class participant based on their responses to the LSA and JE6 are captured in Table 83.

Table 83

Prominent Themes Between LSA and JE6 for Visual Thinking, Listed for Each Class Participant

		Learning Strategies Assignment		Journal Entry #6		
No.	Name	Using Visualization for Academics	Drawing and Seeing Thoughts	Using Visualization as a Strategy to Support Learning	Connection Between Drawing and Mental Images	Mental Imagery Supports My Thinking / Learning
1	Abby	X	-	-	-	-
2	Alena	-	-	-	-	-
3	Ana	-	X	-	-	-
4	Ashley	-	-	-	-	-
5	Cathleen	-	-	-	-	-
6	Chea	X	X	X	-	X
7	Coreen	X	-	X	-	-
8	Dalisay	-	-	-	X	-
9	Daniel	X	X	-	-	-
10	Eduardo	-	-	-	-	-
11	Efrain	-	-	-	-	-
12	Eli	-	-	-	-	X
13	Emanuel	-	-	-	-	-
14	Kai	-	-	-	-	-
15	Kalani	-	X	X	-	X
16	Lucía	-	-	-	X	-
17	Makaio	-	-	-	-	-
18	María	-	-	-	X	-
19	Melia	-	-	-	-	X
20	Miguel	X	-	X	-	-
21	Renzo	-	X	-	-	-
22	Valentina	-	-	-	-	-
23	Valeria	-	-	X	-	X

Note. “X”’s denote the participant was coded for this theme. Dashes denotes the participant was not coded for this theme. Last Note.

The themes listed in Table 83 were merged into “cumulative” themes which represented an accumulation of themes between the LSA and JE6 with similar meanings, e.g., applied/integrated strategies, similar meta-learnings. Merged themes are captured in Table 84.

Table 84

Cumulative Themes from Class Activities Related to Visual Thinking

Themes Merged into Cumulative Theme	Merged Into Category	Cumulative Themes
1) Using Visualization for Academics (from LSA) 2) Using Visualization as a Strategy to Support Learning (from JE6)	Applied and/or Integrated Strategies	Using Visualization to Support Self in Academics (7/23)
1) Drawing and Seeing Thoughts (from LSA) 2) Connection between Drawing and Mental Images (from JE6) 3) Mental Imagery Supports My Thinking/Learning (from JE6)	Primary Meta-Learning Themes	Learned about Visual Thinking (11/23)

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for.

As illustrated in Table 83, between the LSA and JE6, seven of 23 class participants utilized visualization as a strategy to support themselves in academics, primarily for learning. Additionally, eight of 23 class participants knew to utilize visual thinking (i.e., imagination, visualization) while drawing. Meaning students understood to connect the physical act of drawing with their visual-mental thoughts. Between the cumulative themes “Learned about Visual thinking” and “Using Visualization to Support Self in Academics,” 14/23 class participants were coded for at least one theme that related to visual thinking. This indicates half the class if not more had a degree of metacognitive knowledge for their visual thoughts (i.e., mental images) as it pertained to learning (either directly or indirectly) at the end of the learning and thinking block.

It should be noted that although the terms *visualization* and *visual thinking* are similar, there is a difference. Visualization involves thinking about concepts one already knows to achieve a goal, not necessarily related to learning. On the other hand, mental imagery (i.e., visual thinking) can also occur when learning language-based concepts (Arwood, 2011). Utilizing mental imagery in the learning process, involves being metacognitive about one's mental imagery, for the purposes of learning and scaffolding one's own learning. The term "visualization" in almost all contexts in the study thus far, is used to represent one's utilization of visual thinking (i.e., mental images or mental pictures) to understand new ideas. Only on a few occasions in the class activities (and pre-assessment) has the term "visualization" been meant to describe the utilization of visual thinking outside the context of the learning process. Themes that involve utilization and learning about one's *language as a source of thinking* is discussed next.

Taking Notes in My Own Words. In response to questions in the LSA and JE6 related to what strategies students applied and integrated at the latter stages of the learning and thinking block, 12 of 23 students applied and/or integrated notes in their own words (i.e., natural language) as a strategy for learning. Six of 23 students applied and integrated notes in their own words as a strategy (between the LSA and JE6). Table 85 captures the themes within the class activities that make up the cumulative theme, "Taking Notes in My Own Words."

Table 85

Themes from Class Activities that Encompass "Notes in My Own Words Supports Learning"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	Applied Strategies from ASC	Taking Notes in My Own Words (7/21) [CK | MK| MR (Control) | ML]
Journal Entry #6	Integrated Strategies from ASC	Taking Notes in My Own Words (10/21) [CK | MK, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

Themes listed in Table 85 are discussed next.

Taking Notes in My Own Words (for LSA). In response to the LSA, nine class participants mentioned that they took notes using their own words as a strategy for learning. Taking notes in one's own words is a strategy discussed in the ASC that asks students to move beyond copying the teachers' notes or words and instead think about the meaning behind what the teacher is saying and/or presenting and write down their understanding. The researcher presented the phrases "your own words," "natural language," and "your own voice," in the ASC to mean use your own thinking or use your own language to display your thinking. Six participants' responses were provisionally coded as being metacognitive; four coded as "MR" and the other two as "MK" for responses that primarily included knowledge about the strategy, rather details of how/why the participant engaged in the strategy. Three participants' responses were coded as "CK," as the participants mentioned trying the strategy for the LSA but did not elaborate.

Four participants, merged drawing and taking notes in their own words as applied strategies for the LSA. Of these four participants, Ana, Renzo, and Chea's notes (artifact) were previously shown in the sections on drawing and visual thinking. In theory, these artifacts should display the participants thinking of the subject matter through their own words.

Dalisay and Coreen's notes, were chosen to support class participants explanations of taking notes in their own words. The words from the picture (artifact) supplied to the researcher were not easy to identify, so the words from their notes are included in Table 86 below. Dalisay's notes were based on concepts from the book, "We Can't Talk About That at Work" for a leadership class and Coreen's notes pertained to concepts and strategies discussed in the ASC.

Table 86

Segment of Notes Supplied by Coreen and Dalisay for "Taking Notes in My Own Words"

Class Participants	Notes in Own Words
Dalisay	Education - beware of media reports as the only source of education about difference. lets stop punishing - true fear of offending or not knowing enough can loom large in these situations, and unless people are inclined to dig deeper & do their own learning, they may alienate themselves from that group. Build cross-cultural trust - one of the key readiness steps before embarking on bold, inclusive conversations is building trust.
Coreen	- you know you understand a topic when you can teach it to someone - also a great way to strengthen your own understanding - take notes in your own words - look over material before class

	- the more you go over/review something the stronger your understanding (patterns vs. concepts - neurons fire faster & faster each time you fire it - create & take practice tests, get feedback from prof." - attach something to a topic, ex. physical motion, a song, a drawing (visual flowcharting).

In Table 86, the format (e.g., bullet pointing) Dalisay and Coreen utilized to organize their notes is largely kept intact apart from color-coding. Dalisay and Coreen indicated in the LSA, that they thought about what new ideas meant in their own words and wrote those ideas down. Dalisay and Coreen also utilized notetaking in their own words in the pre-assessment (as a new strategy) so in terms of change there have been multiple opportunities for Dalisay and Coreen to learn from notetaking in their own words. Class participants use of taking notes in their own words as reported in JE6 is discussed next.

Taking Notes in My Own Words (for JE6). In response to a prompt in JE6, that asked whether participants integrated strategies taught in the ASC, nine participants responded that they've used or integrated taking notes in their own words as a strategy. Six class participants provided little-to-no elaboration on how the strategy supported cognition, so their responses were coded as "CK," while three participants detailed how the strategy supported cognition, and their responses were provisionally coded as "MK." Class participants' metacognitive thinking, primarily in the context of taking notes int their own words is discussed next.

Metacognitively Reflecting on New Ideas. In response to questions in the LSA and JE6, four of 23 class participants discussed metacognitively reflecting on new ideas, predominantly in the context of the strategy/theme – "Taking Notes in My Own Words." *Metacognitively* *reflecting on new ideas* relates to participants' monitoring of their understanding and/or creating understanding (e.g., translating) with their words to take notes (i.e., writing in one's natural language). Three participants discussed metacognition in note-taking situations in both the LSA and JE6, two of which were focal participants, Dalisay and Coreen. Table 87 captures the themes within the class activities that make up the cumulative theme, "Metacognitively Reflecting on New Ideas."

Table 87

Themes from Class Activities that Encompass "Metacognitively Reflecting on New Ideas"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	Applied Strategies from ASC	Metacognitively Translating Ideas for Notes (4/21) [MK, ML | MR, ML]
Journal Entry #6	Integrated Strategies from ASC	Metacognitively Reflecting on Ideas (3/21) [MK, MR [Control], ML]

Note. The themes in Table 86 were structured hierarchically under the theme "Taking Notes in My Own Words" in both the LSA and JE6 template. Additional Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Last Note. Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, ML = Meta-learning, CK = Cognitive Knowledge, "|" = Difference in Provisional Codes between Participants.

Themes listed in Table 87 are discussed next.

Metacognitively Translating Ideas for Notes. In response to the LSA, four participants discussed thinking about how to incorporate academic ideas into their own words. This strategy/theme encompasses the mental activity of translating new academic ideas into one's own ideas, represented as words, to promote engagement and understanding. Responses in Table 88 and some not listed were deductively coded for the theme "Metacognitively Translating Ideas for Notes."

Table 88

Prominent Quotes from Theme in LSA – "Metacognitively Translating Ideas for Notes"

Class Participants	Prominent Quotes
Coreen	So for exam 3, I've decided to try something different and instead of taking notes, just to listen. While I listen to what my professor says I am using visualization *to organize her words into meaningful notes in my own words* in my head.
Dalisay	This influences me to use metacognition in my studying skills which helps me memorize concepts much clearer in my brain preparing me for discussion and quizzes.
Chea	At first, I read the important concept in the text, then I processed the information in my mind and tried to understand what it really meant.
Alena	...multitasking both what my professor was going more into depth about the subject and the summarization of that subject in my head in my own words was something that helped me better retain information in my class

Note. Coreen's quote was mentioned previously in the visual thinking section but because she's also thinking about how to organize ideas in her own words the quote is mentioned here.

As illustrated in Table 88, participants primarily utilized metacognition to monitor their understanding. For instance, when using 'notes in her own voice' as a strategy Alena stated that she was "...multitasking both what my professor was going more into depth about… and the summarization of that subject in my head, in my own words." Thus, Alena was monitoring what the teacher was saying while simultaneously trying to (metacognitively) summarize (in her own words) the auditory words of the teacher. This type of controlled metacognitive behavior indicates metacognitive regulation for learning. Additionally, when reading Chea stated she "processed the information in my mind and tried to understand what it really meant." Thus, Chea monitored her understanding while she read, to make sure she understood before beginning to write down the ideas in her own language. This indicates some participants understood and/or learned that they should think about their own understanding when taking notes in their own words. This theme was provisionally coded as being metacognitive and showing elements of regulation, "MR." Class participants metacognitive reflection as reported in JE6 is discussed next.

Metacognitively Reflecting on Ideas. In response to JE6, three class participants mentioned (directly or indirectly) that they've been utilizing more metacognitive thinking in their learning. All three class participants mentioned reflecting on academic ideas in the context of making sense of academic ideas in their own language. Responses in Table 89 and some not listed were deductively coded for the theme "Metacognitively Reflecting on Ideas."

Table 89

Prominent Quotes from Theme in JE6 – "Metacognitively Reflecting on Ideas"

Class Participants	Prominent Quotes
Dalisay	Chris shared a study habit strategy that helps the brain think about what it is thinking through a note taking strategy where the note taker writes notes using their own words. Or in other words, paraphrasing concepts instead of copying texts word for word as notes. I've implemented that strategy in my studies which has helped me understand my learning more efficiently.
Coreen	I've started to apply this method of learning to my method of studying, by constantly thinking of different ways to understand what has been said to me.

Chea	Furthermore, I started to apply more of metacognitive strategies into my learning and some aspects of my daily life. Sometimes, I reflect on things around me and my studies.
Chea	However, I learned to pay more attention to my own thinking and reflections.

As illustrated in Table 89, the three participants report utilizing their thinking or "metacognition" to independently make sense of academic ideas. This mental behavior occurred primarily in the context of reflecting/translating information for taking notes in one's own words. For instance, Dalisay stated she paraphrased ideas instead of copying the teachers' words "...paraphrasing concepts instead of copying texts word for word as notes." This theme was provisionally coded as being metacognitive and showing elements of regulation, "MR." Class participants' meta-learning as it involves taking notes in their own words is discussed next.

Notes in My Own Words Supports Learning. In response to questions in the LSA and JE6, eight class participants discussed how writing notes in their own words supported an aspect of their learning. Class participants' responses reflected knowledge they had gained from applying and/or integrating the strategy of taking notes in one's own words. These responses were coded into two themes listed in Table 90, which were later merged into the cumulative theme "Notes in My Own Words Supports Learning."

Table 90

Themes from Class Activities that Encompass "Notes in My Own Words Supports Learning"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	What I Learned	Notes in Own Words Supports Aspects of Learning (4/21) [MK, ML]

Journal Entry #6	What I Learned	Writing in My Own Words Supports Learning (7/21) [MK, ML]

Provisional Codes: MK = Metacognitive Knowledge, ML = Meta-learning.

Themes listed in Table 90 are discussed next.

Notes in Own Words Supports Aspects of Learning. In response to questions in the LSA, four class participants mentioned how writing notes in their own words supported their ability to understand ideas, remember ideas and/or learn class material. Responses in Table 91 and some not listed were deductively coded for the theme "Notes in Own Words Supports Aspects of Learning."

Table 91

Prominent Quotes from Theme in LSA – "Notes in Own Words Supports Aspects of Learning"

Class Participants	Prominent Quotes
Renzo	While taking notes in my own voice I found that I understood the information so much better. I gained a much richer picture of what I was learning, and the ideas became much more clear and concrete in my mind.
Cathleen	This strategy is very helpful because I changed the wording so that I can understand the material better...
Alena	...and it made me feel so much better as a student because I was understanding what was being taught by catching up on every slide that was being explained without feeling left behind.
Valentina	I think that this strategy was really helpful in (Theology) class because there were a lot of concepts that might not make that much sense at first, so it really helped to say things my own way.

In Table 91, class participants shared what they learned about taking notes in their own words as it applied to their learning. This theme was provisionally coded for showing metacognitive knowledge, “MK,” and meta-learning, “ML.” Class participants’ meta-learning from notetaking in their own words as reported in JE6 is discussed next.

Writing in My Own Words Supports Learning. In response to questions in JE6, six class participants mentioned or indicated that writing notes in their own words supported an aspect of their learning. This is a broad meta-learning theme as students discussed different benefits of writing in their own words as a strategy for learning. Responses in Table 92 and some not listed were deductively coded for the theme “Writing in My Own Words Supports Learning.”

Table 92

Prominent Quotes from Theme in JE6 – “Writing in My Own Words Supports Learning”

Class Participants	Prominent Quotes
Dalisay	Taking notes using my own words helps me understand my thoughts better and drawing visual concepts helps me “see” my thoughts which both are ways I believe works best for me.
Renzo	...I found that after giving these learning strategies a longer shot they were actually incredibly helpful to me. They made learning and note taking and reading notes so much more enjoyable. I found it was easier to stay focused when I could doodle or translate crazy information into my own thoughts.
Cathleen	But I now have figured out how to take effective notes in my own voice so that I am able to get the information that I need down, and I’m able to understand what is written down in my own ‘language’/voice.

Valeria	From class I have learned how to take better notes that are suited more towards my personal understanding. For example, I used to write notes by copying the information word for word as it was given to me. However, now I know that it is best to write the information down in my own words.
Emanuel	I have learned proper notetaking in putting slides into my own words and not writing for quantity but for quality in my learning.
Efrain	I think I learn best by writing down notes in my own words instead of just copying down what the professor has on the board or on the projector. I noticed that if I am able to write those concepts in my own words onto my notes, it means that I know and understand the concepts being taught.

In Table 92, class participants shared what they learned about taking notes in their own words as it applied to their learning (i.e., meta-learning). Participants responded to questions about how they learned best and about why they've integrated specific strategies into their lives. While most students said that writing in their own words supports understanding (e.g., Cathleen, Efrain) some mentioned the strategy helped with other aspects of learning (e.g., Renzo for staying focused). This theme was provisionally coded for showing metacognitive knowledge, "MK," and meta-learning, "ML." Class participants' meta-learning as it involves use of their language is discussed next.

Language Supports Thinking/Understanding. In response to questions in the LSA and JE6, seven class participants explained how using their language supported their thinking and/or understanding. Class participants discussed using their language in multiple ways, e.g., through taking notes, teaching the material, and communicating with peers. The through line is that participants understand that using their language (or words) was beneficial to their thinking and/or understanding during the learning process. Two students, Coreen and Emanuel, indicated that their language supported an aspect of their learning in both the LSA and JE6. Class participants responses reflected knowledge they had gained primarily from applying/integrating strategies for learning. These responses were coded into two themes listed in Table 93, which were later merged into the cumulative theme "Language Supports Thinking/ Understanding."

Table 93

Themes from Class Activities that Encompass "Language Supports Thinking/Understanding"

Class Activity	Category	Themes
Learning Strategies Assignment (LSA)	What I Learned	Language Supports Thinking (4/21) [MK, ML]
Journal Entry #6	What I Learned	Discussion with Peers Supports Understanding (5/21) [MK, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, VT = Visual Thinking, ML = Meta-learning.

Themes Listed in Table 93 are discussed next.

Language Supports Thinking. In response to questions in the LSA, four participants showed knowledge that use of their language (e.g., own words) supported their thinking, either in the strategies they applied or the way they overcame challenges to their applied strategies. This theme was provisionally coded for showing metacognitive knowledge, "MK," and meta-learning, "ML." Their responses showed meta-learning because they were discussing how to overcome a challenge, apply the strategy successfully, or their summative learnings. Responses in Table 94 and some not listed were deductively coded for the theme "Language Supports Thinking."

Table 94

Prominent Quotes from Theme in LSA – "Language Supports Thinking"

Class Participants	Prominent Quotes
Coreen	I can start *using the blurting method* of studying, and then going back to my professor's PowerPoint notes for parts I don't understand which I think (along with increasing my understanding) *will also help strengthen the connection between my words and hers* to make translating in class easier.
Valentina	I also added commentary about certain topics while I was writing my notes as a way to kind of show my thinking and I think that helped a lot in this class so that I could later ask question with my teacher during office hours.
Emanuel	Overall I *found the teaching* and oral visual strategies very helpful as it helped me think more and recall certain bits of information...
Kai	Another way I can overcome these challenges *is by teaching my drawings to others because it will test if I understand my drawings* and if it genuinely works for me.

In Table 94, class participants shared what they learned about using language as it applied to their thinking. Two class participants, Kai and Emanuel, found that teaching the material supported their thinking, while two others, Coreen and Valentina, that using language individually could support and/or refine their thinking. Class participants' meta-learning as it involves use of their language with peers is discussed next.

Discussion with Peers Supports Understanding. In response to questions in JE6, five participants mentioned or indicated that discussing new academic ideas with peers supported their understanding of the subject matter. Discussing ideas with peers (e.g., teaching) was a strategy discussed in the ASC to utilize one's language as a source of thinking and understanding. This theme represents class participants' meta-learning in terms of using discussion and/or dialogue as a strategy. Therefore, this theme was provisionally coded for showing metacognitive knowledge, "MK," and for meta-learning, "ML," for four of five participants. Responses in Table 95 and some not listed were deductively coded for the theme "Discussion with Peers Supports Understanding."

Table 95

Prominent Quotes from Theme in JE6 – "Discussion with Peers Supports Understanding"

Class Participants	Prominent Quotes
Coreen	Then speaking out the understanding I gained from that and having them (either the teacher or a partner) correct me. If I have a correct understanding explaining the topic to someone who doesn't understand helps me strengthen my understanding by thinking of different ways to explain it.
Ashley	So far, the most helpful has been to put lessons and topics into my own words, *teach or talk about the subject to someone*...
Ana	...it's hard for me to sit through lectures without zoning out unless the topic interests me, for example learning something *and then getting time to either discuss it or answer some questions about it* or visually drawing something has always made it easier for me to understand and be able to reference it later when needed.
Melia	Strategies and ideas that I learned in class were...being able to present to or teach someone else the information you are learning to assure you are retaining and completely understanding the information or singling out the parts you don't fully understand...

Emanuel	...I learn best through bouncing my ideas off others and through collaboration as I feel that through going through a topic with others I can refine my understanding...I can fix gaps within my own knowledge too that I didn't know I had...
Emanuel	...I have learned that I need to understand the concept in my own language and speak to others to re-enforce my grasp on (a) concept whether it is me asking questions or teaching another person to reenforce my understanding of a concept.

In Table 95, class participants responded to questions about how they learned best and about the strategies they integrated into their lives. Participants shared what they learned about using language for learning, primarily that using external dialogue with peers supported their understanding of new concepts. For instance participants reported that utilizing their language (or words) helped, a) support/strengthen understanding, b) refine understanding, c) “fix gaps” in their knowledge, and d) be aware of their current understanding. A summary of the previous ‘language themes’ is discussed next.

Summary for Language in Class Activities. The language themes that emerged for each class participant based on their responses to the LSA and JE6 are captured in Table 96 and 97. Table 96 lists themes that primarily relate to application of notetaking in one’s own words.

Table 96

Prominent Themes Between LSA and JE6 for Taking Notes in One's Own Words, Listed for Each Class Participant

		Learning Strategies Assignment			Journal Entry #6		
No.	Name	Taking Notes in My Own Words	Meta-cognitively Translating Ideas for Notes	Notes in Own Words Supports Aspects of Learning	Taking Notes in My Own Words	Meta-cognitively Reflecting on Ideas	Writing in My Own Words Supports Learning
1	Abby	-	-	-	-	-	-
2	Alena	X	X	X	-	-	-
3	Ana	X	-	-	X	-	-
4	Ashley	-	-	-	X	-	-
5	Cathleen	X	-	X	X	-	X
6	Chea	X	X	-	-	X	-
7	Coreen	X	X	-	X	X	-
8	Dalisay	X	X	-	X	X	X
9	Daniel	-	-	-	-	-	-
10	Eduardo	-	-	-	-	-	-
11	Efrain	-	-	-	-	-	X
12	Eli	-	-	-	-	-	-
13	Emanuel	-	-	-	X	-	X
14	Kai	-	-	-	-	-	-
15	Kalani	-	-	-	-	-	-
16	Lucía	-	-	-	-	-	-
17	Makaio	-	-	-	-	-	-
18	María	-	-	-	-	-	-
19	Melia	-	-	-	X	-	-
20	Miguel	X	-	-	X	-	-
21	Renzo	X	-	X	X	-	X
22	Valentina	X	-	X	-	-	-
23	Valeria	-	-	-	-	-	X

Note. "X"'s denote the participant was coded for this theme. Dashes denotes the participant was not coded for this theme. Last Note.

Table 97 lists two themes that relate to participants' utilization of language (and the meta-learning therein) to support learning.

Table 97

Other Prominent Themes Between LSA and JE6 for Using Language, Listed for Each Class Participant

No.	Name	Language Supports Thinking	Discussion with Peers Supports Understanding
1	Abby	-	-
2	Alena	-	-
3	Ana	-	X
4	Ashley	-	X
5	Cathleen	-	-
6	Chea	-	-
7	Coreen	X	X
8	Dalisay	-	-
9	Daniel	-	-
10	Eduardo	-	-
11	Efrain	-	-
12	Eli	-	-
13	Emanuel	X	X
14	Kai	X	-
15	Kalani	-	-
16	Lucía	-	-
17	Makaio	-	-
18	María	-	-
19	Melia	-	X
20	Miguel	-	-
21	Renzo	-	-
22	Valentina	X	-
23	Valeria	-	-

Note. "X"'s denote the participant was coded for this theme. Dashes denotes the participant was not coded for this theme. Last Note.

The themes listed in Table 96 and 97 were merged into "cumulative" themes which represented an accumulation of themes between the LSA and JE6 with similar meanings, e.g., applied/integrated strategies, similar meta-learnings. Merged themes are captured in Table 98.

Table 98

Cumulative Themes from Class Activities Related to Language

Themes Merged into Cumulative Theme	Merged Into Category	Cumulative Themes
1) Taking Notes in My Own Words (from LSA) 2) Taking Notes in My Own Words (from JE6)	Applied and/or Integrated Strategies	Taking Notes in My Own Words (12/23)
1) Metacognitively Reflecting on Ideas (from LSA) 2) Metacognitively Translating Ideas for Notes (from JE6)	Applied and/or Integrated Strategies	Metacognitively Reflecting on New Ideas (4/23)
1) Notes in Own Words Supports Aspects of Learning (from LSA) 2) Writing in My Own Words Supports Learning (from JE6)	Primary Meta-Learning Themes	Notes in My Own Words Supports Learning (8/23)
1) Language Supports Thinking (from LSA) 2) Discussion with Peers Supports Understanding (from JE6)	Primary Meta-learning Themes	Language Supports Thinking/Understanding (7/23)

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for.

As illustrated in Tables 96, 97, and 98, between the LSA and JE6, 12 of 23 class participants, utilized (applied and/or integrated) taking notes in their own words to support learning. Additionally, four of the twelve participants who took notes in their own words knew to utilize their thinking (i.e., metacognition) to reflect on and/or translate information into their own words (i.e., language) before taking notes. Meaning students understood they had to think about new ideas before translating the information into their own words, rather than copying ideas directly from the teacher or from a text. Between the cumulative themes “Metacognitively Reflecting on Ideas,” “Notes in My Own Words Supports Learning,” and “Language Supports Thinking/Understanding,” 14 of 23 class participants were coded for at least one theme that related to meta-learning for *use of one’s own words* (for thinking). Thus, half the class if not more had a degree of metacognitive knowledge for using their words (i.e., natural language) as it pertained to learning at the end of the learning and thinking block.

Additionally, class participants showed substantial metacognitive depth for why taking notes in their own words and using dialogue supported their thinking and understanding, comparatively to other class activity-based themes. The concept of using language to support thinking and engage with academic ideas, seemed to ‘click’ for several class participants, similar to the way Coreen and Dalisay reported that it made sense for them during the pre-assessment. Notable meta-learning themes that fell outside the application and/or integration of strategies are discussed next.

Meta-Learning Themes from Class Activities Related to Self. Three additional themes that help answer RQ**3d** emerged from JE6. These themes fell outside the learnings from applied and/or integrated strategies and were related to knowledge of oneself as a learner. The three themes are captured in Table 99.

Table 99

Themes from JE6 that Relate to Knowledge of Self as a Learner

Class Activity	Category	Themes
Journal Entry #6	Knowledge of Self as a Learner	I am a Visual Learner (5/21) [CK, Learning | MK, ML]
Journal Entry #6	Outcomes from ASC	Ability to Improve Learning (5/21) [MK, ML]
Journal Entry #6	Dispositions Toward Learning	Feel In Control of My Learning (9/21) [MK, MC, ML]

Note. The first number in parenthesis represents the number of students the theme was coded for, and the second number represents the total number of students that theme could have been coded for. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, MC = Metacognitive Confidence, ML = Meta-learning.

Themes listed in Table 99 are discussed next.

I am a Visual Learner. Five class participants mentioned they were visual learners and/or learned best through visual learning. Three of the five participants indicated they learned (i.e., discovered) they were visual learners during their time in the learning and thinking block of the ASC. For instance, Ana stated, “I never realized I was such a visual/hands-on kind of learner...”. Correspondingly Chea stated, “I learned that visual learning and metacognitive strategies work best for me.” Such responses were deductively coded for the theme “I am a Visual Learner.” Two participants responses were provisionally coded as metacognitive knowledge, “MK,” and meta-learning, “ML,” as they supported statements of being a visual learner with rationale supporting how they learned visually.

Ability to Improve Learning. Five class participants discussed an ability to improve their learning because of what they learned and/or the knowledge they gained in the context of the ASC. Some students offered that they improved their learning or were able to improve their learning for the future. Class participants' statements came primarily in response to the question, "Does learning about your own learning help you to feel empowered – as in you have power over the ways that you learn?" Because participants discussed the state or progression of their learning, i.e., what they had learned about the progress of their learning, this theme was provisionally coded for showing metacognitive knowledge, "MK," and meta-learning, "ML." Responses in Table 100 and some not listed were deductively coded for the theme "Ability to Improve Learning."

Table 100

Prominent Quotes from Theme in JE6 – "Ability to Improve Learning"

Class Participants	Prominent Quotes
Ashley	Overall, I would agree that learning about my learning helped me be more aware of how I can improve myself and take in as much material as possible.
Eli	I have learned in this class that I have control over my learning and I have control over my success and I think that has really helped me a lot with improving my learning.
Lucía	Learning about my learning helps me to better understand how to study, and *how to master my learning* so it can reflect my grades.
Kalani	Yes totally it does (make me feel empowered)! And just knowing ways that you can adjust the strategy gives us that and knowing our options as well just shows that it's unlimited *and we can go over and improve in many factors in many situations and scenarios*.

As illustrated in Table 100 there's overlap in students' knowledge of their ability to improve learning and a feeling of being in control and/or empowered by their learning. This was the case for several students' responses. Thus, there's overlap in the themes, "Ability to Improve Learning," and the theme discussed next, "Feel in Control of My Learning."

Feel in Control of My Learning. Nine class participants mentioned feeling in control of their learning and/or learning strategies. This theme was not queued directly from a question but came about in responses to the question of whether learning about their own learning made class participants feel empowered. Some statements that highlighted feeling in control of learning were shown in the previous theme, "Ability to Improve Learning," as there was substantial overlap between the two themes. Because participants discussed knowledge of a new disposition (i.e., feeling) associated with their learning, and often shared why they felt that way, this theme was provisionally coded for showing metacognitive knowledge, "MK," metacognitive confidence, "MC," and meta-learning, "ML." Responses in Table 101 and some not listed were deductively coded for the theme "Feel in Control of My Learning."

Table 101

Prominent Quotes from Theme in JE6 – "Feel in Control of My Learning"

Class Participants	Prominent Quotes
Ashley	I do feel more empowered and in control of my learning because this lesson has taught me how to focus on specific aspects of my learning and studying habits that I can fix and improve.
Eli	Yes I do think learning about my own learning helps me feel empowered because it makes me feel in control over my own success and know it's in my own hands and not someone else's. I have learned in this class that I have control over my learning

Ana	Yes, learning about my learning has helped me feel empowered because it gives me a sense of control, and like I said it helps me figure out why I sometimes don't understand as easily as others which is nice to know.
Chea	Learning about the way I learn makes me feel empowered because it helps me to be more in control of my learning strategies, aware of what works best for me, and learn to make those of them
Cathleen	School has been a lot easier to manage and I'm finally able to be the student I have always wanted to be but struggled to achieve.
María	I've learned that you're in control of your own learning.
Valeria	For the majority of high school, I felt as though I had no idea what I was doing or how to actually study well. I didn't feel like I was in control of my own learning, and was simply just hearing information every day, only to forget it the next day. However, *I now feel like I have some control over this problem and can use it to become a better student.*

As illustrated in Table 101, the feeling (i.e., disposition) that class participants reported often had a connection to feeling empowered. In other words, because of what they learned about their own learning (meta-learning) in the ASC class participants felt empowered, which related to them feeling more in control of their learning than they did previously. The three meta-learning themes that relate to knowledge of oneself as a learner are listed in Table 102 for each class participant.

Table 102

Notable Meta-Learning Themes from JE6 Related to Knowledge of Self

		Meta-Learning Themes from JE6		
No.	Name	Ability to Improve Learning	I am a Visual Learner	Feel In Control of My Learning
1	Abby	-	X	-
2	Alena*	-	-	-
3	Ana	-	X	X
4	Ashley	X	-	X
5	Cathleen	-	-	X
6	Chea	-	X	X
7	Coreen	-	-	-
8	Dalisay	-	X	-
9	Daniel	-	-	-
10	Eduardo	-	-	-
11	Efrain	-	-	-
12	Eli	X	-	X
13	Emanuel	-	-	X
14	Kai*	-	-	-
15	Kalani	X	-	X
16	Lucía	X	-	-
17	Makaio	-	-	-
18	María	-	X	X
19	Melia	-	-	-
20	Miguel	-	-	-
21	Renzo	-	-	-
22	Valentina	-	-	-
23	Valeria	X	-	X

Note. *Alena and Kai did not complete journal entry #6. Additional note. "X"'s denote the participant was coded for this theme. Dashes denotes the participant was not coded for this theme. Last Note.

A summary of RQ3d is discussed next.

Summary of Research Question 3d. Several prominent and notable themes emerged from the class activities (LSA and JE6), which answer research question **3d** and provide results for the primary research question, RQ**3**. Most themes that related to meta-learning emerged in response to class participants applied and/or integrated strategies. Three additional themes that related to knowledge of oneself as a learner emerged from JE6 and were indirectly related to the knowledge participants had attained as a result of applied and/or integrated strategies. Those themes, as well as the categories they are structured are captured in Table 103.

Table 103

Themes that emerged Class Activities Related to Class Participants' Meta-learning

Categories	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
Primary Meta-learning Themes	Drawing Supports My Learning (10/23) (MK, ML)	Language Supports Thinking /Understanding (7/23) (MK, ML)	Learned about Visual Thinking (11/23) (MK, ML, VT)	Notes in My Own Words Supports Learning (8/23) (MK, ML)	Diverse Learnings from Drawing (9/23) (MK, ML)
Notable Meta-Learning Themes from JE6	I am a Visual Learner (5/21) [CK, Learning | MK, ML]	Ability to Improve Learning (5/21) [MK, ML]	Feel In Control of My Learning (9/21) [MK, MC, ML]	--	--

Note. Primary meta-learning themes came from applied and/or integrated strategies. Several students applied and/or integrating more than one strategy. Three class participants reported that they did not integrate any strategies learned in the ASC into their lives.

Drawing. In total, 16/23 class participants applied and/or integrated drawing as a strategy for their learning between the class activities (LSA and JE6). Eight of those sixteen participants reported utilizing drawing as a strategy for their learning in both the LSA and JE6. Ten of 23 students learned that drawing supported their learning/understanding (coded as "Drawing Supports Aspects of My Learning" in the LSA and "Drawing Helps to Better Understand Material" in JE6). There were various other learnings from drawings, captured in the themes "Various Learnings from Applying Drawing" in the LSA and "Various Learnings from Drawing" in JE6. Thus, over half of class participants (12/23) reported knowledge they had attained (in most cases, meta-learnings) from utilizing drawing as a strategy for learning.

Commonly mentioned challenges to drawing were that it was time consuming and that it was difficult to think about what to draw.

Visual Thinking. Eight class participants understood aspects of the connection between drawing and visual thinking (coded as “Drawing and Seeing Thoughts” in the LSA, and “Connection between Drawing and Mental Images” in JE6), which means more than one-third of total class participants, including one half of those who applied and/or integrated drawing as a strategy, had knowledge of using visual mental-thoughts with drawing to represent ideas. Additionally, seven of 23 class participants indicated applying and/or integrating visualization as a strategy to support themselves in academics and/or to support their learning. Five class participants reported that their mental imagery when used as a strategy (i.e., visualization) supported an aspect of their learning, (captured by the theme “Mental Imagery Supports My Thinking/Learning” in JE6). Thus, eleven class participants assigned meaning to knowledge related to visual thinking (in the context of visualization and drawing), which was captured by the meta-learning theme “Learned about Visual Thinking.”

Between the cumulative themes “Learned about Visual Thinking” and “Using Visualization to Support Self in Academics,” 14/23 class participants were coded for at least one theme that related to visual thinking. Thus, at least half the class had a degree of metacognitive knowledge for their visual thoughts (i.e., mental images) in direct or indirect support of learning at the end of the learning and thinking block.

Language. Twelve of 23 class participants applied and/or integrated notes in their own words as a strategy for learning between the class activities (LSA and JE6). Five students applied “Taking Notes in My Own Words” in the LSA and affirmed they integrated the strategy into their daily life in JE6. Additionally, eight class participants discussed how writing notes in their own words supported aspects of their learning (captured by the meta-learning theme "Notes in My Own Words Supports Learning"). Furthermore, four of the twelve participants who took notes in their own words knew to utilize their thinking (i.e., metacognition) to reflect on and/or translate information into their own words before taking notes. Metacognitive behavior primarily related to monitoring understanding and/or creating understanding with one's own words (i.e., thoughts) during notetaking.

Additionally, between the LSA and JE6, seven class participants explained how using their language supported their thinking and/or understanding. These class participants understood that using language (i.e., their own words) was beneficial to their thinking and/or understanding during the learning process. This knowledge was captured by the (cumulative) meta-learning theme, "Language Supports Thinking /Understanding." Similar to what was discussed in the ASC, class participants reported using language in the following ways: 1) teaching academic material, 2) discussing ideas with others (teachers and peers), 3) writing ideas in their own words (e.g., rewording or summarizing information), and 4) metacognitively reflecting on (or translating) academic material.

Some participants utilized language with other strategies, drawing being the most mentioned. Dalisay, Coreen and Chea specifically discussed using language in connection with visual thinking, but not in the context of their language being a supportive mechanism or tool for visual thinking. Between the cumulative themes "Metacognitively Reflecting on Ideas," "Notes in My Own Words Supports Learning," and "Language Supports Thinking / Understanding," 14 of 23 class participants were coded for at least one meta-learning theme that related to *use of one's own words* to support thinking. Thus, half the class if not more had some metacognitive knowledge for using their words strategically (whether writing ideas in their notes or communicating ideas) to support learning at the mid-point of the study.

Knowledge of Self as a Learner. In response to the question five of JE6, 16/23 class participants answered affirmatively that they felt empowered from learning about their own learning. These responses were captured by the theme, “Learning about My Learning Makes Me Feel Empowered.” Four other participants mentioned that they felt more confident in their learning. These responses were captured by the theme, “What I've Learned Helps Me Feel Confident in My Learning.” The latter two themes from JE6 were not provisionally coded as “ML” but because they have strong correlations with the meta-learning theme, “Feel in Control of My Learning,” the researcher felt it important to mention. Template analysis revealed that learning about one’s learning in the context of the ASC was connected to feeling empowered, which related to feeling in control of one’s learning, as well as feeling that one had improved or had the ability to improve learning through the application of learning strategies. For instance, Emanuel stated, “I feel that understanding my own learning helps me feel empowered in the sense that I am able to understand that I don't work the same way as everyone else and I know what to look for and what I need to give myself in order to succeed...”. Several class participants reported feeling more in control of their learning because they understood more about themselves as learners and could apply specific strategies that supported thinking and learning when needed.

Class participants mentioned a variety of challenges they faced in college, e.g., finding motivation, understanding academic material, difficulty paying attention, and less than satisfactory academic performance (see Appendix N for themes). These challenges, along with the reports of not previously learning how to study often framed the reasons why class participants chose to apply and/or integrate specific strategies for learning.

Lastly, five class participants mentioned they were visual learners and/or learned best through visual learning. Being a visual learner, or learning one was a visual learner during their time in the ASC, was not discussed by class participants in the context of feeling in control of one's learning. The primary research question, RQ3, is discussed next.

Research Question 3

Research question 3 asks, *what themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?* In RQ3, the researcher explored what (if any) themes emerged over the course of FYFG students first semester in college that showed changes to participants visual thinking and learning. RQ3 focuses on comparisons between themes that emerged in the pre-assessment and class activities and themes that *emerged* or *accumulated* by the post-assessment. Post-assessment themes emerged as a result of 1st cycle, provisional, and pattern coding methods (Saldaña, 2021). Post-assessment themes were then compared with previous themes using longitudinal analysis (Saldaña, 2003; 2021) within a time ordered matrix (Miles & Huberman, 1994).

The following criteria from Saldaña (2003; 2021) were structured within a time ordered matrix to deduce themes that showed change during the course of the ASC. 1) What *emerges* through time? 2) What is *cumulative* through time? 3) What *turning points* occur through time, if any? 4) What *decreases* or ceases through time? 5) What remains *constant* through time? See Chapter 3 for an explanation of each criterion. Themes were analyzed across time for each focal participant and analyzed as a group which helped deduce and corroborate interpretations. Most questions in the post-assessment interview mirrored questions in the pre-assessment to accurately assess changes. Class participants responses in the class activities helped to substantiate changes occurring at the mid-point of the study.

Six primary changes are subsequently reported as well as post-assessment themes that substantiated each of the six change themes. The six change themes do not represent change for every focal participant, but rather represent prominent changes for at least half of focal participants during the study. Sections of participants' case summaries (developed with participants in member checks) are presented at the conclusion of each change theme to provide depth to participants' statements and verify the researcher's interpretations of post-assessment transcripts.

Change Theme 1 - Reflecting on Visual Thoughts in Learning Scenarios

"Reflecting on Visual Thoughts in Learning Scenarios" is a change theme that was deduced from various themes that emerged over the course of the ASC that relates to being more metacognitive in relation to one's visual thinking (i.e., mental imagery) The researcher incorporated themes for visual thinking (i.e., "visualizations") over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. Focal participants *reflected more* on their visual thoughts over the course of the semester because they learned that using mental imagery (i.e., "visualization") was beneficial for learning and for factors related to learning (i.e., anxiety, attaining goals). The researcher deduced from template analysis, longitudinal analysis, and case summaries that learning about mental imagery and applying "visualization" in the ASC helped the majority of focal participants become more aware of their mental images in learning scenarios. This "change" is supported by the emergence and accumulation of themes reported in Table 104.

Table 104

Emergent and Cumulative Change for "Reflecting on Visual Thoughts" Based on Themes Over the Course of the ASC

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Theme
Seeing (Understanding) with Mental Images	Primary Meta-learning Theme "Learned about Visual Thinking" [MK, ML] (11/23 Ps.) Incorporates the following themes: a) Drawing and Seeing Thoughts b) Connection between Drawing and Mental Images c) Mental Imagery Supports My Thinking/Learning	1) Explaining Visual-Mental Thoughts in Learning Scenarios 2) Seeing (Understanding) with Mental Images 3) Learned About Using Mental Imagery 4) Reflective Thinking for Learning	Reflecting on Visual Thoughts in Learning Scenarios

Note. "Seeing with Mental Images" was considered a cumulative theme in the change analysis. See Appendix O for provisional codes.

As illustrated in Table 104 post-assessment themes represent an 'endpoint' in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, "Reflecting on Visual Thoughts in Learning Scenarios" revealed that focal participants' (and class participants) developed personal knowledge of their own visual thinking (e.g., "Explaining Visual-Mental Thoughts in Learning Scenarios") as well as knowledge for visual thinking as a source of understanding (e.g., "Seeing with Mental Images"). The post-assessment themes which comprise the change theme in Table 104 are discussed next.

Explaining Visual-Mental Thoughts in Learning Scenarios. Five focal participants discussed what their mental imagery looked like (e.g., compositionally and/or structurally) in the context of learning. This theme illustrates how students were aware of their own visual thinking, to the degree they could describe, in detail, what their streams of thought looked like and/or how they mentally behaved in learning situations (e.g., reading, listening to a lecture). The post-assessment theme, "Explaining Visual-Mental Thoughts in Learning Scenarios" was coded predominantly in response to the AoC section, specifically question six, which first asked focal participants to picture themselves sitting in one of their classes while listening to their classmates talk about something the class is learning. Once participants confirmed they could see the event the researcher asked, "How do you 'reflect on' or just 'think about' the ideas they're discussing? Meaning, how do you think about the ideas they are discussing internally?" Question six of the post-assessment mirrored question eight in the pre-assessment, which was also structured in the AoC section. Whereas focal participants in the pre-assessment primarily answered that they focused on the visual movements of the speaker, represented by the theme, "Focusing on Visual Movements of Speaker to Understand Their Words," focal participants in the post-assessment primarily focused on how they understood their classmates spoken words by describing their metacognitive thoughts, primarily their mental imagery and/or "visualization". Focal participants regularly used metaphors to describe their mental imagery, drawing relations and/or comparisons to tangible events or objects to describe their visual thoughts. Prominent quotes for this theme are listed in Table 105 below.

Table 105

Prominent Quotes for Post-assessment theme, "Explaining Visual-Mental Thoughts in Learning Scenarios"

Class Participants	Prominent Quotes
Abby	I have this general outline of all the concepts that we've learned and what falls under certain concepts and stuff like that.
Daniel	I think about the words and just pictures within the video or whatever I was reading. And I just start visualizing them in my mind, and I really kind of blow them up on the big screen in my at home mind movie theater, and I just see them. And they feel more clear, I guess.
Coreen	... that's how my brain visualizes important information. When I'm reading there's this line that tells me where I am and when something important comes it pops out.
Coreen	...just as the words flow in, they come in like a text. It's like a typewriter, but each button is a word that comes in, and they just like they filter in, it's like a flow from -- You know how soundwaves work, so it's like they flow towards me, and they go into my brain, and they start writing out on this page.
Dalisay	I like picture like a leader being empathetic towards their people. Yeah. Kind of like less words, but more tangible stuff in my head.
Dalisay	So, it's like in this corner of my site, is what they're saying but then while they're thinking I'm building on my own site on this corner, but it's slowly overtaking theirs, but it's taking some others to inspire my thinking.

Lilly	Lilly: Well, for the pump, I know that the pump, it opens out and three sodium ions leave and before it goes back to the way it was, two potassium ions go quickly and then the phosphate group from the ATP detaches, and it goes back to its normal state. And I just think of that, like with that one I think of like ahh – kind of like a seesaw, is what I think about. Chris: Does this help you picture a seesaw? Lilly: A little bit, yes.

As illustrated in Table 105 participants often explained their visual thinking in learning scenarios (e.g., when listening to a speaker, when watching a video and when reading). This theme was provisionally coded as “MK” and “VT,” as it represents metacognitive knowledge focal participants shared for their visual thinking. “Explaining Visual-Mental Thoughts in Learning Scenarios” was a strong theme for Lilly and Coreen, as they regularly described in detail their thinking throughout the interview. Coreen, for instance, discussed what her mind does when reading to recognize important ideas, “So, it's not like zooms in on the paper, it’s like zooms in on the mental image that's in my mind of the paper. Because I remember telling you I'm a very visual person so when I'm reading a document it's in my brain.” Such explanations indicate changes to metacognitive knowledge as Coreen did not assign meaning to visual thinking during the pre-assessment.

Abby, Dalisay and Daniel also described their visual thinking in detail (e.g., when listening to others speak) in learning scenarios. Similar to Coreen, Abby did not assign meaning to visual thinking in the pre-assessment. This was not as strong a theme for Ashley, but she did explain her visual thinking in at least one response. Overall, there were more focal participants who assigned meaning to their visual thinking in the post-assessment, and these focal participants explained their visual thinking with greater detail/meaning than in the pre-assessment. Knowledge that mental imagery is a source of understanding is discussed next.

Seeing (Understanding) with Mental Images. Four focal participants showed knowledge or awareness that they 'see' (understand) ideas through mental images. This theme was coded in response to questions two, three, five, six, and eight of the post-assessment. Thus, responses were primarily coded in the AoC section of the post-assessment. Prominent quotes for this theme are listed in Table 106 below.

Table 106

Prominent Quotes for Post-assessment theme, "Seeing with Mental Images"

Class Participants	Prominent Quotes
Abby	I more likely pay attention to a lecture if there were pictures on the board or something being displayed, something that I can visually see in my mind that connects to the material that we're learning.
Abby	If they're just talking, I can't really see any structure behind it visually, so I catch myself zoning off.
Coreen	This is my understanding of it. And then I would ask a question, and then it would come in and then filter and slot in where it's needed, where I was missing information. But if it's a completely new idea and this teacher is teaching us, it's a blank document, and their words come in, and they go out on the page.
Coreen	It's like these words match up perfectly with my thesis you know, or these words are really close to my thesis, if I change my thesis this fits perfectly. So, it's like I'd call it instant replay where it zooms in, focuses on it, and it makes its own story about it to fit it in with what I need or already know.

Daniel	As I'm reading the interview transcript, that event in your mind. When it's very much clicking in that perfect sense, I'm seeing every single word just pop up. And if there were pictures along here, I would see those pictures really be blown up and I would see them, like I would know really well.
Dalisay	So, now it's a big picture of what my overall thinking is. Like my answer or my vision of what they're saying.

As illustrated in Table 105, focal participants understood that their visual thoughts were connected to their ability to understand ideas. Focal participants again reported their mental imagery in detail in response to questions that prompted them with visual stimuli (e.g., reading) and auditory stimuli (e.g., listening to a speaker). This theme was provisionally coded as meta-learning, “ML,” for Coreen and Abby, who did not discuss such knowledge in the pre-assessment. Abby, for instance, discussed how she had difficulty understanding ideas in some lecture-based classrooms, referencing difficulty with paying attention because of an inability to see “any structure” in her thoughts. Abby explained that when there’s more visual stimuli in the learning environment (e.g., pictures) she is more able to see her thoughts. Such responses indicate Abby developed metacognitive knowledge for her visual thinking in terms of how she understands spoken ideas in a classroom. “Seeing with Mental Images” represents metacognitive knowledge, “MK,” for visual thinking, “VT,” for all four participants. Learning about mental imagery is discussed next.

Learned About Using Mental Imagery. In response to question two of the post-assessment, which asked focal participants to explain *what, if anything, they learned in the ASC about their thinking and learning that helped them*, three focal participants specifically mentioned that they learned about (or found relevant) the concept of mental imagery. Prominent quotes for this theme are listed in Table 107 below.

Table 107

Prominent Quotes for Post-assessment theme, "Learned about Using Mental Imagery"

Class Participants	Prominent Quotes
Ashley	I want to say mental imagery really helped.
Coreen	With the mental imagery and visualization, I paired that with the drawing. (cont'd) I don't actually draw, but I definitely put that imagery in my head. So, I imagine a little person in the chair, and the world above their head.
Lilly	Lilly: In this class, it was more just learning different methods and putting, I guess, a word or a term for what I've been doing, and I guess I just never really thought of it, it's just something that worked for me. Being able to go in-depth more on why I do that and how it helps was definitely very interesting for me. Chris: Can you give one example? Lilly: So, the visual, creating visual imagery and something to associate that with, we talked about the dictionary where you write a term and draw a picture to associate with that, I've started doing that a lot more, and I've definitely noticed how it's helped.

In Table 107 participants mentioned that the concept of mental imagery (as part of the ASC curriculum) was helpful to them. For example, Lilly found that using mental imagery in connection with drawing was helpful, and she stated that she's been "doing that a lot more." Lilly did not participate in the class activities, and this response indicates similar knowledge to the cumulative theme, "Learned about Visual Thinking," at the midpoint of the study. Participants such as Coreen, did not always use mental imagery as discussed in the ASC, but rather used visual thinking as they saw relevant to their own thinking and learning. "Learned

About Using Mental Imagery," was provisionally coded as "ML" and "MK" for Lilly and Abby, and "CK" for Ashley. Reflective thinking in learning situations is discussed next.

Reflective Thinking for Learning. Four focal participants indicated reflecting on their thinking to learn and/or understand new academic ideas. The post-assessment theme, "Reflective Thinking for Learning" was coded for questions two, three, six, seven, eight, which means the majority of statements for this theme came in response to questions in the AoC section. Three focal participants were specifically coded for question six, which asked how they "reflect on or think about" the ideas their classmates are discussing. Question six of the post-assessment mirrored question eight in the pre-assessment, which also was structured in the AoC section. Whereas focal participants in the pre-assessment primarily answered that they focused on the visual movements of the speaker, represented by the theme, "Focusing on Visual Movements of Speaker to Understand Their Words," focal participants in the post-assessment primarily focused on how they understood their classmates spoken words by describing their visual-mental thoughts. "Reflective Thinking for Learning" however, relates less to participants awareness/control of their visual thoughts and more on the *act* of reflection to support learning. Prominent quotes for this theme are listed in Table 108 below.

Table 108

Prominent quotes from Post-assessment Theme - "Reflective Thinking for Learning"

Class Participants	Prominent Quotes
Ashley	I would start with the video and what I got from it. Then from there, I would think of any bigger pictures that I got from it or what the video is supposed to be teaching me. Then I would try to see if I actually understood it and if not, then I would replay it.

Coreen	And then the most important part is in class, when we talk about the assignment or the article or the textbook, I have my understanding of it, and my history professor, when he talks about it, I make sure that my understanding aligns with what he's saying.
Dalisay	Yes, I make notes in my head too - the notes that I have in my head are things that I already know.
Dalisay	So, when it's my turn to speak, I try to relate to what they said and then add my own reasoning and knowledge and then like, just say it. I realize when I reflect on things -- maybe it sounds bad, but sometimes I don't listen to them because I'm busy thinking on my own thoughts.
Lilly	But sometimes I can't always keep up with the notes, so I'm usually staying a few minutes after to get notes from the slide or just like trying to rethink, "What did my professors say for this slide?"
Lilly	When I was thinking about it, I was thinking about a computer, "Okay, what kind of ports are there now?" And my parents had a computer in mid-late 2000s and just being able to see the differences and how it changed over time, and just seeing those transitions and just thinking about those transitions and how USB ports have changed. And just thinking about that, and for me, that's how I was able to put it together.
Lilly	As time has passed and just thinking about it and I've definitely caught myself thinking about my thought processes more and just noticing that I do that a lot more.

As illustrated in Table 108, the post-assessment theme, “Reflective Thinking for Learning,” captured metacognitive statements about reflection in learning situations. Focal participants (as a group) discussed three elements related to reflective thinking, 1) monitoring of their understanding, 2) development of their understanding, and/or 3) awareness/control of visual thoughts. All focal participants responses indicate they were attempting to develop their understanding through reflection. Lilly, Dalisay, and Ashley’s responses also relate to awareness/control of their visual thinking, while Coreen's responses also relate to monitoring of understanding. Reflective behaviors in learning scenarios include, 1) asking oneself questions about the material, 2) aligning one's understanding with the teachers' understanding, 3) thinking about what one is missing (cognitively), 4) thinking about (reflecting on) one's understanding of videos, and 5) thinking about (reflecting on) the relevance of videos. Because participants' statements are contextualized in broad terms, as *moments of reflection* to support thinking, they were assigned to a specific theme.

Focal participants responses for reflective thinking fit the criteria for *emergence* in the longitudinal analysis, i.e., change occurring in smooth and average trajectories (Saldaña (2003; 2021). For example, all participants explicitly mentioned they paid more attention to their own thinking in learning scenarios, and most participants gave more detailed responses for their thinking processes in learning situations. This theme was provisionally coded as "MR," "ML," and "MetStrat" for all four participants. Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 1 - "Reflecting on Visual Thoughts in Learning Scenarios." The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants' statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

"Reflecting on Visual Thoughts in Learning Scenarios," is a change theme that relates to becoming more reflective towards one's own visual thoughts in learning scenarios. Table 109 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 109

Conversations in Second Member Check Relevant to Change Theme - "Reflecting on Visual Thoughts in Learning Scenarios"

Focal Participant	Chris (Questions/Interpretations)	Focal Participant Answering
Abby	Visualization is something your learned about in (the ASC).	I gained more awareness of visualization in (the ASC), not first discovered.
Ashley	What would you say from metacognition, visualization, and mental imagery did you apply, if any to your own thinking or learning last semester?	"Through those concepts I was able to grasp what I meant when I say, 'I'm a visual learner.'" I knew how to explain what I needed to help me learn properly. These concepts helped me understand more about what I needed to learn and be a visual learner.
Coreen	So, you previously used metacognition, visual imagery and visualization as strategies in high school (or before high school)?	"I used them without knowing what they were (all three of those strategies to a point)." Once I have the definition, I can learn more about it and actually use it. When I sat in the (the ASC), I thought "I do that, just not that well." So, I need to keep doing that, which was the most helpful thing I learned – the definitions for those ways to learn (metacognition, mental imagery, visualization).
Dalisay	When you are not able to understand what somebody has said, you tend to pause and reflect on what you may not understand.	"I do that a lot."

Dalisay	What happens to your visuals (mental pictures) when you don’t understand what somebody has said?	When I try to make a visual representation in my head and it doesn’t make sense, it feels like the “story” is left on a cliffhanger or that it has to be continued…or “it's like the tv just shuts off.”
Lilly	During these times of awareness and reflection you often try to think of how the ideas relate or shape the ‘big picture’ [which may be the primary meaning of class material represented in mental imagery]?	Yes, I do that a lot. (cont’d) What I meant by the “big picture” is (at least with the ligand) there’s three steps in the transduction pathway and so I was referring to how that process plays out. The big idea is the whole process of the transduction pathway. But finding the start button (ligand binding to membrane receptor) was what helped me visualize the process from beginning to end. The big idea is usually more about the main process, but with this specific example there’s more detail. For me, it’s seeing the whole process play out.

Sections from the case summaries in Table 109 provided verification and in some cases depth to participants’ responses in the post-assessment. Ashley, Coreen, and Lilly confirmed that they learned more about metacognition, visualization, and mental imagery, and saw those concepts as relevant to their own learning. Additionally, focal participants’ responses in the post-assessment showed many could explain from a cognitive standpoint how they understood new academic ideas, in primarily visual or auditory learning environments. Although, participants explanations were more descriptive when prompted with a primarily auditory learning situation (e.g., lecture-based classrooms). These explanations were captured by the theme, “Explaining Visual-Mental Thoughts in Learning Scenarios.”

As focal participants became more reflective toward their own thinking in learning scenarios, they also became more metacognitive toward their own visual thoughts likely because of what they learned about mental imagery in the ASC. For instance, Coreen and Abby explained their visual thinking in moments of reflection for the first time in the post-assessment, and Lilly and Dalisay explained their visual thinking in greater detail. This means, the majority of focal participants underwent changes to metacognitive knowledge for their visual thinking. These changes were more discernible for Abby, Coreen, Dalisay, and Lilly. Daniel had a substantial degree of metacognitive knowledge for visual thinking during the pre-assessment and gained more knowledge for engaging in visual thinking when drawing but not necessarily for his visual thoughts in general learning situations. Changes for Ashley were less discernible, but responses listed previously (and in other change themes) led the researcher to believe that changes to visual thinking may have occurred, but the degree to which is unknown.

There were no statements in the member checks that led the researcher to believe that focal participants did not reflect more on their visual thoughts in learning scenarios over the course of the semester. However, the degree or magnitude of this change for focal participants is unknown without further observation. Additionally, it's not possible to know whether participants' *reflection for their visual thoughts* is intermittent or consistent in learning scenarios.

In summation, the change theme, "Reflecting on Visual Thoughts in Learning Scenarios" indicates focal participants became more reflective toward their own visual thinking in learning situations than they were at the beginning of the semester. The researcher concluded that focal participants reflective thinking for new academic ideas, combined with the knowledge students gained about visual thinking led to more reflection/awareness of their visual thinking in learning scenarios. This change theme overlaps with the post-assessment theme, "Learned about Metacognition, Visualization, Mental Imagery in ASC," which is discussed later in RQ3, and post-assessment themes which comprise the change theme, *"Visualizing" in Learning Scenarios to better Understand New Ideas,* which is discussed next.

Change Theme 2 - "Visualizing" in Learning Scenarios to Better Understand New Ideas

"'Visualizing' *in* Learning Scenarios to better Understand New Ideas" is a change theme that was deduced from various themes that emerged over the course of the ASC that related to focal participants' statements about "visualization," "imagination," and other terms denoting control for one's mental imagery. This change theme incorporates all the themes provisionally coded as "MR," related to "visualizing ideas" in the pre- and post-assessments as well as cumulative theme, "Using Visualization to Support Self in Academics" in the class activities. The researcher incorporated themes for "visualization" over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. Overall, focal participants reported visualizing ideas in more learning situations to understand new ideas and did so in more strategic ways (i.e., deliberate mental activities to achieve a goal) over the course of the semester. For example, five focal participants in the post-assessment reported actively relating ideas to existing thoughts through mental images. This was not a theme that emerged until the post-assessment. The researcher deduced from template analysis and case summaries that most focal participants gained personal knowledge for applying "visualization" (i.e., using mental images) over the course of the ASC to better understand new academic ideas. This "change" is supported by the emergence and accumulation of themes reported in Table 110.

Table 110

Emergent and Cumulative Change for "Visualizing" in Learning Scenarios to Better Understand New Ideas

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Theme
1) Focusing on Visual Movements of Speaker to Understand Their Words	Applied/Integrated Strategies	1) Visualizing Ideas to Understand Speakers' Words	"Visualizing" in Learning Scenarios to Better

2) Visualizing Ideas to Understand Speakers' Words 3) Visualizing Ideas in Visual Environments 4) Creating Context Through Visual Thinking	"Using Visualization to Support Self in Academics " - In total 7/23 students indicated applying and/or integrating visualization as a strategy for their academics and/or learning.	2) Visualizing Ideas in Visual Environments 3) Creating Context Through Visual Thinking 4) Creating Visual Images to Support Understanding as Learned in ASC 5) Actively Relating / Connecting Visual Ideas	Understand New Ideas

Note. There is a strong connection between this change theme and the previously discussed change theme, "Reflecting on Visual Thoughts in Learning Scenarios". They share much of the same rationale that support a change event. The difference is this change theme represents metacognitive control or regulation for visual thinking in learning situations, rather than more awareness of visual thoughts due to reflecting on one's thinking more. See Appendix O for provisional codes.

As illustrated in Table 110, post-assessment themes represent an 'endpoint' in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, "'Visualizing' in Learning Scenarios to better Understand New Ideas" revealed that focal participants' (with validation from class participants responses), developed personal knowledge for their own visual thinking (e.g., "Creating Visual Images to Support Understanding as Learned in ASC") and for strategies to use visual thinking to understand academic ideas, (e.g., "Actively Relating / Connecting Visual Ideas"). For instance, in the pre-assessment, four of six focal participants reported a theme provisionally coded as "MR" related to "visualization." By the post-assessment all six participants reported at least one theme provisionally coded as "MR" related to "visualization."

Metacognitive regulation, "MR," for visual thinking (i.e., "visualization") was apparent in the pre-assessment but was not reported for at least half of focal participants in response to a specific question or section of the interview. In other words, there was not one question or section of the interview where at least three participants made a statement that indicated participants controlled their visual thinking (provisionally coded as "MR"). In the post-assessment, there were four themes reported in response to the AoC section that were provisionally coded as “MR” and “MetStrat” for at least three focal participants. Thus, regulation (i.e., control) for visual thinking was reported in more breadth in general; though, not all focal participants statements were robust in terms of procedural knowledge for how they engaged in “visualization.” The post-assessment themes which comprise the change theme in Table 110 are discussed next.

“Visualizing” Ideas in Post-assessment. All six focal participants indicated using (i.e., controlling) aspects of their mental imagery to understand new academic ideas. Participants predominantly used the terms “visualize,” and “imagine,” to metacognitively assign meaning to their visual thinking. Most responses related to control for mental imagery were categorized into themes reflecting the primary stimuli in the learning environment, i.e., auditory and visual learning environments. In the post-assessment four of six focal participants indicated visualizing ideas to "think about" the ideas their classmates were discussing. Four of six focal participants also indicated visualizing ideas in visual environments (e.g., when reading or watching a video). This means that one more participant was coded for the themes, “Visualizing Ideas to Understand Speakers’ Words” and “Visualizing Ideas in Visual Environments” in the post-assessment than the pre-assessment. Thus, metacognitive regulation or control for “visualization” (i.e., using mental images) was reported more (i.e., more themes, more responses, and more themes in more learning situations coded as “MR” and “MetStrat”) in the post-assessment than in the pre-assessment. In Table 111, the themes related to “visualization” (i.e., control of one’s mental imagery) are presented the way they are hierarchically structured in the post-assessment template (Appendix O).

Table 111

Post-assessment Themes for "Visualization" that Emerged from the AoC Section - Listed by Category

Category	Themes
Mental Strategies for Learning	4.1 Creating Visual Images to Support Understanding as Learned in ASC [MR (Control), VT, MetStrat, ML]
	4.4 Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat | MetSkills]
Mental Strategies for Learning	4.4.1 Creating Context Through Visual Thinking [MR (Control), VT, MetStrat]
	4.4.2 Actively Relating / Connecting Visual Ideas [MR (Control), VT, MetStrat, MetSkills]
	4.5 Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills]
Mental Strategies for Learning	4.5.1 Creating Context Through Visual Thinking [MR (Control), VT, MetStrat]
	4.5.2 Actively Relating / Connecting Visual Ideas [MR (Control), VT, MetStrat, MetSkills]

Note. Some themes were parallel coded to show the environment the visualization was taking place and the mental activity the participants engaged in. Additional Note. Provisional Codes: MK = Metacognitive Knowledge, MR = Metacognitive Regulation, VT = Visual Thinking, MetStrat = Metacognitive Strategies, MetSkills = Metacognitive Skills, ML = Meta-learning, "|" = Difference in Provisional Codes between Participants.

The post-assessment themes listed in Table 111 are discussed next.

Visualizing Ideas in Visual Environments. Four focal participants indicated they visualized ideas (i.e., used mental images) to understand class material in situations where they had access to primarily visual input, such as when reading or watching videos. The post-assessment theme, "Visualizing Ideas in Visual Environments" was coded for questions five, seven, and eight, with the majority of participants being coded in the AoC section. Prominent quotes for this theme are listed in Table 112 below.

Table 112

Prominent quotes from Post-assessment Theme - "Visualizing Ideas in Visual Environments"

Class Participants	Prominent Quotes
Abby	This is my English class (beat) where *I would visualize things to help me*. Like this is when we're analyzing a book, reading it, I would make a timeline of what's going on, and *try to organize my ideas*.
Daniel	I think about the words and just pictures within the video or whatever I was reading. And *I just start visualizing them in my mind, and I really kind of blow them up on the big screen in my at home mind movie theater* and I just see them. And they feel more clear, I guess.
Lilly	So, when I read a certain paragraph, *I try to, I guess, visualize it or just try to put context to it.* A lot of the books I've read-- In English, we read one book, *Ceremony*, that takes places in a pueblo that is actually from the state where I'm from. So, when I think about that and the way they describe certain things, because I'm familiar with it, and I'm familiar with the idea and the climate, I'm able to imagine it.

Note. Daniel's quote was previously mentioned when discussing the theme, "Explaining Visual-Mental Thoughts in Learning Scenarios." The researcher felt it important to also mention the quote here as it touches on both themes and shows some of the overlap that exists between themes. Another note. Parts of the response that denote metacognitive regulation (i.e., control) are denoted in italics.

As illustrated in Table 113, focal participants explained how they visualized ideas primarily when reading to understand the ideas in the text. For instance, the researcher asked Daniel about reading or watching a video, "So, you're reading or watching a video in this place, and then you think you know something well. As in, something makes perfect sense. What occurs inside your mind?" Daniel responded that he visualized the words and pictures in his mind, or his “at home mind movie theater,” which helped him understand the ideas more clearly. Furthermore, Lilly spoke about how she visually thought about the stories she read for English class. If the ideas were something she already had previous knowledge of, she was able to picture those ideas. Lastly, Abby created and visualized a “timeline” of the events that occurred in a book (for English class) to organize the various ideas/events. Visualizing ideas in primarily auditory environments is discussed next.

Visualizing Ideas to Understand Speakers’ Words. Four focal participants indicated they visualized ideas to understand or think about classmates or teachers’ spoken words. The post-assessment theme, “Visualizing Ideas to Understand Speakers’ Words” was coded for questions four, six, and eight, with most overlap in focal participants’ responses at question six, which means most statements for this theme came in response to questions in the AoC section. Four focal participants were coded for question six, which asked how they “reflect on or think about” the ideas their classmates are discussing. Question six of the post-assessment mirrored question eight in the pre-assessment, which also was structured in the AoC section. Prominent quotes for this theme are listed in Table 113 below.

Table 113

Prominent quotes from Post-assessment Theme - “Visualizing Ideas to Understand Speakers’ Words”

Class Participants	Prominent Quotes
Abby	When I think about what people are discussing and learning, or talking about, *I definitely try to visualize it in my mind*, from what we've learned in class.

Coreen	...my column of my thinking of what I think I understand and then their words come in and they go up in this column next to me, *and I see how they match up, what's different.*
Dalisay	So, when they're talking, *I tend to visualize what they're talking about*, and then *I try to relate that to my thought.*
Lilly	I recently had to do a presentation on a nurse. And so, just *thinking about that nurse, like what was going on during that time - just kind of like imagining things.* Not necessarily imagining an entire story, *but just trying to think*, "Okay, this was the nurse's life, this is how she chose to take her life and go into nursing." And how does she emulate the concepts of being a nurse?
Lilly	And the way they explained it, the way they worded it didn't make sense initially. It took a little bit of explaining. It took maybe another extra class or so for me to finally understand. But eventually it was able to click *and being able to create a correlation to a big idea.*

Note. Parts of the response that denote metacognitive regulation (i.e., control) are denoted in italics.

As illustrated in Table 112, focal participants discussed using visualization in various aspects to think about or understand spoken ideas. For example, Abby reported that she tried to understand her classmates spoken words by visualizing them in her mind. Additionally, Coreen compared her own stream of thoughts with the stream of thoughts of her classmates, which allowed her to develop understanding and form a response. Both Coreen and Abby did not report this behavior in the pre-assessment.

Additionally, Lilly reported moments of reflection where she used her visual thoughts to think about the “big idea,” or main idea being conveyed in the class, which helped her find/identify meaning in relation to new ideas. Lastly, Dalisay reported visualizing ideas when classmates were speaking and relating those thoughts to her previous knowledge.

Focal participants also engaged in two mental strategies related to their visualization, “Actively Relating/Connecting Visual Ideas," and "Creating Context through Visual Thinking." Focal participants reported using these mental strategies in both visual and auditory environments. This means that focal participants created context for their thinking and actively connected /related ideas to understand spoken words and to read and/or watch videos. These two themes are discussed next.

Creating Context Through Visual Thinking. Three focal participants discussed creating context for their thinking (when learning) with visual-mental thoughts. This mental activity often helped participants create meaning for the ideas they were thinking about or reflecting on when learning. The post-assessment theme, “Creating Context through Visual Thinking” was coded for questions three, four, six, seven, and eight, with all three participants being coded for questions in the AoC section. Prominent quotes for this theme are listed in Table 114 below.

Table 114

Prominent quotes from Post-assessment Theme - “Creating Context Through Visual Thinking”

Class Participants	Prominent Quotes
Abby	Yes, I definitely feel like, I know that if I categorize something that I'll understand it, or I'll find a way to remember it better. (cont’d) I just like to organize a lot, organize my notes and even my thoughts.
Dalisay	When it's basically when they're saying something, I try to visualize it through pictures of their sentences. So, if it's like a sentence about having empathy for others, I like picture like a leader being empathetic towards their people.
Lilly	Lilly: So, just being able to imagine like, "Okay, as a child, Clara Barton only had her father, so she didn't have a mother figure." So, she had a very different upbringing than many other young girls in that time. So, as a result

	she...stood her ground a lot more. She believed in equality. And she stood up for herself in ways that women in that time would not. Just being able to imagine that like, "Okay.” (cont’d) Chris: In this instance, imagining her and what she was going through and her experiences. That was something that you did to help you understand the ideas? Lilly: Yes.
Lilly	There was one specific spot that (the book *All about Love* by Bell Hooks*)* talked about, the way we love is very similar to the love our parents gave us, most of the time, which is one explanation why domestic abuse, child abuse, that kind of thing is a cycle. And that made me think of memories from when I was a kid, how my parents, how they showed their love and affection and that kind of stuff, and I was able to put that into context, but there were certain parts where it was a little harder to do that.
Lilly	...when I read about it or just going back trying to understand, okay, what am I trying to gain from this, or what is the big idea?

Note. Focal participants’ responses for Visualizing Ideas in Visual Environments and Visualizing Ideas to Understand Speakers’ Words were parallel coded with “Creating Context Through Visual Thinking.”

As illustrated in Table 114 participants attempted to create visual context for their thinking by organizing mental images or creating imagined environments. For example, Abby reported organizing her thoughts (represented as words) into an outline which helped her create context for the new ideas she was learning. Additionally, Dalisay and Lilly discussed creating story-based scenes with spoken ideas in class. The stories or mental landscapes that Dalisay and Lilly pictured held specific meaning for them, allowing them to better think with and understand new ideas being presented. The post-assessment theme, “Creating Context Through Visual Thinking” was provisionally coded as “MR” and “MetStrat” as participants responses indicated deliberate and strategic control over their visual-mental thoughts. Focal participants also discussed relating their visual-mental thoughts to other thoughts to creating meaning, which is discussed next.

Actively Relating / Connecting Visual Ideas. Five focal participants reported actively relating and/or connecting ideas with mental images to help them understand and/or learn new academic ideas. The post-assessment theme, "Actively Relating / Connecting Visual Ideas" emerged in response to questions three, five, and six, with most participants being coded in the AoC section. Prominent quotes for this theme are listed in Table 115 below.

Table 115

Prominent quotes from Post-assessment Theme - "Actively Relating / Connecting Visual Ideas"

Class Participants	Prominent Quotes
Abby	I'll definitely *try to visualize the basic subject and concept* and, listen for certain keywords *that would fall under that concept, kind of like an outline*.
Ashley	Ashley: I want to say *I start making connections with that video or reading to better understand it*. Again, with that thought web. Yeah. Yeah. Chris: Okay. Do you do that on paper or is it something else or-- Ashley: I do that mentally unless I need to write it on paper, but usually it's mental.
Coreen	So, yeah. It's just *putting what I think right next to what's coming in about what they're saying and comparing the two*. And then I have my conversation and it was like, "so it sounds like we agree on this, but this part doesn't really make sense." Yeah.

Dalisay	Dalisay: I think just simply *visualizing what they're saying in my head and try to make connections with my thinking with theirs*. Or like what I know what they know, and I *try to connect - like find a relation to it that helps me understand.* Chris: Okay, is that a mental relation? Dalisay: Yes, it's a mental relation.
Dalisay	...but yeah, it's more like going beyond that visual, so like *adding my own visual towards and on top of theirs*.
Lilly	Usually, it's after the class, I notice myself trying to process it and break it down in my head. Usually, people like to talk after class and I follow like my friends and everything, but I'm still processing everything. So, I'm very quiet in the back just trying to process everything and *just trying to put it together into a big picture*.

Note. Parts of the response that denote mental relation are denoted in italics.

As illustrated in Table 115, focal participants reported relating new ideas to other new ideas or to ideas they already understood. This often occurred in moments of reflection. Focal participants reported relating and/or connecting ideas in both (primarily) visual and auditory learning scenarios. The pre-assessment theme, “Relating Prior Knowledge/Experiences to What I'm Learning,” coded for Abby and Ashley, indicated a similar mental activity but was never discussed in the context of visual thinking. The post-assessment theme, “Actively Relating / Connecting Visual Ideas” represents strategic use of visual thinking for the purpose of learning. Creating visual-mental images in the context of what was learned in the ASC is discussed next.

Creating Visual Images to Support Understanding as Learned in ASC. Three focal participants reported actively creating mental images to 'see' and/or understand ideas (i.e., words, pictures) when learning. The post-assessment theme, “Creating Visual Images to Support Understanding as Learned in ASC” was coded for questions two and six. All three participants mentioned engaging in this activity because of what they learned and/or was discussed in the ASC. Prominent quotes for this theme are listed in Table 116.

Table 116

Prominent quotes from Post-assessment Theme - "Creating Visual Images to Support Understanding as Learned in ASC"

Class Participants	Prominent Quotes
Abby	Visualizing it in my mind so that I can visually see in my head, what is it that they're discussing and stuff like that.
Coreen	I used the definitions of the mental imagery stuff, and then I used the structure that we took from the drawing, and I put that structure that we put on paper, and I put it into my head to visualize for that.
Coreen	**Chris:** Like a mental activity, so not like necessarily, it's not a drawing activity, you're using it as a mental activity. Is that correct? **Coreen:** Yes. This is specifically for biology and nursing, just because there's so many visual elements in there. If I find myself struggling to understand, then that's when I do go to paper, but oftentimes, it stays in my own head.
Lilly	So, the visual, creating visual imagery and something to associate that with, we talked about the dictionary where you write a term and draw a picture to associate with that, I've started doing that a lot more, and I've definitely noticed how it's helped.

In Table 116, Coreen explained a mental strategy where she placed ideas in her mind and tried to connect and/or branch those thoughts into new ideas, like flowcharting was discussed in the ASC. Additionally, when The researcher asked Abby, how she thought about the ideas her peers were discussing internally, she reported visualizing them in her mind similar to what was discussed in the ASC. Lastly, Lilly discussed using mental imagery with drawing to create associations between ideas, similar to what was discussed in the ASC. The post-assessment theme, "Creating Visual Images to Support Understanding as Learned in ASC" represents participants active regulation of their visual thinking because of what they learned in the ASC about mental imagery. Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 2 – "'Visualizing' in Learning Scenarios to Better Understand New Ideas." The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants' statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

"'Visualizing' in Learning Scenarios to Better Understand New Ideas" is a change theme that relates to developing (metacognitive) regulation for one's visual thinking in learning situations for the purpose of understanding new academic ideas. Table 117 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 117

Conversations in Second Member Check Relevant to Change Theme – "'Visualizing' in Learning Scenarios to Better Understand New Ideas"

Focal Participant Name	Chris (Questions/Interpretations)	Focal Participant Answering
Abby	When you think about what other people (e.g., classmates) are discussing you try to visualize those ideas in your mind to understand what they are saying.	This interpretation is accurate. I would like to add that whatever key topics are being said I would try to picture it in terms of the flowchart or the outline, so that it takes me back to the main concepts. So, I can play a scenario in my head, to relate it to what is being said. When my classmates are discussing those ideas, when I hear words that I understand, in my mind I try to categorize it to the section I relate it to. "It's kind of like an outline in my head." An outline of the subject, the lesson being taught, the order of ideas like in notes. I relate whatever is being said to what I already know.
Coreen	Instead of drawing on paper you place the drawing in your mind (as mental images).	This is mostly, accurate. It's based on the time that I have in class. If I do have time to draw, I engage in that strategy and see greater benefits when I do (in terms of recall.) I put it in my mind because it's quicker and easier. It's harder to transfer ideas from your brain to paper. When I quickly take notes in class, you don't always have time to move over to the white board (paper).
Daniel	When watching a video, you actively visualize ideas to understand them better.	Yeah, I find visualizing the idea (viewing them in my mind's mental at-home theater) when watching a video helps me understand the ideas better. If I'm mentally visualizing the ideas from a video as I am watching it, I don't have to put as much mental energy into understanding the ideas, because I'm actively constructing meaning during the viewing.

Dalisay	Can you describe the mental relation in any more detail?	“While someone is speaking, I picture their words into actions in my head. While I do that, it makes me understand what they're saying more clearly. As a visual learner, I tend to picture images in my head more than words sometimes.”
Lilly	When you hear others talk about ideas you try to picture (or imagine) those ideas in a context that makes sense to you. For instance, in the example you gave about Clara Barton, imagining her and some of her experiences helped you to understand what her life might have been like and some of the reasons why you are learning about her as a nurse.	Yes, that’s accurate.

Sections from the case summaries in Table 117 provided verification and in some cases depth to participants’ responses in the post-assessment. Focal participants reported using mental images - what they often termed “visualizations” or “imagination” - to understand new academic ideas in various learning situations, e.g., when teachers or peers were speaking, and when reading or watching videos. For example, Daniel stated in the member check that visualizing ideas similar to a “movie theater” helped him construct meaning for video-based concepts, “…I feel like I’m really there watching all these words and pictures and their visualizations in my mind. I imagine literally blowing them up on the big screen.”

Most focal participants also reported creating context and/or additional meaning through their visual-mental thoughts, represented by the themes “Creating Context Through Visual Thinking” and “Actively Relating / Connecting Visual Ideas.” Participants engaged in these behaviors by, 1) purposefully thinking about story-based scenarios, 2) organizing their thoughts into structures that held meaning to them, and/or 3) connecting/relating new ideas to previous knowledge. For example, Dalisay confirmed in the member check that she created mental relationships between her reasoning of what classmates were discussing and previous knowledge to develop understanding of the spoken words. “When given a word and definition, I picture that meaning in my head through actions or visual representations which helps me understand the definition.” When asked if her ‘relation building’ “was based in mental images or something else,” Dalisay stated “I guess mental images and prior knowledge.”

In the class activities several class participants reported applying and/or integrating visualization as a strategy and learning about mental imagery. Additionally, four participants mentioned in the post-assessment that they used mental imagery similar to how it was discussed in the ASC or what they learned about mental imagery was helpful. Template analysis, provisional coding and longitudinal analysis indicate that focal and class participants learned about mental imagery, metacognition, and visualization and began to apply/integrate strategies that capitalized on visual thinking, e.g., drawing while thinking about mental images. As they did, focal participants recorded more responses provisionally coded as “MR,” particularly in the post-assessment, which indicated more metacognitive regulation (or control) for visual thinking in learning situations. For instance, Abby and Coreen did not assign meaning to visual thinking as it directly related to learning in the pre-assessment but did assign meaning to visual thinking themes that showed regulation for learning in the post-assessment, e.g., both coded for “Actively Relating / Connecting Visual Ideas.”

In summation, visual thinking expanded in both breadth and depth for the interview group. More focal participants, by the post-assessment, *engaged in more metacognitive strategies related to visual thinking* to understand the ideas they were learning. Additionally, responses provisionally coded as “MR” for *visual thinking* (e.g., “visualization”) were more focused in the AoC section and often related to reflective thinking, as was discussed in the ASC.

For example, Lilly reported using her visual thinking in a more reflective manner to understand new academic ideas in the post-assessment as compared to the pre-assessment. She confirmed in the member check that she often put new ideas in a story-based form which gave her thoughts more structure and meaning.

Lastly, participants' application of visual thinking did not always mirror what was taught in the ASC but reflected what they thought would be impactful to their learning. Other post-assessment themes, not mentioned in this section, that overlap with the change theme "'Visualizing' in Learning Scenarios to Better Understand New Ideas," are 1) Explaining Visual-Mental Thoughts in Learning Scenarios, 2) Reflective Thinking for Learning, 3) Learned About Using Mental Imagery, and 4) Learned about Metacognition, Visualization, Mental Imagery in ASC.

Change Theme 3 - Monitoring "Understanding" when Learning More.

"Monitoring "Understanding" when Learning More" is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants' statements of monitoring (i.e., paying attention to) their awareness and understanding in learning situations. This change theme incorporates the themes provisionally coded as "MK" and "MR," for metacognitive monitoring in the pre- and post-assessments as well as the cumulative theme, "Metacognitively Reflecting on New Ideas" in the class activities. It's important to note that other themes, particularly strategy-based themes in the class activities and post-assessment templates, which were provisionally coded as being metacognitive (e.g., Taking Notes in My Own Words), also influenced this change theme, as they required metacognitive monitoring to be successful.

The researcher incorporated themes for *metacognitive monitoring* over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. Overall, focal participants reported monitoring their attention/understanding more frequently in learning situations and monitored their thinking in more strategic ways (i.e., deliberate mental activities to achieve a goal) over the course of the semester. For example, all six focal participants in the post-assessment confirmed that they paid more attention to their understanding when learning than they did at the start of the semester. Furthermore, all focal participants provided examples of how they monitored their understanding during the last semester in the post-assessment.

The researcher deduced from template analysis, longitudinal analysis, and case summaries that all focal participants gained personal knowledge for applying their thinking towards their attention and/or understanding over the course of the ASC to better understand new academic ideas. This “change” is supported by the emergence and accumulation of themes reported in Table 118.

Table 118

Emergent and Cumulative Change for Metacognitive Monitoring Based on Themes Over the Course of the ASC

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Themes
1) Monitoring Learning 2) Asking for Clarification	Applied/Integrated Strategies “Metacognitively Reflecting on Ideas” - [4/23 Ps. applied or integrated metacognitive strategies for learning. Those metacognitive strategies primarily have to do with monitoring understanding or creating understanding with one’s words (i.e., language,	1) More Attention to Thinking when Learning 2) Learned about Metacognition, Visualization, Mental Imagery in ASC 3) Improved Monitoring when Learning 4) Reflective Thinking for Learning	Monitoring "Understanding" when Learning More

	thoughts) (also considered meta-learning theme).	5) Monitoring Understanding while Learning 6) Monitoring Attention in Class 7) Taking Notes Before/After Class to Pay More Attention in Class 8) Asking Self Questions About Understanding in Learning Scenarios

Note. All strategy-based and meta-learning themes from the class activities could and may have impacted metacognitive monitoring as they all require monitoring to be successful.

As illustrated in Table 118, post-assessment themes represent an 'endpoint' in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, "Monitoring "Understanding" when Learning More" revealed that focal participants' (with validation from class participants responses), developed personal knowledge for metacognition (e.g., "Learned about Metacognition, Visualization, Mental Imagery in ASC") and for strategies to use metacognition to understand academic ideas (e.g., "Asking Self Questions About Understanding in Learning Scenarios"). For instance, in the pre-assessment, four of six focal participants reported a theme provisionally coded as "MR" for the theme, "Monitoring Learning." By the post-assessment all six participants reported at least one theme provisionally coded as "MR" related to monitoring of one's thinking. Focal participants reported they engaged in monitoring behaviors directed at their attention (e.g., "Monitoring Attention in Class") and their understanding (e.g., "Asking Self Questions About Understanding in Learning Scenarios"), which helped them engage in additional behaviors that supported learning, such as "Asking Clarifying Questions to Support Thinking."

As a change theme, "Monitoring "Understanding" when Learning More" brings together metacognitive knowledge, "MK," and regulatory based themes that demonstrate focal participants engaged in more strategic monitoring behaviors for learning over the course of the semester. The post-assessment themes which comprise the change theme in Table 104 are discussed next.

More Attention to Thinking when Learning. All six focal participants confirmed that they paid more attention to their own thinking when learning because of what they learned in the ASC. This theme emerged in response to question 3, which asked, “Because of what you learned this semester, do you find yourself paying attention to your own thinking more, when you’re learning something?” All participants affirmed that they paid more attention to their own thinking when learning. This affirmation supports other themes in the post-assessment that relate to strategic monitoring behaviors. Reports of improved monitoring in learning scenarios is discussed next.

Improved Monitoring when Learning. Five focal participants supported ‘yes’ statements in response to question #3 of the post-assessment with additional statements about improved monitoring of their thinking and/or learning during their first semester in college. Participants reported various monitoring behaviors in learning situations, e.g., monitoring how I learn. Prominent quotes for this theme are listed in Table 119.

Table 119

Prominent Quotes from Post-assessment Theme - “Improved Monitoring When Learning”

Class Participants	Prominent Quotes
Abby	I would definitely say that I've been more aware of what makes me a better learner. What certain types of things catch my attention maybe or I'm more attentive to.
Ashley	...but I've been more aware about it (my learning). So, because I'm more aware now, I try to give myself a better chance of grasping the stuff that's being taught.

Dalisay	And if people are saying things that I don't understand, I have to stop my thinking and be curious about it. And I kind of switch the focus on that… So, it's like, "Okay, wait, let me think again."
Lilly	I think the class has definitely allowed me to focus on it more and just made me more aware of it (my learning) and, yes, it made me more aware of how I think and just why I think the way I do.

As illustrated in Table 119, focal participants reported improved monitoring by, 1) being more aware of (i.e., attending to) their attention in class, 2) monitoring thinking (i.e., understanding) in learning situations, and 3) monitoring how they learn best. Monitoring Understanding is discussed next.

Monitoring Understanding while Learning. All six focal participants reported how they focused on their own understanding in learning situations (e.g., listening to a teacher, reading, studying) in the post-assessment. The post-assessment theme, "Monitoring Understanding while Learning" emerged in response to questions two, three, six, seven, and eight, with most overlap coming in the PK and AoC sections. Prominent quotes for this theme are listed in Table 120.

Table 120

Prominent Quotes from Post-assessment Theme – "Monitoring Understanding While Learning"

Class Participants	Prominent Quotes
Abby	Probably just try to listen until I hear something that I do understand. Mostly listen to keywords, key concepts, and then I'll try to drawback onto that.
Ashley	I focus on how well I'm taking in what the professor is saying now because I feel like in the beginning, I would just let it go in through one ear out the other.

Ashley	…in my psych class, she posts the slides, then we just take notes off of that, while she's also going through it. But I felt that before I was more focused on trying to write down notes or type them, rather than listening to the other additions to the notes that she's giving verbally. Now I've been more aware of what she's saying than I am of the notes.
Coreen	This one's recent…when the teacher pauses, I use that time to search back and make sure I heard what they were saying...
Coreen	…so, I'll look at it, I'll read it through once, I'll judge my understanding of it, I’m like, "Does that make sense? Is this what I'm talking about here?
Daniel	...as (classmates are) talking about what steps to do, I’m checking the steps in my head to make sure they're correct as I'm performing them on the paper, to make sure I've got this down to the same degree they do.
Dalisay	When I'm learning something new that's where I talk to myself a lot in my head. Because I try to make it clear within myself first.
Lilly	When I think about something, I don't make a lot of eye contact. Usually, when I do that, I'm usually processing something or I'm just trying to think about my answers.

As illustrated in Table 120 focal participants primarily reported monitoring their understanding, a) while reading, and b) while the teacher presented information in class. The post-assessment theme, “Monitoring Understanding while Learning” was provisionally coded as “MR” and “MetStrat,” indicating participants had a degree of regulation over their metacognitive monitoring in learning situations. For example, Coreen explained, that when she’s in learning situations she asks about her own understanding, “And then for the metacognition, thinking about your own thinking, was, I would reflect, like in a pausing moment, I'd be like, "Did I understand that? Does this make sense to me?"

Additionally, three participants contextualized their monitoring by stating it was something they learned in the ASC. For example, Ashley, stated, "I feel like this class has opened up that thought. Because I was introduced by that idea in the class, I've been trying to take a step back and seeing if I'm actually doing those things in other classes." Monitoring attention in class settings is discussed next.

Monitoring Attention in Class. Three participants reported how they monitored their attention and/or focus while in class, e.g., catching themselves not paying attention. This theme is specifically focused on the act of being aware of one's attention rather than paying attention to one's understanding. The post-assessment theme, "Monitoring Attention in Class" emerged in response to questions three and ten, with all three participants being coded for question three in the PK section. Prominent quotes for this theme are listed in Table 121.

Table 121

Prominent Quotes from Post-assessment Theme – "Monitoring Attention in Class"

Class Participants	Prominent Quotes
Abby	Sometimes she (the teacher) talks about the concepts that are listed on the board, but she'll go into depth on those concepts. That's when I start to zone out and then I'm like, "What is she talking about again?" Then I try to zone back in, listen to a few keywords. And then see what concept on the board it is that she's talking about because it's not clear."
Ashley	For me, I definitely try to look at the professor a little more often because I found that if I look at them rather than just staring at their slides the whole time, I can understand what they're saying better, and just pick it up faster.
Coreen	Checking in with myself to make sure I'm listening is the difficult one.

Coreen	So, just making sure that I'm in the moment, and I'm actually listening is a big one.

As illustrated in Table 121, all three participants reported attending (or focusing) on the teacher and the material being presented in class. For instance, Abby reported shifting her attention back to the teacher after zoning out. This theme was provisionally coded as “MR” and “MetStrat.” Taking notes before/after class to pay attention during class is discussed next.

Taking Notes Before/After Class to Pay More Attention in Class. Two focal participants reported they took notes before or after class so they could pay attention while in class. The post-assessment theme, “Taking Notes Before/After Class” is an extension of monitoring for both focal participants coded for this theme. For example, Lilly, took notes before class so she could comprehend and keep up with her notes during class, “...I go in beforehand, do a few notes, just so I can keep up with the notetaking and just so I'm able to comprehend it a little bit, but then she (the teacher) can go back and elaborate and fill in all the holes for me. Because I start with maybe one or two slides of notes before she starts so I can continue and listen.” Lilly also reported taking notes and reflecting on her understanding after class. Additionally, Coreen took notes outside of class so she could pay attention and try to understand the lecture while in class, “...I listened first, and then I take notes later in my own time. Which you mentioned, you were worried about me like just listening in class and not writing notes at all, but I go back and watch the lectures.” Thus, participants took notes before or after class, which helped them monitor comprehension in class. Responses for this theme were provisionally coded as “MR.” Asking oneself questions about understanding is discussed next.

Asking Self Questions About Understanding in Learning Scenarios. Three focal participants reported asking questions of their own understanding in learning situations, and/or stated the questions they asked themselves to monitor their understanding in the post-assessment.

The post-assessment theme, “Asking Self Questions About Understanding in Learning Scenarios” emerged in response to questions two, three, seven and nine, with most responses being coded in the PK section. Prominent quotes for this theme are listed in Table 122.

Table 122

Prominent Quotes from Post-assessment Theme – “Asking Self Questions About Understanding in Learning Scenarios”

Class Participants	Prominent Quotes
Ashley	Now I'm trying to be like, "Okay, what are they actually saying? How can I use that in my notes and learning overall?"
Coreen	It's a question that I've started to ask myself a lot, is like, "Does that make sense to me? Did I get all the information that I need?
Coreen	It starts with, "Did I hear it?" Then it goes with, "Did I understand that?" Then it goes, "What am I missing?”
Dalisay	So, like I ask myself like, "Okay I know this about this, but I don't know this about this.” So, it kind of helps me identify what I don't and do know and that way I can move on to again like reaching out for help from my peers.

As illustrated in Table 122, all three participants ‘checked in’ or monitored their understanding by asking themselves questions of academic material. Asking questions of oneself about understanding was a strategy discussed in the ASC to develop thinking and learning when engaging with new academic concepts. Two participants, Coreen and Dalisay, mentioned they asked more questions about their understanding than they did previously (at the time of the first interview). For instance, when the researcher asked in a follow-up to question seven in the post-assessment, *what part of your approach to reading is new*, Coreen stated, “Checking in on if I understood what I was reading, because oftentimes it would be like, ‘I read that, that's a semi-summarization,’ but now it's like, ‘Okay, did I actually understand that, or did I just skim through it?’” Coreen later referenced the exact questions she asked herself, “It starts with, ‘Did I hear it?’ Then it goes with, ‘Did I understand that?’ Then it goes, ‘What am I missing?’” Additionally, when the researcher asked Dalisay whether she asks more questions about her understanding than she did previously (in high school), Dalisay stated, “Oh, yes, I do that more definitely. Because in that class (the ASC), I've noticed that they really push us to think deep within ourselves. Because even the environment – like going into that class it makes you think a lot. And then when you leave that class, you're left thinking what you thought about in class, and then when you're in your dorm, you're forced to be by yourself and then that's what you're thinking about more.” Learning about metacognition, visualization and mental imagery is discussed next.

Learned about Metacognition, Visualization, Mental Imagery in ASC. Three participants indicated they learned about (or found relevant) the concepts of metacognition, mental imagery, and visualization in the specific class (in the ASC) that discussed those three interconnected concepts. The post-assessment theme, “Learned about Metacognition, Visualization, Mental Imagery in ASC” emerged in response to questions one and two. Prominent quotes for this theme are listed in Table 123.

Table 123

Prominent Quotes from Post-assessment Theme – "Learned about Metacognition, Visualization, Mental Imagery in ASC"

Class Participants	Prominent Quotes
Abby	I feel as in class when you introduce all the different types of ways we could learn. I definitely see myself falling into those categories. Some more than others obviously, but I do feel I could step into other categories more.
Ashley	I feel like that one lesson on metacognition and critical thinking in that lesson really helped me understand my learning and thinking because it took three different ideas...helped me focus on what I actually meant when I said I would learn visually or whatever. **Chris: So,** metacognition, visualization, and mental imagery? Those three. **Ashley:** Yes. Those three helped me focus on what I actually need to learn properly.
Coreen	Yeah. Okay. So, out of those, the classes that definitely helped the most, were the metacognition, visual imagery, or mental imagery and visualization.
Coreen	Once you're given these definitions that are like well-known on the internet, you can go look it up, you can learn more about yourself, more about other people and other strategies that you can use that are branched off from that. And so yes, that one helped a lot.

As illustrated in Table 123, three focal participants mentioned that metacognition was a relevant concept to their own learning. Ashley and Coreen specifically utilized the concept of metacognition to ask questions about their own understanding, and Abby utilized metacognition to monitor her understanding in class. Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 3 – "Monitoring "Understanding" when Learning More." The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants' statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

"Monitoring "Understanding" when Learning More" is a change theme that relates to developing regulation of one's metacognitive monitoring in learning situations for the primary purpose of understanding new academic ideas. Table 124 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 124

Conversations in Second Member Check Relevant to Change Theme – **"***Monitoring "Understanding" when Learning More"*

Focal Participant Name	Chris (Questions/Interpretations)	Focal Participant Answering
Abby	You said, "I definitely know that I'm more attentive when I'm being spoken to." Does that mean that you are more aware of your own thinking (e.g., understanding) when somebody else is speaking or that you are more aware of what the speaker is saying or both?	I'm more likely to pay attention and more likely to engage with the material, in terms of thinking about it. More likely to pay attention, rather than zone out.

Ashley	As a result of what you learned in (the ASC) - when a teacher is speaking you might be actively thinking 'how do I best incorporate that into my notes or to my learning overall?'	Yes.
Coreen	As a result of what you learned in the (ASC), you find that you are checking in with yourself more to make sure that you hear and understand what the teacher is speaking about.	Yes.
Dalisay	Having a name, definition, and purpose for this reflective behavior made it easier to engage in. As a result, you find yourself engaging in this type of reflective behavior even more in college.	Yes, because it helps me know that it exists. It's frustrating to not know things - being confused. But making this a thing, in terms of asking those questions of myself, "helps me know that learning is more than just what you know in terms of what you are expected to learn. Again, going back to when I said, it's deeper than just academics, it's also learning more about who I am and what I am capable of."
Daniel	You are more aware of your thinking when learning than you were at the beginning of last semester. You do not maintain this awareness for long durations, but rather use it in specific instances.	For French, if we're getting a new vocabulary list, then a quiz is coming up. So, I'm thinking "how am I going to study for that?" Then I put the vocab into a Quizlet and create representations between the word and the definition for that word. So, developing that strategy helps me learn in that specific instance.

Sections from the case summaries in Table 124 provided verification and in some cases depth to participants' responses in the post-assessment. Focal participants reported monitoring their understanding more than they did at the start of the semester to better learn academic concepts. In the post-assessment, participants engaged in monitoring by, 1) purposefully thinking about their own understanding inside and outside class, 2) monitoring their attention while teachers presented information in class, and 3) asking questions about their own understanding when engaging with new academic ideas. Additionally, two focal participants engaged in notetaking before and after class so they could monitor their attention/comprehension while in class. In the member check, focal participants verified that they monitored their understanding more, including asking more questions of themselves, than they did at the start of the semester.

In the class activities most class participants reported learning about and/or applying metacognition in connection with other strategies such as “Taking Notes in My Own Words.” Additionally, four focal participants mentioned during the semester that they learned about metacognition in the ASC and applied it in some capacity toward their learning. Provisional coding and longitudinal analysis indicate that focal and class participants learned about metacognition and began to apply/integrate strategies that capitalized on metacognitive monitoring, e.g., asking self-questions about understanding. As they did, focal participants recorded more responses provisionally coded as “MR,” particularly in the post-assessment, which indicated more metacognitive regulation (or control) for monitoring in learning situations. For instance, Ashley and Lilly did not assign meaning to monitoring in the pre-assessment but did assign meaning to monitoring themes, provisionally coded as “MR” in the post-assessment, e.g., both coded for “Monitoring Understanding while Learning.”

Template analysis and provisional coding reveal that focal participants engaged in ‘monitoring understanding’ deliberately, recurringly, and in some cases effectively. Overall, focal participants reported behaviors that demonstrated they applied monitoring in more strategic ways during their first semester in college. “Monitoring “Understanding” when Learning More” is the primary change that occurred for focal participants during the semester and the central finding of the study. Focal participants additionally reported benefits to thinking more about their learning, including 1) understanding more about their own capabilities, 2) learning more about new concepts, and 3) improved academic performance. In some cases, tuning into their thinking more, primarily in class, led to additional strategies that supported learning, such as asking clarifying questions.

In summation, metacognitive monitoring expanded in both breadth and depth for the full group of focal participants. More focal participants, by the post-assessment, engaged in more monitoring strategies related to understanding and learning academic material. Post-assessment responses provisionally coded as “MR” for monitoring often corresponded to participants reflective thinking. Other post-assessment themes, not mentioned in this section, that overlap with the change theme are **“**Using Internal Dialogue to Support Thinking/Learning” and “Reflective Thinking for Learning.”

Change Theme 4 - Using My Own Words to Create Understanding

“Using My Own Words to Create Understanding” is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants’ statements of using their own words, voice, and/or language (i.e., natural language) to better think about and/or understand academic material. Focal and class participants were taught in the ASC that their natural language (also termed "own words" and "own voice"), when used to think about academic concepts, supports higher thinking (e.g., critical thinking) and development of neurosemantic brain networks. Participants were presented with several strategies to try, such as, a) teaching academic material, b) discussing ideas with others (e.g., peers), c) writing notes in their own words, and d) asking questions of their own understanding, to support higher thinking about academic concepts. The change theme, “Using My Own Words to Create Understanding” incorporates the themes provisionally coded as “MK” and “MR,” for using one’s words in the pre- and post-assessments as well as the cumulative theme, “Taking

Notes in My Own Words," and meta-learning themes - "Notes in My Own Words Supports Learning," and "Language Supports Thinking/Understanding" in the class activities.

The researcher incorporated themes for using one's words/language over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. Overall, focal participants reported using their own words/language to create understanding more frequently and did so in more strategic ways (i.e., deliberate mental activities to achieve a goal) over the course of the semester. For example, five of six focal participants in the post-assessment confirmed they wrote ideas in their own words whereas three participants in the pre-assessment used this strategy, two of which had just begun to use this strategy because of what they learned in the ASC. Furthermore, all focal participants provided examples of how they used their words and/or language to support thinking between the post-assessment and second member check, while four participants mentioned a language strategy in the pre-assessment and first member check. The researcher deduced from template analysis, longitudinal analysis, and case summaries that all focal participants gained personal knowledge for applying their language strategically over the course of the ASC to better understand and/or learn academic ideas. This "change" is supported by the emergence and accumulation of themes reported in Table 125.

Table 125

Emergent and Cumulative Change for "Using My Own Words to Create Understanding" Based on Theme Over the Course of the ASC

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Themes
1) Writing Ideas in My Own Words to Understand 2) Using Dialogue to Support Thinking/Learning 3) Communication in Groups Helps with Challenging Ideas	Applied/Integrated Strategies "Taking Notes in My Own Words" [In total 12/23 students applied and/or integrated notes in their own words (i.e., natural language) as a strategy for their learning in the LSA and JE6. 5/23 students applied and integrated notes in their own words as a strategy (in the LSA and JE6). Primary Meta-learning Themes 1) "Notes in My Own Words Supports Learning" 8/23 Ps. discussed how writing notes in their own voice supported aspects of their learning. 2) "Language Supports Thinking/Understanding" (11/23 Ps.) In total, 11/23 students mentioned, among three themes in the LSA and JE6, that using their own language (whether writing in their notes or speaking about ideas with peers), supported an aspect of their learning.	1) Writing Own Meaning (Words) in Notes 2) Discussing New Ideas with Peers 3) Using Internal Dialogue to Support Thinking/Learning 4) Using My Own Words (Language) Helps Thought Processes	Using My Own Words to Create Understanding

As illustrated in Table 125, post-assessment themes represent an 'endpoint' in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, "Using My Own Words to Create Understanding" revealed that focal participants' (with validation from class participants responses), developed personal knowledge for utilizing their natural language (i.e., own words) strategically to better think about and/or understand academic ideas, e.g., “Taking Notes in My Own Words” in class activities and “Writing Own Meaning in Notes,” among other strategies in the post-assessment.

As a change theme, “Using My Own Words to Create Understanding” brings together post-assessment themes provisionally coded as, metacognitive knowledge, “MK,” metacognitive regulation, “MR,” metacognitive strategies, “MetStrat” and meta-learning, “ML,” which indicates focal participants learned about and engaged in more behaviors/strategies for their own language during the last semester. In the post-assessment, focal participants reported utilizing their own words/language, 1) for notetaking (e.g., “Writing Ideas in My Own Words to Understand”), 2) when communicating with others (e.g., “Discussing New Ideas with Peers”), and 3) with internal dialogue (e.g., “Using Internal Dialogue to Support Thinking/Learning), which supported their thinking/understanding, (e.g., “Using My Own Words Helps Thought Processes).” Additionally, more than half of focal participants confirmed in the post-assessment they utilized their language (internally or externally) more often because of what they learned in the ASC. The post-assessment themes which comprise the change theme in Table 125 are discussed next.

Writing Own Meaning (Words) in Notes. Five focal participants in the post-assessment indicated they captured meaning (i.e., thinking) by using their own words in their notes. As guest instructor in the ASC, the researcher taught that writing ideas in your own words, as opposed to copying the teachers’ notes, is an effective strategy for learning. The strategy compels students to engage with academic material metacognitively to translate the concepts into their own language (i.e., own thinking). The post-assessment theme, “Writing Own Meaning (Words) in Notes” emerged in response to questions two, three, six, seven and eight, with most responses being coded in the AoC and S&S sections of the post-assessment. Prominent quotes for this theme are listed in Table 126.

Table 126

Prominent Quotes from Post-assessment Theme – "Writing Own Meaning (Words) in Notes"

Class Participants	Prominent Quotes
Abby	I'd basically just write who's speaking, who they were so that I could remember to put myself back into that place that I was in, and then write down my main takeaways and key concepts that I felt that were important, stuff like that.
Ashley	Sometimes I would annotate when I actually understand a part of it so that when I go back for a more thorough read, I will have that note and be like, "Okay, I don't need to go back and read that section because I already have this understanding of it."
Coreen	Chris: I know you said you write a lot of bullet points now, and is that kind of that thinking, that metacognition thinking that you were talking about, is that reflected in those bullet points? Coreen: I would say yes, but more in the process of writing down the bullet points, because when I do have a gap where I miss something, or if I need more clarification, then it's not going to be written yet, and then after I ask the question then I'll go back and add it in.
Dalisay	Yeah. So**,** like these, these are all on my own voices, but the ones I put in quotation marks are the ones that were straight from -- I don't know, I have this feeling of plagiarizing, I don't want to plagiarize, so I put quotation marks over the ones that I wrote word for word, and these are just all in my own words. Chris: Okay, so everything, basically, below the orange table is your own words? Dalisay: Yes, it's all my own words. Chris: Okay. Great. Does that help you? Dalisay: Oh, yes. Definitely. Because it makes me feel like I actually understood what they were saying.
Lilly	Sometimes I just try to change words or just try to rephrase something, or just jumble the words into a term that makes sense. Sometimes it's proper grammar on the board but sometimes the proper grammar doesn't always

	stick. Just rewording it in a way that makes sense and just that my brain can process I'll either write it down or-- Chris: When you reword it, it's normally you're writing it down in your own language, or is there something else too? Lilly: No, I definitely write it down in my own language. But definitely, I try to think it through a little bit first before I put it down on paper.

As illustrated in Table 126, participants often discussed capturing academic ideas in their notes in a way that made sense to them while in class. They then wrote (or typed) the ideas in their own words. For instance, when the researcher and Lilly reviewed her notes in the post-assessment, she stated that she worded ideas in her biology notes "in a way that makes sense" and often added notes in specific areas of the page which helped her *reflect* on academic concepts later. Ashley mentioned annotating ideas while reading. When the researcher asked Ashley what annotation helps with, she stated, "The annotation part makes it easier for me to remember what I just read because sometimes I'll be reading to read, not reading to understand. So, it definitely helps me be more aware of what I need to focus on." Focal participants reports that using their own words was helpful to their thinking/learning is discussed next.

Using My Own Words (Language) Helps Thought Processes. Four focal participants in the post-assessment described how using their own words, as a strategy for learning, helped their thought and/or learning processes. The post-assessment theme, "Using My Own Words Helps Thought Processes" emerged in response to questions one, two, seven, and eight, with most responses being coded in the S&S section of the post-assessment. Prominent quotes for this theme are listed in Table 127.

Table 127

Prominent Quotes from Post-assessment Theme – "Using My Own Words (Language) Helps Thought Processes"

Class Participants	Prominent Quotes
Coreen	It's something I've always tried to do, but this class has helped me stress importance on realizing. It's helped me stress on the realization of how important that actually is, because that's the part that you actually learn from. Not just getting that text in your head, but the understanding of it, that's the actual part where you learn, and that is what I learned from (the ASC). Definitely one of the most important things I've learned
Daniel	I felt like the information you brought to the table really helped me think like, "Oh, that's how my brain is going to start moving about these things." When you said that the brain learns something better and can verify its own understanding of something when you're repeating it to somebody else - that wasn't something I really attempted before, and as I started doing it, I was thinking, "Wow, this is crazy, this works."
Dalisay	Yes. It tends to click way better than trying to understand what our professor is saying because it's his own thinking. This is my thinking. And then when I go back to it, it helps explain why I wrote it that way - because I knew what I wrote - so it made me click into more information that's easier for me to understand.

As illustrated in Table 127, focal participants found that using their own words to think about academic concepts was useful to their thinking and learning. Coreen and Daniel discussed this strategy in the context of what they learned in the ASC. Additionally, Dalisay stated previously (in the pre-assessment and class activities) that she took notes in her own words because of what she learned in the ASC. In the post-assessment, Dalisay stated that she recently started writing ideas in her own words, "and it has helped a lot, so I'm going to keep doing it." Coreen, Dalisay, and Abby all reported writing down ideas in their own words while Daniel used his own words for communicating with others. Focal participants reports of discussing ideas with their peers is discussed next.

Discussing New Ideas with Peers. Four focal participants in the post-assessment reported how explaining, teaching, and/or discussing new ideas in groups supported their thinking and/or learning. The researcher, as guest instructor in the ASC, explained how using language to communicate ideas with peers and/or teachers can be an effective strategy to develop (i.e., scaffold) thinking and learning. The post-assessment theme, “Discussing New Ideas with Peers” emerged in response to questions one, three, four, five, eight, nine and ten with most responses being coded in the PK section of the post-assessment. Prominent quotes for this theme are listed in Table 128.

Table 128

Prominent Quotes from Post-assessment Theme – “Discussing New Ideas with Peers”

Class Participants	Prominent Quotes
Abby	We also do our retake. We retake our tests as a group, a group correction test, I guess. It's a lot of collaborating with each other I'd say which help a lot.
Ashley	I want to say in chemistry class, recently, we went over a new chapter, and it was kind of confusing in some parts because I didn't learn about that stuff in high school...and so my friends and I, we just grouped up and tried to go over what we knew. Then from there, we would try to teach each other the information so that we would understand it better.
Dalisay	...I would try my best to take notes first, and then after I get together with my friends, and we discuss it. So, like expressing to them what I learned and based off their ideas, it makes me understand things more clearly.

Dalisay	Chris: Okay. And then, just for in-class strategies, is there anything else that you would like to share about what helps you learn? Dalisay: Talking with my peers, definitely, like exchanging ideas. Chris: In class? Dalisay: Yes, in class. In class. Yes, because when we have those group discussions with our learning communities, it helps me express my thinking more. Chris: Does that help you in any way? Dalisay: Yes. It helps give me more clarity on what I'm trying to learn...
Lilly	So, I happen to have one of my friends, I sit next to one of my friends, he always asks me like, "What is this? What is this?" And so, I always end up explaining things to him. When I do that, it definitely makes more sense to me...it just helps solidify what I think about.
Lilly	Putting things into my own language was something I never had done often. But now that I do it, like I said at the beginning, my studying time has definitely gone down a lot. I'm able to explain things in a way that makes sense to others and myself.

As illustrated in Table 128, participants primarily discussed how collaborating, teaching, and/or discussing ideas with their peers supported their thinking and/or learning. “Discussing New Ideas with Peers” is a post-assessment theme provisionally coded as “MR,” “ML,” and “MetStrat” for Ashley, Dalisay, and Lilly. This theme indicates that at least four focal participants utilized discussion or dialogue with others as a way (or strategy) to support their thinking and learning. Reports of using internal dialogue to support thinking and/or learning is discussed next.

Using Internal Dialogue to Support Thinking/Learning. Three focal participants indicated they used their language internally (i.e., mentally) to develop their understanding, thinking, and/or to provide clarity in areas of confusion. The researcher, as guest instructor in the ASC, explained how using language internally to reflect on ideas can be an effective strategy to develop (i.e., scaffold) thinking and learning. The post-assessment theme, "Using Internal Dialogue to Support Thinking/Learning" emerged in response to questions two, three, five, six, seven, and ten with all three participants being coded in the AoC section of the post-assessment. Prominent quotes for this theme are listed in Table 129.

Table 129

Prominent Quotes from Post-assessment Theme – "Using Internal Dialogue to Support Thinking/Learning"

Class Participants	Prominent Quotes
Abby	If I don't understand it, I'll usually try to use the synonyms of the words I don't understand. I'll try paraphrasing it into words that I'm more familiar with rather than trying to learn a new word over and over again that's not sticking out, rather just replace certain words with more common words that I do understand. That way, my thought process can flow easier. Chris: Do you do that on paper, or do you do that mentally or in another way? Abby: I feel like it depends on how long the passage is, and how important it is. If I'm doing it just to understand, or I'm reading a textbook just to retain the information, I'll probably do it mentally.
Coreen	I'll move it into my own language. Oftentimes, it's so annoying. It'll be like two pages long and then when I put it into language that makes sense to me, it's three sentences, because that's what happens in history textbooks.
Lilly	When I think through ideas, I definitely think that I try to reword it in a way that makes sense. Sometimes the way things are written, or the way things are explained, they make sense but then when I actually think about it looking back, it just doesn't make the same amount of sense like that. So, just trying to reword it and trying to think about it in a way that makes sense to me, that's my thought process.

Lilly	For example, tyrosine and kinase, so I wasn't sure about that. I asked my professor, she explained it and as I walked out, I was like, okay. The two ligands bind to the two separate tyrosine kinases, which causes them to bind together and that's what phosphorylates it. So, being able to just see that and the way she explained it to me, it was just me trying to figure out, "Okay, how does this come together?

As illustrated in Table 129, focal participants explained ways in which they utilized their language (mentally) to support thinking, e.g., "rewording," "paraphrasing," and "moving it (ideas) into my own language." This theme indicates that participants used their natural language (to a degree) to strategically to support their conceptual understanding and learning. For instance, when The researcher asked Lilly, what occurred inside her mind when something she was reading or watching made perfect sense, she stated, "I know when something makes perfect sense to me when I'm able to break it down and explain it from beginning to end." She then explained a process in Biology for how glucose goes into the body and stated the ability to explain the process to herself is how she "knew it made perfect sense." "Using Internal Dialogue to Support Thinking/Learning" is a post-assessment theme provisionally coded as "MR" and "MetStrat" for all three participants. Additionally, this theme was provisionally coded as meta-learning, "ML" for Coreen and Lilly. Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 4 – "Using My Own Words to Create Understanding." The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants' statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

"Using My Own Words to Create Understanding" is a change theme that relates to developing regulation for using language internally (e.g., mental dialogue) and externally (e.g., discussing ideas with peers) to clear up areas of confusion and/or develop understanding. Table 130 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 130

Conversations in Second Member Check Relevant to Change Theme – "Using My Own Words to Create Understanding"

Focal Participant Name	Chris (Questions/Interpretations)	Focal Participant Answering
Ashley	When do you prefer to write down what the teacher is saying versus using your own words? Or vice versa – using your own words instead of what the teacher is saying or presenting?	If they are saying a really long sentence, then I would choose to use the key points of what they are saying. And if it's something that I can't quickly summarize - as in a key point - then I would stick to what they are saying, as in copying what they are saying.
Coreen	You ask yourself questions about whether you understand the subject matter inside and outside of class. You did this before college, and you continue to engage in this strategy.	"This started in college." I did not engage in this is high school. "I didn't know to engage in this in high school."

Daniel	Did you practice this strategy (discussing ideas with peers) regularly last semester? If so, can you give an example?	Absolutely. Macroeconomics - every week we had a quiz, and I would put together a study guide and discuss it with my classmates to make sure that we all understood the ideas being discussed, and that helped my verification of my understanding.
Dalisay	Discussing ideas with your friends helps you feel comfortable in your own thinking and helps you to see how others think about ideas, so you can gain a more complete understanding.	Yes. Every time I work with other people I always say, “two brains (are) better than one.”
Dalisay	You take notes in your own voice (i.e., language) which helps you to engage in your own thinking while learning.	“I do that more often now.”
Lilly	When learning something new, the ideas make sense to you when you can see how all the pieces fit together and explain the ideas in your own language from beginning to end.	Yes, that is accurate. I like to think of it like a puzzle - my language as a puzzle and I’m just putting the pieces together (pieces are words).
Lilly	When you explain concepts to your classmate in your biology class you are aware that it helps solidify your own understanding.	Yes, that’s accurate. I would come up with analogies related to the ideas we’re learning. Using analogies that are uncommonly related to the ideas we’re learning helps to make the material understandable.

Sections from the case summaries in Table 130 provided verification and in some cases depth to participants’ responses in the post-assessment. The majority of focal participants reported using their own words (or language) more than they did at the start of the semester to better think about and understand academic concepts. In the post-assessment, participants engaged in using language by, 1) writing meaning in their own words, 2) discussing ideas with peers, and 3) using internal (or mental) dialogue when engaging with academic ideas. In the member check, focal participants verified they used language in these ways. Furthermore, four participants (Coreen, Daniel, Dalisay, and Lilly) verified they used their language (externally and/or internally) more at the end of the semester than the beginning because of what they learned in the ASC. The same focal participants verified that using their language helped them develop and/or verify their understanding of academic ideas.

In the class activities, more than half of class participants reported applying and/or integrating the language strategy, “Taking Notes in My Own Words.” Additionally, the meta-learning themes, “Language Supports Thinking/Understanding” and “Notes in My Own Words Supports Learning,” emerged in response to class participants responses in the class activities. Provisional coding and longitudinal analysis indicate that focal and class participants learned about using language and began to apply/integrate language strategies to verify, clarify, and develop their understanding. As they did, focal participants recorded more responses provisionally coded as “MR,” particularly in the post-assessment. For instance, three of six focal participants were coded for the theme “Using Dialogue to Support Thinking/Learning,” in the pre-assessment, which represented use of inner (mental) or vocal dialogue to support their thinking/learning. This pre-assessment theme was provisionally coded as “MR” for two of the three participants. In the post-assessment, this behavior (i.e., use of dialogue) became two themes, “Discussing New Ideas with Peers” and “Using Internal Dialogue to Support Thinking/Learning,” because the behavior was reported more often and in more detail among focal participants. Five focal participants were coded for a response between these two themes, and all participants responses were provisionally coded as “MR.” The focal participant who was not coded, Daniel, made clear that he used his language more often in the post-assessment, and engaged in “Discussing New Ideas with Peers” in the member check. Thus, all six focal participants reported using a strategy related to language, in the post-assessment and second member check, compared to four participants in the pre-assessment and first member check.

Additionally, Coreen and Dalisay reported in the pre-assessment that they had begun to take notes using their own words because of what they learned in the ASC. In the post-assessment, Coreen and Dalisay reported that they continued to take notes in their own words, and that it was helpful to their understanding. Additionally, Lilly and Ashley reported behaviors (e.g., annotating) indicating they also took some notes in their own words. Thus, at least four participants reported a new strategy related to writing meaning in their own words, since the beginning of the semester.

Template analysis and provisional coding reveal that focal participants reported behaviors indicating they regulated their use of language more during their first semester in college. However, it's unclear if focal participants recurringly engaged in this behavior and to what degree they controlled this strategy. While focal participants utilized their language, particularly among peers more than any strategy reported in the pre-assessment, learning about how language can be used as a 'tool' or strategy for learning, helped some participants use language more strategically for their learning during their first semester in college.

In summation, focal participants use of language (i.e., own words) expanded in both breadth and depth for the group as a whole. More focal participants, by the post-assessment, engaged in more language strategies, which in many cases helped develop understanding of academic material. Post-assessment responses provisionally coded as "MR" for use of internal dialogue (e.g., explanations) often overlapped with participants reflective thinking. Other post-assessment themes, not mentioned in this section, that overlap with the change theme are "Writing Formula Logic on Paper to Support Thinking," "Asking Self Questions About Understanding in Learning Scenarios," and "Reflective Thinking for Learning." Other class-activities themes, not mentioned in this section, that overlap with the change theme are "Metacognitively Reflecting on New Ideas."

Change Theme 5 – Developing Visual Systems to Support Understanding

"Developing Visual Systems to Support Understanding" is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants' statements of formatting their notes by color-coding, bullet pointing, and arranging ideas, as well as representing ideas by drawing, writing key ideas to learn later, and writing ideas in their own words. "Systems" references the strategic ways participants captured and organized ideas on paper/screens. "Formatting" in this sense references a meaningful way to organize/arrange ideas. The change theme, "Developing Visual Systems to Support Understanding" incorporates the themes provisionally coded as "MK" and "MR," for representing ideas and formatting notes (in visual ways) in the pre- and post-assessments as well as the cumulative theme, "Drawing as an Adapted Strategy for Learning," and the meta-learning themes, "Drawing Supports My Learning" and "Diverse Learnings from Drawing" in the class activities. Focal and class participants were not taught in the ASC how to format their notes but were taught how to draw concepts to learn conceptually (e.g., flowcharting).

The researcher incorporated themes for *representing ideas/thoughts in notes* and *formatting notes in meaningful ways* over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. The majority of focal participants by the second member check reported and/or indicated they developed unique "systems" over the course of the semester to represent/format academic ideas, which supported their recognition (e.g., identification, separation, organization, and/or connection) of ideas and understanding. Focal participants developed the system (or systems) primarily in response to lecture-based notes/slides. Although, focal participants engaged in various strategies, the common theme among participants is they *developed unique systems allowing them to 'see' (or understand) the ideas on the page (or screen)*. Although, five focal participants formatted their notes in the pre-assessment, at least four of those focal participants made adaptations to their formats over the course of the semester, and one focal participant, Coreen, who hadn't previously reported *formatting notes in way she could understand* reported doing so in the post-assessment. The researcher deduced from template analysis, longitudinal analysis, and case summaries that all focal participants gained personal knowledge for visually representing and/or formatting academic ideas to best support their understanding over the course of the ASC. This "change" is supported by the emergence and accumulation of themes reported in Table 131.

Table 131

Emergent and Cumulative Change for "Developing Visual Systems to Support Understanding" Based on Themes Over the Course of the ASC

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Themes
1) Breaking Down Ideas on Paper to Understand 2) Creating (Meaningful) Visual Formats for Learning 3) Visual Shapes Support Understanding	Applied/Integrated Strategies "Drawing as an Adapted Strategy for Learning" [In total 16/23 students applied and/or integrated drawing as a strategy for their learning between the LSA and JE6. 8/23 students both applied and integrated drawing as a strategy (in the LSA and JE6).] Primary Meta-Learning Themes "Drawing Supports My Learning" [10/23 Ps. mentioned that drawing supported their learning/understanding. "Diverse Learnings from Drawing" - [9/23 participants had unique/diverse learnings from drawings as well,	1) Developing (Meaningful) System for Notes to Support Thinking 2) Structures Notes as a Visual (Semantic based) System to Understand Ideas 3) Writing Down Key Ideas to Learn Later 4) Drawing to Represent Ideas Visually 5) Drawing Icons and Diagrams in Notes 6) Visual Elements in Notes are Helpful to Learning	Developing Visual Systems to Support Understanding

captured in the themes “Various Learnings from Applying Drawing” in the LSA and “Various Learnings from Drawing” in JE6.]	7)	Writing Formula Logic on Paper to Support Thinking

As illustrated in Table 131, post-assessment themes represent an ‘endpoint’ in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, “Developing Visual Systems to Support Understanding” revealed that focal participants’ (with validation from class participants responses), developed personal knowledge for capturing ideas visually, particularly strategies to better represent academic ideas to support understanding, e.g., “Drawing as an Adapted Strategy for Learning” in class activities and “Drawing to Represent Ideas Visually,” among other strategies in the post-assessment.

As a change theme, “Developing Visual Systems to Support Understanding” brings together post-assessment themes provisionally coded as, metacognitive knowledge, “MK,” metacognitive regulation, “MR,” and metacognitive strategies, “MetStrat,” which indicates focal participants learned about and engaged in more behaviors/strategies for capturing their notes in ways that supported their ability to mentally ‘see’ and/or understand academic ideas during their first semester in college. In the post-assessment, focal participants reported more 1) drawings (e.g., “Drawing Icons and Diagrams in Notes”), and 2) formatting with bullet points and color-coding (e.g., “Structures Notes as a Visual System to Understand Ideas”). All focal participants changed how they represented academic ideas and at least five focal participants, (Abby, Coreen, Dalisay, Daniel, and Lilly) changed how they formatted their notes. The post-assessment themes which comprise the change theme in Table 131 are discussed next.

Developing (Meaningful) System for Notes to Support Thinking. Four focal participants indicated developing a unique system for lecture-based note-taking that supported their ability to recognize and understand ideas recorded in their notes. This system varied for each participant but involved, developing diagrams, color-coding, bullet pointing, and/or writing down key ideas. Participants engaged in these strategies within and outside of class, for lecture-based notes and/or slides. The common theme is that focal participants developed the format themselves, which supported their recognition (e.g., identification, separation, organization, and/or connection) of ideas as well as their ability to study/understand their notes outside of class. The post-assessment theme, "Developing System for Notes to Support Thinking" emerged in response to questions three, four, eight, and nine with all four participants being coded at Q8 in the S&S section of the post-assessment. Prominent quotes for this theme are listed in Table 132.

Table 132

Prominent Quotes from Post-assessment Theme – "Developing (Meaningful) System for Notes to Support Thinking"

Class Participants	Prominent Quotes
Coreen	I've probably changed how those bullet points are at least three times. Because we start out with okay, we have three things, nun, wife, spinster, easy, so that's three bullet points. But then I realize we're going talking about each of them separately, so I add in another bullet point, tabbed in underneath each one. But then we don't talk about spinsters so, I get rid of that bullet point. Or underneath these bullet points, there's a lot more meanings in this, so I need to structure this more, so they don't all meld together. **Chris:** Okay. So, as your understanding changes, as your thinking changes, the structure changes, of your notes? **Coreen:** Yes.

Coreen	**Chris:** Okay, so, it looks like this is a hierarchical breaking down of your thought process? **Coreen:** Yes. **Chris:** And how you're categorizing and connecting different ideas. **Coreen:** Yes. This is still the beginning. I started it here with the extra bullet point stuff. For a while I tried to section out things, but then this got confusing with all these (uniform bullet points). So, this is where it really started, I was like, "Okay, let's have a hierarchy."
Dalisay	And like on the top here, it's like a little family tree that I tried to connect while my professor is speaking. (cont'd) This one is specifically about Genesis 12-50, and there's significant stories, multiple stories. And so, I try to break them up based on the main characters, so Abraham, Isaac and Jacob, and then Jacob's sons.
Dalisay	And that way I format it in my notes has helped me better understand it.
Lilly	I always try to color code it because if it's in black and white, it's just like looking at texts, it just becomes one.
Lilly	...the black ink is usually just the regular part, but anything, where an entire phrase is written in colored ink, is usually notes that my professor makes...
Lilly	... just being able to like color code that it's like, okay, inside the endoplasmic reticulum, there's a high concentration of, I'm thinking this, calcium ions and then on the outside, it's a lower concentration. So, being able to color that in sometimes, that's something that's very helpful and a lot of science diagrams are very colorful. For me, that's very easy and I like that.

In the S&S Section of the post-assessment, particularly question eight, most focal participants brought their notes (or a form of notes) to the interview to show the researcher how they had developed their notes. Artifacts of participants notes will be shown later in this section. Quotes in Table 132 represent participants explanations of how they've changed their notes to support understanding. For instance, Coreen stated in the post-assessment, “Yes, so I brought notes. And I just really like how this shows how I have changed my notetaking.” Coreen changed how she bullet pointed and indented paragraphs of text which helped her represent the separation and connection between specific ideas or thought processes. Coreen added “I've probably changed how those bullet points are at least three times.” Additionally, Lilly, had a system in place during the pre-assessment but continued to develop/adapt a color-coding system, among other strategies, to support her understanding. The post-assessment theme, “Developing (Meaningful) System for Notes to Support Thinking” indicates that participants were developing visual systems (in a corrective fashion) to represent and organize lecture-based (auditory) ideas to support processing (i.e., recognition) and/or understanding. This theme was provisionally coded as “MR.” Focal participants reports of why formatting notes supported understanding is discussed next. Sub-themes that make up participants’ ‘visual systems’ are discussed in subsequent sections.

Structures Notes as a Visual (Semantic based) System to Understand Ideas. Four focal participants indicated that they visually structured/formatted their notes because it allowed them to mentally ‘see’ or understand the ideas they were capturing on paper or on screen. In other words, focal participants developed a system of organizing and connecting ideas in their notes (to create visual context), which supported their understanding and/or memorization of ideas. This theme was provisionally coded as “MK” for all four participants and “ML” for three participants (Coreen, Abby, and Ashley). The post-assessment theme, “Structures Notes as a Visual System to Understand Ideas” emerged in response to two, three, four, six, seven, and eight with three participants being coded at Q8 in the S&S section and three participants being coded in the PK section of the post-assessment. Prominent quotes for this theme are listed in Table 133.

Table 133

Prominent Quotes from Post-assessment Theme – "Structures Notes as a Visual (Semantic based) System to Understand Ideas"

Class Participants	Prominent Quotes
Abby	I feel like I've been doing this more like I've learned to organize my notes this way because it just helps me understand better. I don't think I would have done a timeline or these little diagrams right there. I probably only did them because it was what was written on the board or what she asked us to do. But I do feel like they helped in certain contexts more than others.
Abby	It just helps to create a timeline so that you could picture the greater events that were happening, something to put into consideration when you're talking about the characters and what they've done during those times, for a sense of relation, I guess, connecting those certain concepts, having certain events be close to other certain events, and stuff like that, yeah.
Coreen	This bullet point stuff was I had thought about it because of the visualization and the drawing class because it was like, "You know there's probably a reason I don't understand all (this) uniform stuff. If go out and I structure this like an artwork, it will make more sense.
Coreen	It took a long time for me to understand how to do it, because you need to know what's important, and you need to know the subcategories. So, you definitely have to be really attentive in class to understand where these things should go.
Coreen	And I think I also use it in my notes just with bullet points because I didn't use really bullet points before (the ASC). So, I learned about how to structure them better, so with like main ideas... Like, this is related to this, and that is overall in this big topic, like, women, nuns, what the nuns did, for example.
Dalisay	Chris: Okay. And then what's underneath? Dalisay: It's just under what they've contributed in the story. Chris: Oh, okay. Dalisay: Yes. So, like what their roles were. Chris: Okay. Then, the top, you said it's a family tree. It's basically just connecting everybody. Dalisay: How it connects everyone, yes.

Dalisay	So, I guess that ties into using diagrams, drawing pictures, drawing tables and -- it's kind of like mind mapping, like the steps - like I need to see it, not just write words. I have to go step by step, like use arrows to like “Okay, this goes there and then” -- yeah.

In Table 133, focal participants discussed why elements in their notes supported their understanding. For instance, Abby mentioned that creating a timeline in her notes helped her “picture” the events that occurred in a book she was reading for class. Additionally, Coreen developed a bullet pointed system which she realized would help her mentally see or visualize ideas she was learning. Lastly, Dalisay mentioned that she developed diagrams and other visuals representations in her notes to be able to “see” and make connections between ideas.

Although strategies vary, the common ‘through line’, is that participants represented ideas strategically in their notes and arranged those ideas (e.g., words and diagrams) into formats, allowing them to mentally ‘see’ or understand the ideas. It's possible this theme is an indication that students need space and semantic-based visual organization (that they create) to help them better identify, connect, and separate ideas to develop understanding. For instance, Abby stated, “I'd rather have things connect to some things with arrows, that way I could see it connect, rather than if I didn't have arrows or certain bullet points, then it would just be like words without any organization or context...”. Correspondingly, Coreen stated that the way she structured her notes, helped her break down ideas and study them later, “...it makes it so when I go back and study, I understand.” Reports of color-coding as a source of formatting is discussed next.

Color-coding Notes to Separate Ideas. Two focal participants reported color-coding their lecture-based notes which helped them separate and group ideas on the page. For instance, Lilly used colored pens to distinguish between specific concepts the teacher presented, which helped her mentally separate and organize ideas to find the big idea, i.e., develop meaning for the lesson as a whole. “And as we said, finding the big idea is the way I am able to understand it...”. Correspondingly, Ashley used color-coding in her notes “to separate things...”. Abby and Dalisay also discussed and/or showed in artifacts, that they color-coded notes, but did not mention that they used it to separate ideas. Reports of writing down key ideas (in notes) is discussed next.

Writing Down Key Ideas to Learn Later. Three focal participants reported they wrote down important ideas in their notes which helped them reflect and/or learn more when reviewing their notes. As a post-assessment theme, “Writing Down Key Ideas to Learn Later,” indicates that students engaged with the ideas they did and did not understand and wrote down words that supported their understanding. This sometimes occurred in specific places of their notes to help them identify their ideas/thoughts. The post-assessment theme, “Writing Down Key Ideas to Learn Later” emerged in response to questions six, seven, and eight with all three participants being coded at Q8 in the S&S section of the post-assessment. Prominent quotes for this theme are listed in Table 134.

Table 134

Prominent Quotes from Post-assessment Theme – “Writing Down Key Ideas to Learn Later”

Class Participants	Prominent Quotes
Abby	If I wouldn't understand and if I don't feel comfortable asking questions, I'll usually write down certain keywords that I hear or certain concepts so that I can go back to it later and relearn it myself or see what they're trying to talk about. I’ll go back to my notes, stuff like that.

Abby	I write certain keywords that I could remember, list important things, things I think that are important or things that would resonate with me.
Dalisay	Yes, it's like another set of eyes or brain. Like a little storage. Like another storage of my mind in there. And like it's easier to look back at it when you can just easily forget whenever you take mental notes."
Dalisay	If it seems important, and I don't understand it, I write it down to try to clarify afterwards.
Lilly	When I go back, sometimes I'll even write notes at the bottom like, "I wrote this down because," and then reflecting on that.
Lilly	We did a clicker question, and in adults, mitosis is not something that's always happening. In babies and during fetal development, that's the thing that's always happening. So, I made that note because I got the clicker question wrong.
Lilly	Chris: These are your notes on the side. These side notes aren't your teacher's? Lilly: No, it's just more something if I go back, I'm like, "What's a gamete?" Chris: Oh, got you. So, when you go back, is when you do the margin notes? Lilly: Yes, and usually it's like, words I do myself, or like for this one I did glute four. I didn't know what it was. So, just understanding specific terms and just writing it in a very swift manner in a way that makes sense.

In the S&S Section of the post-assessment, particularly question eight, most focal participants brought their notes (or a form of notes) to the interview to show the researcher how they had developed their notes. In Table 134, focal participants explained, while showing the researcher their notes, that they had written important ideas (in words) to support their thinking/learning about the ideas, particularly when revisiting notes. In some cases, participants wrote down key ideas to keep pace with the current learning activity. The post-assessment theme, “Writing Down Key Ideas to Learn Later” was provisionally coded as “MR” and “MetStrat.” Reports of drawing academic ideas is discussed next.

Drawing to Represent Ideas Visually. Five focal participants reported engaging in forms of drawing to represent academic ideas, which often facilitated understanding. This strategy emerged over the course of the ASC for four focal participants and was an ongoing strategy for Lilly although she confirmed she engaged in drawing more at the end of the semester than she did at the start of the semester. Most of the assigned meaning for this theme is structured under the sub-theme, "Drawing Diagrams and Icons to Represent Ideas Visually," but there are statements about flowcharting, drawing thought bubbles, and drawing a French map, incorporated into this theme as well. The post-assessment theme, “Drawing to Represent Ideas Visually” emerged in response to questions one, two, three, four, eight, nine, and ten with all five participants being coded at Q8 in the S&S section of the post-assessment. Three focal participants were also coded in the PK section of the post-assessment. Prominent quotes for this theme are listed in Table 135.

Table 135

Prominent Quotes from Post-assessment Theme – “Drawing to Represent Ideas Visually”

Class Participants	Prominent Quotes
Abby	We've learned about visual maps and creating those flow charts. Before, I didn't really think I needed it specifically, but I've definitely adapted to it when it comes to certain subjects that it's helpful in.
Ashley	So, these are psych notes that I just type out. They're well organized...but I feel like I don't know as much unless I draw diagrams...
Ashley	Chris: The teacher's providing you a template, it looks like, where you can fill it in with your own notes in your own and then you're drawing your own

	pictures. That's not something that is necessary, that's what you're doing? Ashley: Yes.
Daniel	...I drew the shape and then I placed out every single location. And I repeated that until it was in my memory, to the point where -- I don't want to sound cocky and say I could do it again, from memory, because it's been about a month and a half. But I think if I repeated that process, I would be able to have that map down for you in like an hour or two.
Daniel	I’ve started using small pictures now because I still find I don't have a full-time to really draw out my understanding but for the concepts I feel like are small enough to be put in a picture I can just do that.
Lilly	So, the little icons are just like a very, not in-depth version of a chromosome and just understanding that shape because I also make that association with the chromosome in that x-shape. Because when I think about that, I always think about the X shape and just being able -- even now looking back, I'm like, okay that's an unreplicated chromosome and that's why I labeled those here in case I ever forget. Chris: And that helps you remember? Lilly: Yes.

In Table 135, focal participants reported developing ‘drawings’ (including diagrams) to help represent academic ideas they were learning about. These reports often came in the context of showing the researcher their notes. Two focal participants, Lilly and Ashley reported that they drew more to better process the ideas they were learning. Participants ‘drawings’ did not mirror what was discussed in the ASC, but rather were visual representations of ideas based on what participants thought would be helpful for their learning and/or academic performance. For example, Daniel stated that when he was being directed how to draw in the ASC, the activity wasn’t helpful for him, but when he drew on his own, he realized helpful drawing could be - “when I got to apply it, and the way that I would want to apply it, directly myself, instead of being directed, I got to put in the inputs that I wanted to receive the output I wanted." The "output," being a perfect score on his French map quiz.

Additionally, two focal participants, Abby and Ashley, indicated they learned about flowcharting in the ASC. Abby specifically reported applying flowcharting in her notes. For example, Abby stated in the member check, "I definitely adapted the flowcharts from class. I did modify it to my liking. But generally, it's the same type of approach." No participants engaged in flowcharting (conceptual drawing) the way it was discussed in the ASC. The post-assessment theme, "Drawing to Represent Ideas Visually" was provisionally coded as "MR" and "ML" for Dalisay, Lilly, and Daniel. For Abby and Ashley, the strategy was provisionally coded as "CK," and was something they learned in the context of the ASC. Sub-themes that make up "Drawing to Represent Ideas Visually" are discussed in subsequent sections.

Drawing Icons and Diagrams in Notes. Four focal participants reported drawing icons (small pictures), diagrams, and/or arrows to represent and/or connect ideas in their lecture-based notes. Sometimes the visual representations that participants created consisted of tables with words to give context to academic ideas. For instance, Dalisay modified her Cornell notes to include tables, diagrams, and arrows, which she reported helped her connect ideas. The post-assessment theme "Drawing Icons and Diagrams in Notes" represents the primary way that participants captured drawings in their notes. For example, Lilly drew icons for lecture-based notes, even complex structures like DNA strands. She stated that she did most of her drawings for Biology because the class was lecture-based, and a lot of information was "taught at you." She specifically referenced a drawing of a ligand in her notes, "Like I didn't know what a ligand was before starting, so being able to put a picture to that and it's like, 'Oh, that's what that looks like.'" Provisional coding reveals Ashley, Lilly and Dalisay showed metacognitive regulation, "MR" for "Drawing Icons and Diagrams in Notes." Prominent quotes for this theme are listed in Table 135.

Visual Elements in Notes are Helpful to Learning. Three focal participants reported or indicated that specific visual elements (e.g., diagrams, timelines, formulas) in their notes were helpful to their learning. For instance, Ashley stated, "But I feel like her actually writing it down and having little pictures has helped…". The post-assessment theme was provisionally coded as "CK." Other quotes are previously captured or have limited assigned meaning. Reports of writing logic on paper for mathematical formulas is discussed next.

Writing Formula Logic on Paper to Support Thinking. Two focal participants, Daniel and Dalisay reported writing logic on paper for mathematical formulas in study-based scenarios to see and/or make sense of the equations they were learning about. This strategy was conducted in a structural way to support participants ability to think through formulas (or concepts) and study the formulas for test-taking purposes (i.e., understanding and/or memorization). The post-assessment theme, "Writing Formula Login on Paper to Support Thinking" indicates that Dalisay and Daniel used written logic and formatted the written words/numbers to support understanding of the subject matter. For example, Dalisay developed a template for various formulas for finite math as a study guide.

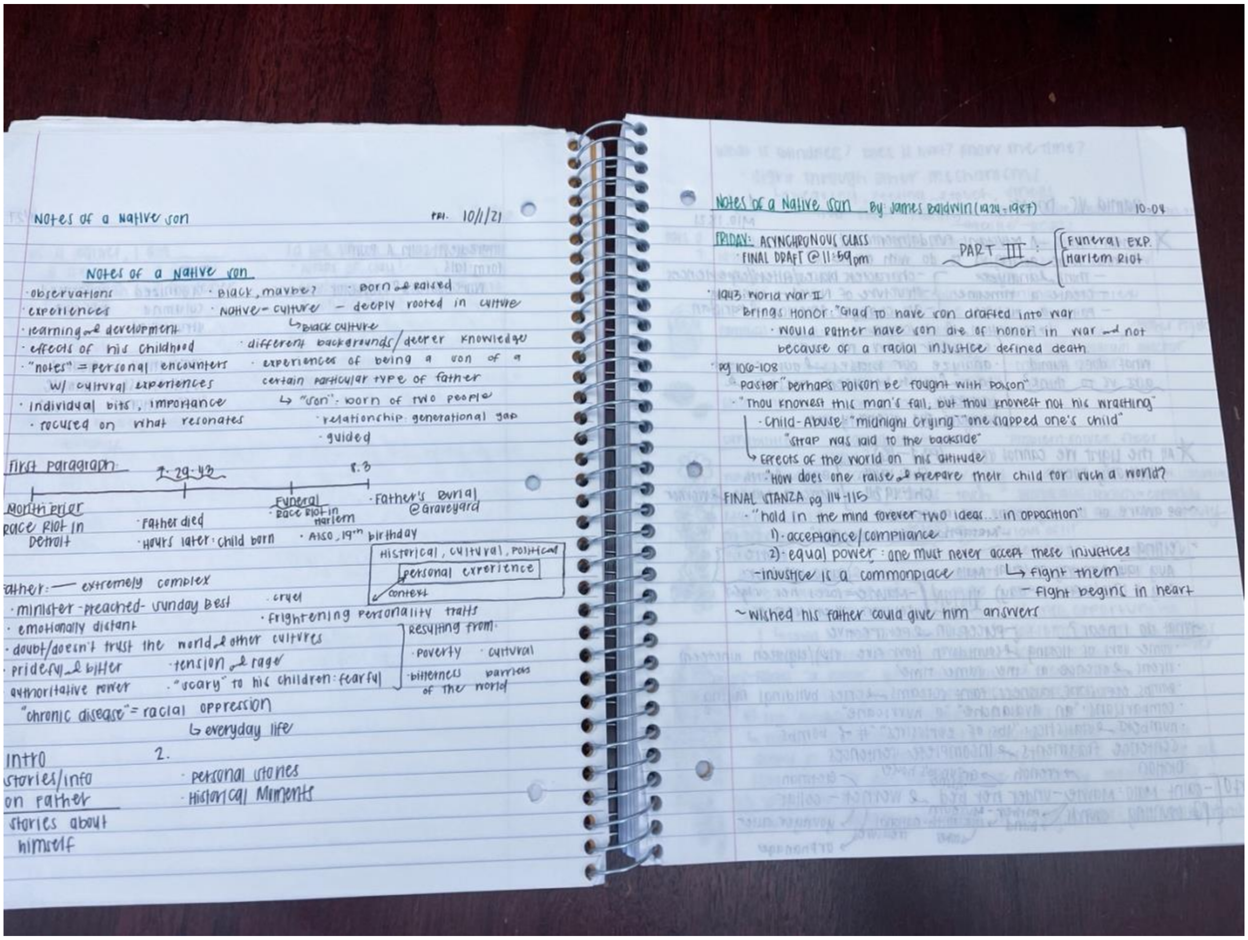
> So, this is my note sheet for finite math on chapter two. So, it's like all of this is all word problems and how I can implement the formulas with it and solving it, and so like that way I know how if I were to have this certain type of problem on a test, I know how to do it because I can see the format of the word problem and the type of formula, I can use to solve it and stuff.

Dalisay also color-coded part of the formulas and formatted the templates, so she knew that specific parts of the template indicated when to use specific formulas and how to solve specific formulas. Artifacts that show participants note-taking strategies are discussed next.

Artifacts related to Change Theme 5 - "Developing Visual Systems to Support Understanding." The researcher asked participants, if they'd like, to bring any strategies they were applying to the post-assessment interview, to show for the study. Five participants brought artifacts and all artifacts shown relate to ways that participants formatted and captured ideas in their notes. Some artifacts are not shown for brevity. The following artifacts support the change theme, "Developing Visual Systems to Support Understanding," and the post-assessment themes previously discussed in this section. Quotes from the post-assessment and member check interviews are utilized to support the researchers' explanations. All paraphrased statements were confirmed with focal participants as being accurate during the member check. Abby's artifact is shown in Figure 1**6**, and subsequently discussed.

Figure 16

Abby's English Notes Given to the Researcher During the Post-assessment Interview



Abby's English notes in Figure 16 were taken to learn concepts from the book, "Notes of a Native Son." Abby showed the researcher how she formatted her notes and the visual elements she included to support her thinking. The notes contained, 1) a timeline of events, 2) arrows pointing to specific ideas, 3) main ideas broken down into smaller ideas, and 4) clear formatting to help segment different sections. Abby reported in the post-assessment that the way she organized her notes, helped her organize her thoughts, and reflect on her main takeaways.

The researcher asked Abby in the member check, "How do you usually organize something in a way that you would understand it?" Abby responded (paraphrasing), "I would usually organize these with an outline but if I needed help in understanding it, I would try to visualize it through a flowchart, or a Venn diagram, or a tree diagram – something visual." Additionally, Abby stated (paraphrasing), "I would probably record some type of visual representation in my notes and after I have done so then I would do that in my head, as in have a visual representation in my head of the diagram I had written. Or if I hadn't written down a diagram, I would try to create one in my head." In summation, Abby formatted her notes by using outlines, and she included visual elements, such as diagrams that supported her ability to visually think about ideas later. Abby's responses show a connection between the physical act of writing notes and the mental act of visualizing elements that were written. This connection was not present in the pre-assessment. Ashley's artifacts are shown in Figures 17 and 18, and subsequently discussed.

Figure 17

Ashley's Statistics Notes Given to the Researcher During the Post-assessment Interview

$$\boxed{t = \frac{\bar{x} - \mu_0}{SE_{EST}}} \quad \boxed{SE_{EST} = \frac{s}{\sqrt{n}}} \qquad t = \frac{\text{obs.} - \text{exp.}}{\text{variation}}$$

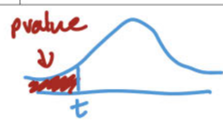
Test Statistic for a One-Sample *t*-Test, where
If conditions hold, the test statistic follows a t-distribution with $df = n - 1$.
Two Conditions:

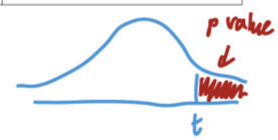
1. Random, independent sample
2. Large sample: The population must be Normal or the sample size must be at least 25. one condition has to be met

One- and Two-sided Alternative Hypotheses
Just as with hypothesis tests for proportions, hypothesis tests can be one-sided or two-sided depending on the research question. The choice of the alternative hypothesis determines how the *p*-value is calculated.

will be given; exp; previous study

	Two-sided	Left; One-sided	Right; One Sided
Null hypothesis	$H_0: \mu = \mu_0$	$H_0: \mu = \mu_0$	$H_0: \mu = \mu_0$
Alternative hypothesis	$H_a: \mu \neq \mu_0$	$H_a: \mu < \mu_0$	$H_a: \mu > \mu_0$





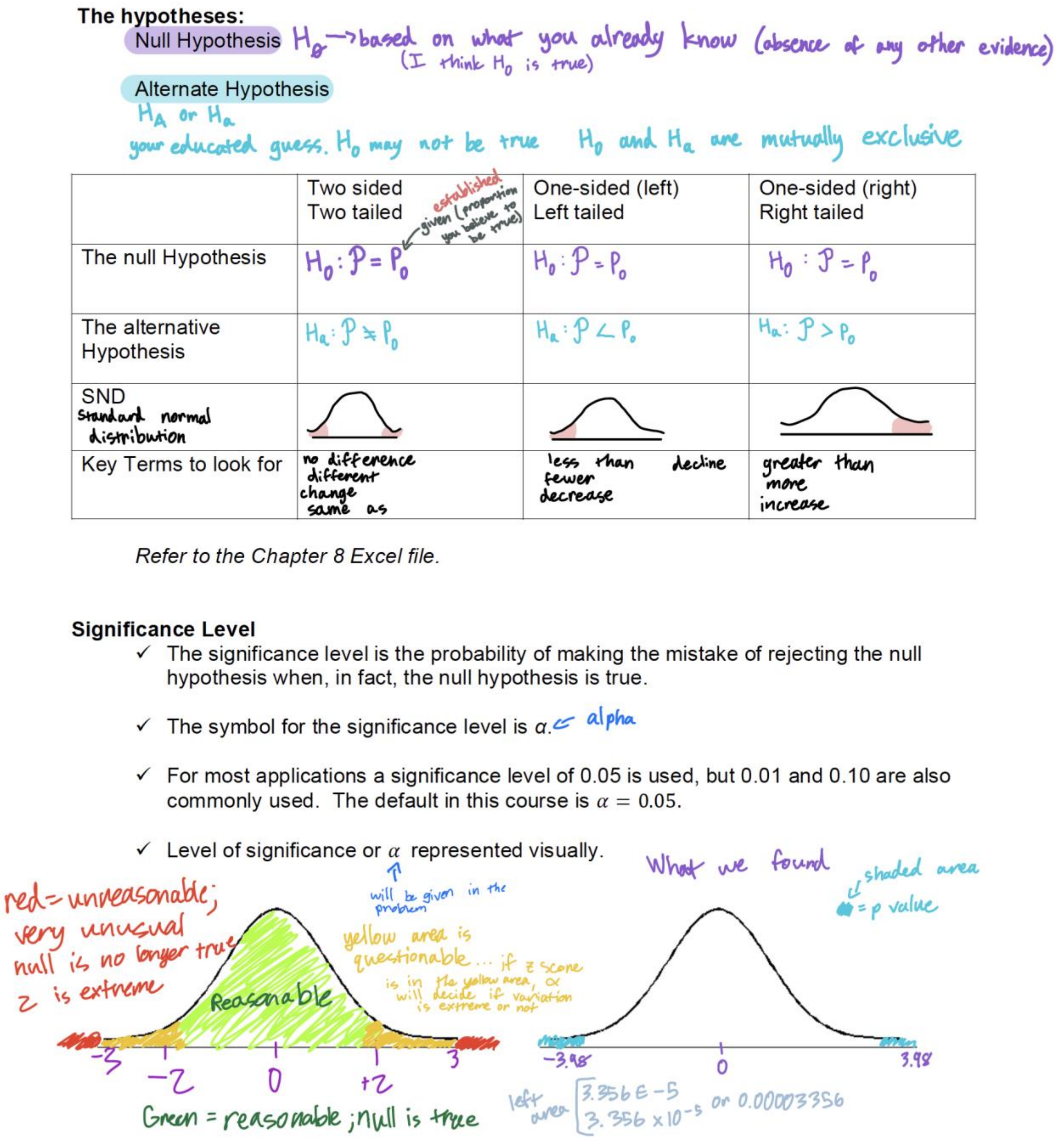
Refer to the Chapter 9 Excel file.

Here are the two websites that are helpful for sec 9.3
Interpretation of CI
Changing CL and Sample Size

If t is negative, the two tail p-value will display as an error. If the t is negative, change cell to =T.Dist.2T(-B9,B7)

Figure 18

Ashley's Statistics Notes Given to the Researcher During the Post-assessment Interview



The hypotheses:

Null Hypothesis H_0 → based on what you already know (absence of any other evidence) (I think H_0 is true)

Alternate Hypothesis

H_A or H_a

your educated guess. H_0 may not be true H_0 and H_a are mutually exclusive

	Two sided Two tailed	One-sided (left) Left tailed	One-sided (right) Right tailed
The null Hypothesis	$H_0: P = P_0$ ← established given (proportion you believe to be true)	$H_0: P = P_0$	$H_0: P = P_0$
The alternative Hypothesis	$H_a: P \neq P_0$	$H_a: P < P_0$	$H_a: P > P_0$
SND Standard normal distribution			
Key Terms to look for	no difference different change same as	less than fewer decrease decline	greater than more increase

Refer to the Chapter 8 Excel file.

Significance Level

- ✓ The significance level is the probability of making the mistake of rejecting the null hypothesis when, in fact, the null hypothesis is true.
- ✓ The symbol for the significance level is α. ← alpha
- ✓ For most applications a significance level of 0.05 is used, but 0.01 and 0.10 are also commonly used. The default in this course is $\alpha = 0.05$.
- ✓ Level of significance or α represented visually.

Ashley's notes in Figures 17 and 18, were templates given to the class by the teacher, that contained tables, diagrams, and headers/sections, some containing sentences of words that represent statistical concepts. Students could fill in the sections, tables, and diagrams with words and other visual elements. Ashley filled in the tables with formulas, used her own words in specific sections, connected those words (ideas) with arrows, and created icons (e.g., small drawings of bell curves) that represented statistical concepts. She also color-coded certain information to separate ideas and to keep herself engaged.

Ashley verified that her statistics notes allowed her to break down important statistical functions (e.g., t-statistic, t-distribution) and concepts/theories (e.g., hypothesis testing, null hypothesis, alternate hypothesis) in a visual way (through formulaic representations, definitions, tables, and diagrams). Having her notes laid out in a structured (step-by-step) fashion, which built on concepts, while having multiple visual representations of ideas (e.g., words, diagrams, tables), helped Ashley study, learn, and memorize the information.

Ashley verified in the member check that she created more visual representations of ideas (e.g., drawings, icons like arrows, diagrams) in her notes during the last semester and wrote ideas in her own words more. Many of these visual representations were copied from what the teacher provided or from what textbooks provided. Ashley stated that creating visual representations, (paraphrasing) “made me more excited about my notes because it made my notes more visually appealing.” Ashley also reported in the post-assessment that she thought more about how she captured ideas in her notes, “Now I'm trying to be like, "Okay, what are they (teachers) actually saying? How can I use that in my notes and learning overall?” Coreen’s notes are shown in Figures 19 and 20, and subsequently discussed.

Figure 19

Coreen's Uniform Notes Given to the Researcher During the Post-assessment Interview

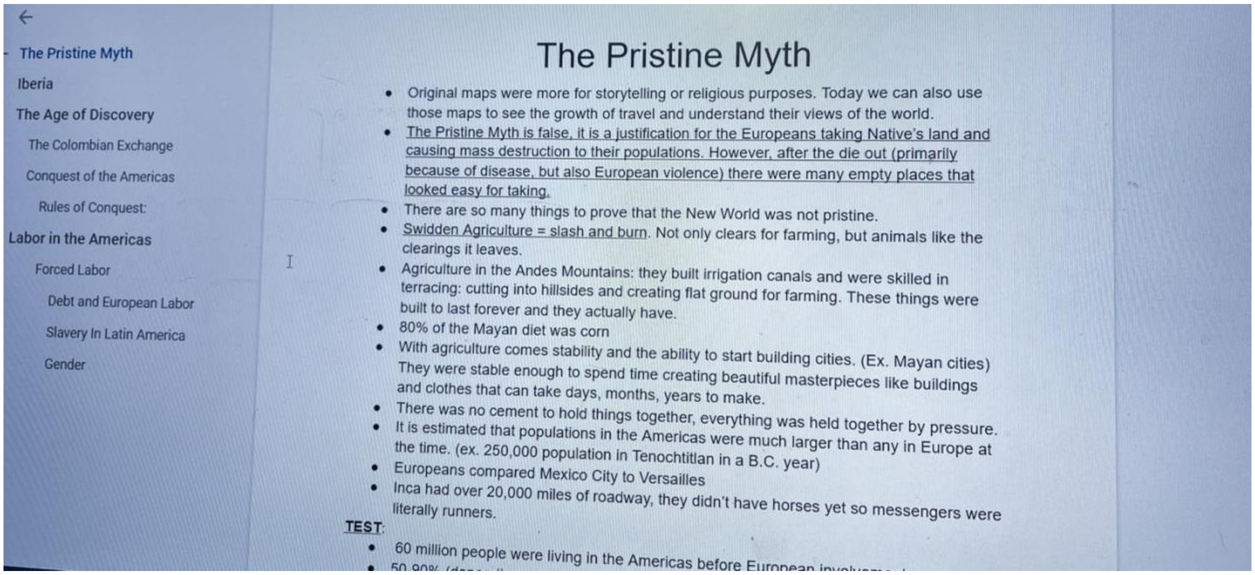
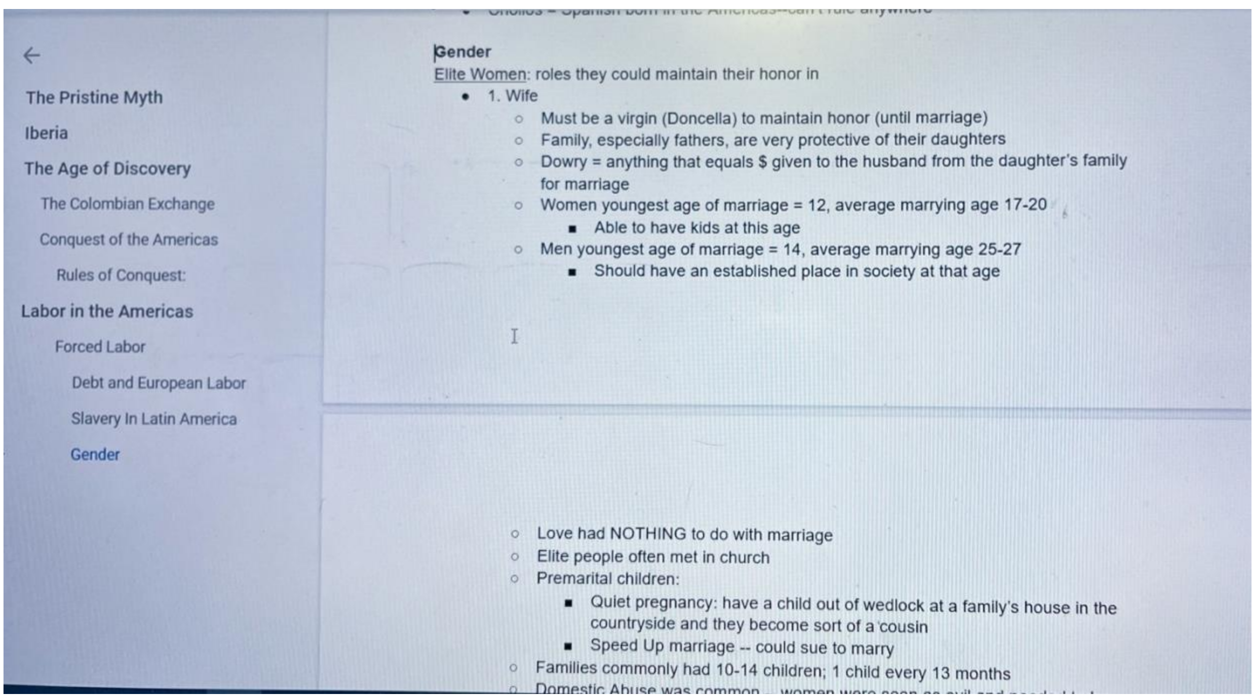


Figure 20

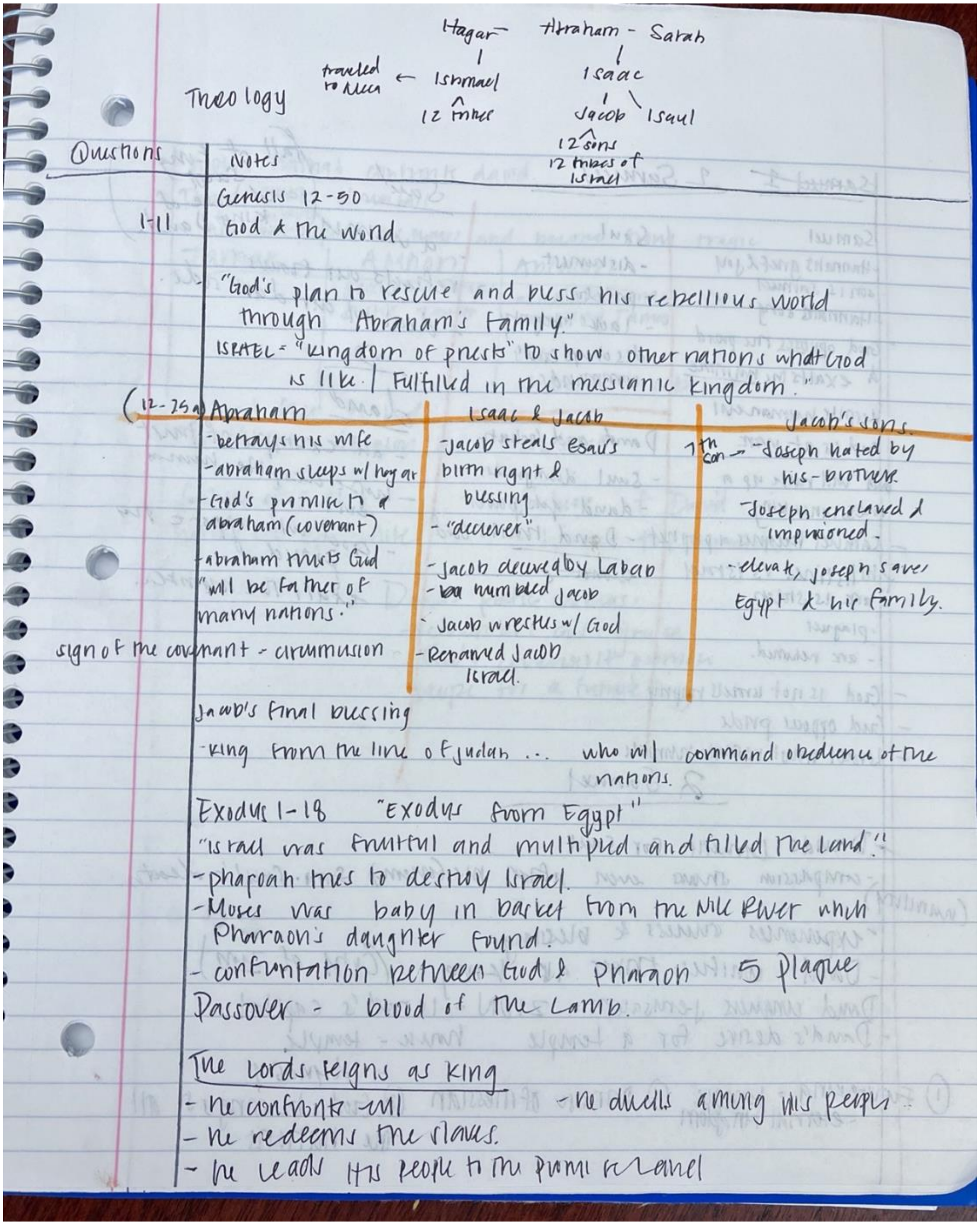
Coreen's Structured Notes Given to the Researcher During the Post-assessment Interview



Coreen’s notes in Figure 19 were shown to the researcher as an example of how she took notes before adapting them. All the bullet pointed sentences are structured on the same line. Coreen later determined, based on what she learned in the ASC, that she should structure her notes in a way that helped her visually structure her thoughts and make sense of the written words. Figure 20 represents Coreen’s notes after making changes. The bullet pointed sentences are structured hierarchically. Coreen stated, “You're not just writing down things word for word, you have to structure out these bullet points and how you want it. Those are definitely challenges in the beginning, but to me it's pretty easy now.” Coreen reported that writing her notes in such a format helped her break down and process ideas so that she could understand the information. She also stated that writing notes in this hierarchical format helped her mentally ‘see’ sections of words when studying for tests. Coreen verified in the member check that she altered her notetaking primarily because of what she learned and reflected on in the ASC. Dalisay’s theology notes are shown in Figure 21, and subsequently discussed.

Figure 21

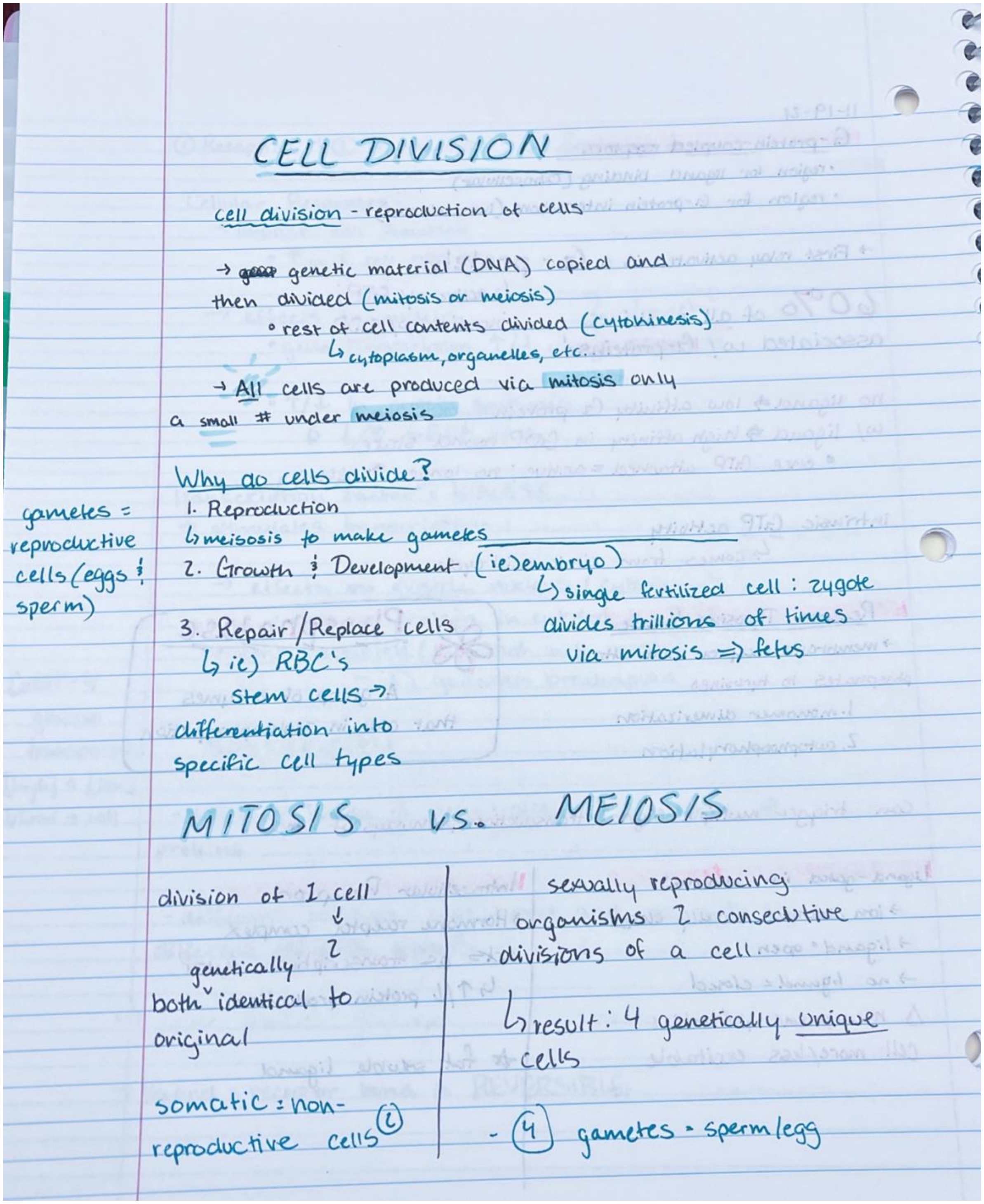
Dalisay's Theology Notes Given to the Researcher During the Post-assessment Interview



Dalisay's theology notes in Figure 21 reflected the way she took notes for several subjects. Dalisay drew lines to establish a "questions" section on the left margin of the page and a “notes” section to the right. Creating sections for “questions” and “notes” is connected to the Cornell Notes strategy Dalisay utilized since high school. On the right side, Dalisay, 1) wrote ideas in her own words, 2) created sections with bullet pointed sentences, 3) drew an orange table where she broke up different characters and parts of their story, and 4) connected characters and parts of their story with lines/arrows. The researcher asked Dalisay in the member check, “You mentioned arrows, diagrams, pictures, and tables here. Of those strategies what, if any, do you use in your notes?” Dalisay responded, “All of them.” The researcher followed up by asking, “Were these strategies effective?” Dalisay, responded, “Yes. Because the diagrams show my thinking on paper.” Lastly, the researcher asked, “Do you use anything besides arrows and tables as visual representations? Dalisay answered, “Circling key points, highlighting main topics and new vocabulary, drawing concept maps and color-coding different topics.” Dalisay reported in the post-assessment and verified in the member check that the way she represented ideas and formatted her notes helped create context for the ideas she was writing and helped her see connections between ideas. Dalisay verified in the member check that she developed a system for how she learned best. Lilly’s notes are shown in Figures 22 and 23, and subsequently discussed.

Figure 22

Lilly's Biology Notes Given to the Researcher During the Post-assessment Interview



CELL DIVISION

cell division - reproduction of cells

→ ~~gene~~ genetic material (DNA) copied and then divided (mitosis or meiosis)

° rest of cell contents divided (cytokinesis)

↳ cytoplasm, organelles, etc.

→ All cells are produced via mitosis only

a small # under meiosis

Why do cells divide?

gametes = reproductive cells (eggs & sperm)

1. Reproduction

↳ meisosis to make gametes

2. Growth & Development (ie) embryo)

↳ single fertilized cell : zygote divides trillions of times via mitosis ⇒ fetus

3. Repair/Replace cells

↳ ie) RBC's

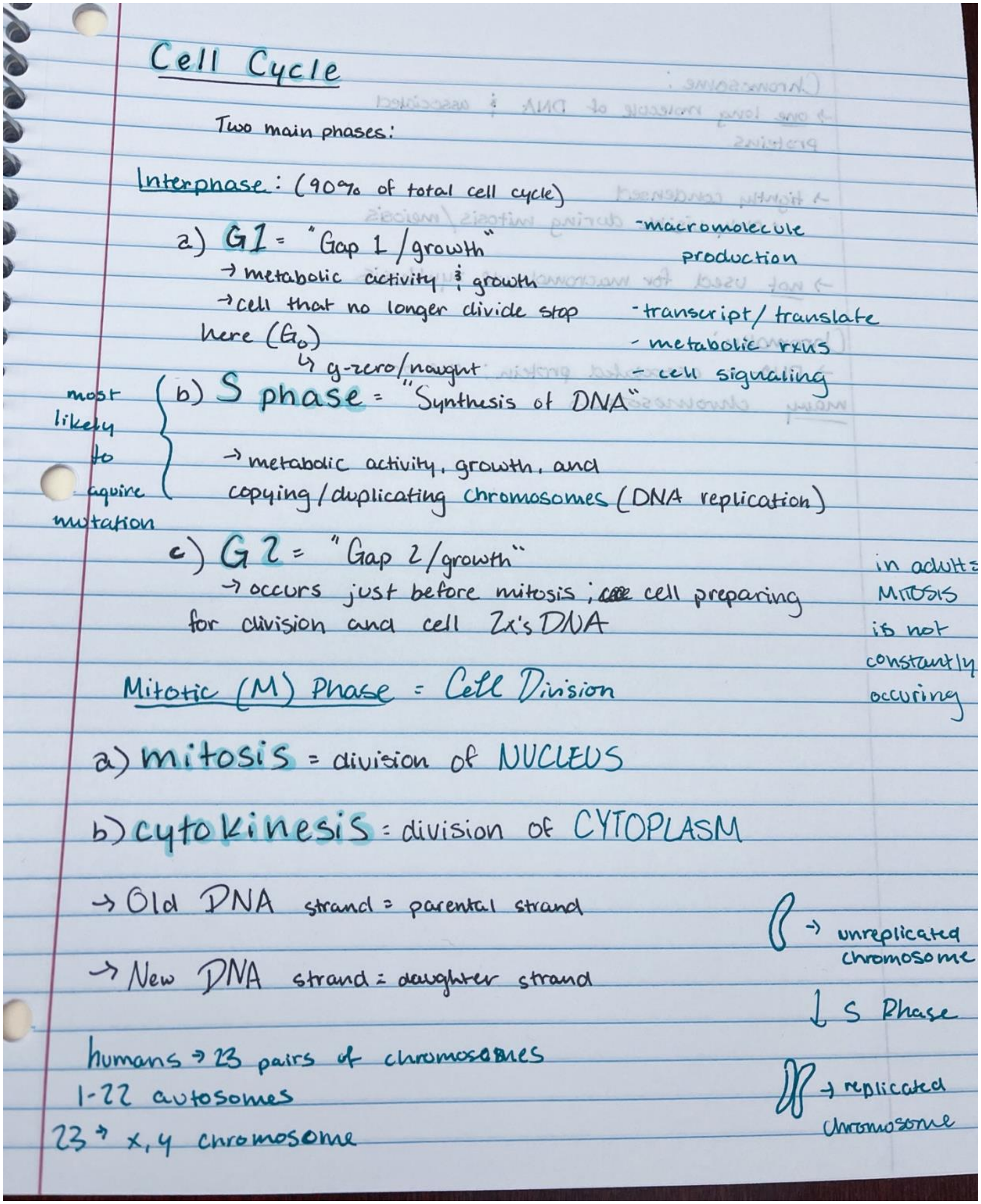
stem cells → differentiation into specific cell types

MITOSIS vs. MEIOSIS

division of 1 cell ↓ 2 genetically both identical to original	sexually reproducing organisms 2 consecutive divisions of a cell
	↳ result: 4 genetically unique cells
somatic: non-reproductive cells (i)	- (4) gametes - sperm/egg

Figure 23

Lilly's Biology Notes Given to the Researcher During the Post-assessment Interview



Cell Cycle

Two main phases:

Interphase: (90% of total cell cycle)

a) G1 = "Gap 1 / growth"
→ metabolic activity & growth
→ cell that no longer divide stop here (G_0)
↳ g-zero/naught

- macromolecule production
- transcript/ translate
- metabolic rxns
- cell signaling

most likely to aquire mutation
b) S phase = "Synthesis of DNA"
→ metabolic activity, growth, and copying/duplicating chromosomes (DNA replication)

c) G2 = "Gap 2/growth"
→ occurs just before mitosis; cell preparing for division and cell 2x's DNA

in adults = MITOSIS is not constantly occuring

Mitotic (M) Phase = Cell Division

a) mitosis = division of NUCLEUS

b) cytokinesis = division of CYTOPLASM

→ Old DNA strand = parental strand

→ New DNA strand = daughter strand

→ unreplicated chromosome
↓ S Phase
→ replicated chromosome

humans → 23 pairs of chromosomes
1-22 autosomes
23 → x, y chromosome

Figures 22 and 23, represent Lilly's biology notes. Lilly developed a system that included, 1) rephrasing and reorganization of what the teacher presented in her own words, 2) writing her own thoughts (usually in the margins), 3) drawings (e.g., icons that helped establish associations between ideas), 4) arrows that connected ideas, logic, and/or processes, and 5) a color-coding process that included a) highlighting techniques, b) simple shapes (i.e., doodles) written with a highlighter, and c) color-coded phrases. The researcher asked Lilly to give an example of her note-taking system in the member check. Lilly responded (paraphrasing), "Every day for my college class I would take notes, draw pictures, because it was medical terminology. I would color-code it by organ system. I would do everything by color. I would write diagrams and use colors to break down a word into different ideas and then color code those." Lilly additionally reported that the words in the margins supported her ability to reflect on the ideas when reviewing them (see Figures 22 and 23).

In the member check, the researcher interpreted Lilly's responses from the post-assessment, and showed Lilly the following statement, "Some of your highlighter drawings are what you called "doodles". These doodles aren't necessarily conceptual, but they help draw your attention to an important idea. For instance, you drew something akin to sun rays coming off "All" in "All cells are produced via mitosis only, a small # under meiosis" in your biology notes (see Figure 19). And there were two small lines under "small." Lilly verified the researcher's statement as being accurate. Lilly also verified the following statement made by the researcher, "Mitosis and Meiosis are the big ideas (in your notes) and so those are written big on the paper, and you drew a table separating these processes to better compare the two processes and to see how each process works on its own. Arrows are written into each side of the table to connect the process (mitosis vs meiosis) result in the following: "sexually reproducing organisms 2 consecutive divisions of a cell" is connected with an arrow to "result: 4 genetically unique cells." Mitosis and Meiosis are also highlighted multiple times to signify their importance (see Figure 19). Lilly reported in the post-assessment and verified in the member check that she color coded notes to separate and group ideas, so the proper ideas connected and made more sense. If everything was in black ink the ideas would jumble together and not be distinguishable.

Additionally, Lilly created more drawings and associated those drawing with ideas (represented as words), over the course of the semester. Lilly reported the drawings helped her recall what concepts looked like and visually think about the ideas in her notes. Lilly reported in the post-assessment that drawing in combination with wording things in her own way helped her perform well on a test. The researcher later asked if drawing and writing in her own words helped her only on the test or with learning overall? Lilly responded, "Overall, definitely. I use it the most, in one specific class and it's definitely something I think I will continue to do. Especially next semester, I'll be taking a lot more classes that are probably are going to be a little bit more lecture-based and science-based, so that's going to definitely help me." Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 5 – "*Developing Visual Systems to Support Understanding*." The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants' statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

"Developing Visual Systems to Support Understanding" is a change theme that relates to developing knowledge and regulation for notetaking strategies that support processing (recognition) and understanding of academic ideas. Most focal participants reported developing a system for notetaking that enhanced their ability to understand or mentally 'see' ideas. Table 136 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 136

Conversations in Second Member Check Relevant to Change Theme – "Developing Visual Systems to Support Understanding"

Focal Participant Name	Chris (Questions/Interpretations)	Focal Participant Answering
Abby	As a result of (the ASC) and your work within the class, you've learned to differentiate your learning strategies based on specific subjects. Can you give an example?	Flowcharting for English. I engaged in this strategy last semester. And visual representation like a diagram for Biology. The (ASC) helped my awareness and knowledge of flowcharting grow, which helped me engage in that strategy more. I first learned about flowcharting in middle school, but I didn't utilize in the way that they (teachers in middle school) would.
Coreen	Visually structuring your notes with the system, you created, helps you to go back and understand it later.	"Yes, that was the entire point of structuring them that way, to understand them when I looked at them later."
Dalisay	A contributing factor to this increase in motivation is that you have developed a system that seems to work well for how you learn best.	(Emphatic) "Yes!"

Daniel	Are your notes different now (as in last semester), than they were prior to the (ASC)?	My notes are different now. Now instead of writing a long paragraph of words, I write down pictures and words to break up the ideas and separate them. If I need to use words, I make sure they are more streamlined and succinct to get to the key ideas.
Lilly	Did you implement color coding in your notes more, less or about the same at the time of our last interview?	I'm very visual with a lot of things. So, color-coding helps to look back on what I've written - like recall, remembering what I've written. I do that a lot more now (as in last semester). I've been refining my color-coding system and the skill around it. The (ASC) helped to push me to improve my color-coding system. It was working well but the class helped me to think about "how do I improve it?"

Sections from the case summaries in Table 136 provided verification and in some cases depth to participants' responses in the post-assessment. Focal participants reported and/or indicated developing systems over the course of the semester to support their understanding of academic ideas. In the post-assessment, participants developed systems through one or more of the following strategies: 1) representing ideas with drawings, 2) writing meaning in their own words, 3) color-coding ideas, 4) arranging/outlining sections of text, 5) connecting ideas with arrows/lines, 6) writing ideas to learn later, and/or 7) bullet pointing sections of text to separate and connect ideas. In the member check, three focal participants verified they developed a "system" for notetaking, while all six participants, verified they made visual changes to their notetaking including, 1) drawing or diagramming more, 2) flowcharting, 3) writing ideas in their own words, and/or 4) breaking down ideas into sections. Lilly, for instance, verified in the member check that she'd been engaging in drawing (and labeling the drawings with words) much more over the course of the semester and was aware how much it helped her learning and understanding of the subject matter. Participants additionally reported adapting drawing from the way it was discussed in the ASC. For instance, in the member check the researcher asked Abby, "can you discuss the adaptation you made and how you use flowcharting in your notes?" Abby responded (paraphrasing), "I tried to make it my own. I simplified things rather than having big pieces of text I would summarize it into key pieces of text, significant words, and pictures."

In the class activities, sixteen of 23 class participants reported applying and/or integrating drawing as a strategy, "Drawing as an Adapted Strategy for Learning." Additionally, the meta-learning theme, "Drawing Supports My Learning" emerged in response to ten class participants responses in the class activities. Provisional coding and longitudinal analysis indicate that focal and class participants learned about using drawing and began to apply/integrate drawing strategies to better represent academic ideas. Doing so, supported their ability to mentally see and/or understand academic ideas.

The change theme, "Developing Visual Systems to Support Understanding" indicates that students developed visual systems to represent/organize (primarily auditory) ideas in a way that allowed them to process and understand the ideas in their notes. Focal participants assigned more meanings to their notetaking strategies, suggesting they thought more about the best ways to capture ideas. Template analysis and provisional coding reveal that focal participants visually represented academic ideas and formatted notes in more deliberate and effective ways to support understanding. For instance, more metacognitive strategies were applied toward note-taking over the course of the semester that capitalized on the way students visually processed and understood new ideas. Participants reflected on their notes, thought more metacognitively about their notes, and engaged in more strategic behaviors to support their understanding. Overall, focal participants reported behaviors indicating they regulated their notetaking more during their first semester in college. However, focal participants did not engage in this behavior for all their classes. It's unclear how consistently focal participants engaged in this behavior and to what degree they metacognitively controlled this strategy.

In summation, focal participants visual notetaking strategies and systems expanded in both breadth and depth for the group as a whole. More focal participants, by the post-assessment, engaged in more note-taking strategies which supported their ability to, 1) identify ideas, 2) separate and make associations between ideas, and 3) mentally see and/or understand ideas. The other post-assessment theme, not mentioned in this section, that overlaps with the change theme is **"**Writing Own Meaning (Words) in Notes."

Change Theme 6 - Understand More About the Ways I Learn Best

*"*Understand More About the Ways I Learn Best*"* is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants' statements of 1) understanding more about the ways they learn best, 2) building foundational elements for learning, 3) incorporating more effective learning strategies from the beginning of the semester, 4) improved academic performance, and 5) being more in control of learning. This change theme additionally incorporates themes related to participants' metacognitive confidence for their learning, including ratings of how well they understood their learning in the pre-assessment as compared to the post-assessment. The change theme, "Understand More About the Ways I Learn Best" incorporates themes provisionally coded as "MK," "CK," "ML," and "MC," in the pre- and post-assessments that relate to judgements of one's understanding and/or development of their learning as well as the meta-learning themes, "Feel in Control of My Learning," "Ability to Improve Learning," and "I am a Visual Learner" in the class activities. Additional themes in class activities were incorporated that provided

context for growth in participants understanding of learning and outcomes related to meta-learning, e.g., "Learning about My Learning Makes Me Feel Empowered."

The researcher incorporated the themes previously mentioned into a time ordered matrix and used the criteria from longitudinal analysis to reach a determination. Overall, focal participants reported understanding more about their own learning and supported those statements with confidence-based ratings, and outcome-based statements about how they felt as a result of learning about their own learning. For example, four of six focal participants in the pre-assessment reported they were "Still Figuring Out What Works Best for My Learning," and seven class participants in JE6 reported they previously "Did Not Know How to Study." In the post-assessment five focal participants reported the themes "Understand More About the Ways I Learn Best" and "Built Foundational Elements for Learning." Furthermore, all focal participants by the end of the post-assessment rated their understanding of learning high (between 8 and 10) compared to a mid-range rating (between 5 and 7) at the beginning of the pre-assessment. The researcher deduced from template analysis, longitudinal analysis, and case summaries that all focal participants gained personal knowledge for their own learning over the course of the ASC. This "change" is supported by the emergence and accumulation of themes reported in Table 137 as well as the change themes previously reported.

Table 137

Emergent and Cumulative Change for "Understand More About the Ways I Learn Best" Based on Themes Over the Course of the ASC

Time Block #1 (Pre-assessment)	Time Block #2 (Class Activities)	Time Block #3 (Post-assessment)	Change Themes
1) Mid-Range Understanding of Learning (Rating) 2) Still Figuring Out What Works Best for My Learning 3) Experiences Learning About Learning / Thinking Lacking 4) Sometimes Unsure of Best Way to Learn Ideas 5) Hand-written Ideas Support Understanding 6) I am a Visual Learner	Primary Meta-learning Themes: 1) Feel In Control of My Learning 2) Ability to Improve Learning 3) I am a Visual Learner Other Relevant Themes: 4) Did Not Know How to Study (Previously) 5) What I've Learned Helps Me Feel Confident in My Learning 6) Learning about My Learning Makes Me Feel Empowered	1) High Understanding of Learning (Rating) 2) Understand More About the Ways I Learn Best 3) Built Foundational Elements for Learning 4) Incorporating More Strategies for Learning 5) Physically Written Notes Help Learning 6) Improved Academic Performance	Understand More About the Ways I Learn Best

As illustrated in Table 137, post-assessment themes represent an 'endpoint' in the matrix. All themes related to time block #1 (i.e., the pre-assessment) and time block #2 (class activities) have been previously discussed in research questions RQ3a, RQ3b, RQ3c, and RQ3d. The criteria leading to the change theme, "Understand More About the Ways I Learn Best" revealed that focal participants' (with validation from class participants responses), developed personal knowledge for their learning (e.g., "I am a Visual Learner," and "Feel in Control of My Learning") as they reflected on their learning and applied/integrated strategies for their learning in the class activities. By the post-assessment participants reported ways they learned best (e.g., "Physically Written Notes Help Learning") and strategies for the ways they learn best. Four of six focal participants also reported "Improved Academic Performance," which provides credibility to participants claims that they understood more about their learning and may have influenced statements of understanding more about learning. All focal participants were coded for a post-assessment theme that related to the change theme. The post-assessment themes which comprise the change theme in Table 131 are discussed next.

High Understanding of Learning (Rating). All six focal participants rated themselves as having a high understanding of their learning, between eight and ten. This is a subjective rating created by the researcher. Eight or above indicates “high,” five to seven indicates “mid-range,” and four and below indicates “low.” All participants rated themselves as high at the end of the post-assessment interview. Five out of six participants rated themselves as high at the beginning of the post-assessment interview. One participant (Daniel) rated themselves as mid-range (a “seven”) at the beginning of the post-assessment interview and high (an “eight”) at the end of the post-assessment interview. These ratings represent participants’ metacognitive confidence for knowledge of their learning. Reports of understanding more about learning is discussed next.

Understand More About the Ways I Learn Best. Four focal participants reported understanding more about the ways they learn because of what they learned and/or applied in the ASC. The post-assessment theme, “Understand More About the Ways I Learn Best” emerged in response to questions one, two, three, and ten with most responses being coded in the PK and UoL sections of the post-assessment. Prominent quotes for this theme are listed in Table 138.

Table 138

Prominent Quotes from Post-assessment Theme – "Understand More About the Ways I Learn Best"

Class Participants	Prominent Quotes
Abby	Yes. I find myself paying attention more because I feel I know more about myself and the way I learn.
Abby	I would definitely say that I've been more aware of what makes me a better learner.
Abby	I feel I know more about myself and the way I learn.
Coreen	I just have an understanding of what I had used before. Like I said, I know why it works and so it makes it easier to use now that I know why it works.
Coreen	And now, it's more like I know why this works. Now I know the information and the definitions behind what works for me, so it makes sense.
Dalisay	...like I study at the (diner) all the time now because I understand well how I learn.
Dalisay	Yes, but I know well how I learn now, what works best for me, definitely.
Lilly	I definitely feel like my approach to thinking has changed, but it's solidified how I learn and just encouraged me to go more in-depth with it. So, I am very aware of how I process things, how I communicate, how I just take in information.

As illustrated in Table 138, focal participants directly reported they understood more about their own learning and/or alluded to knowing more about the ways they learn best. For instance, Coreen gained knowledge for why specific concepts and strategies worked for her in the past, which made those strategies easier to engage in during the first semester. Three participants alluded to the post-assessment theme, "Understand More About the Ways I Learn

Best" recurringly and in detail. Reports of building foundational elements for learning is discussed next.

Built Foundational Elements for Learning. Three focal participants reported or indicated they built foundational elements for learning and thinking with the support from the ASC. Two focal participants, Coreen and Dalisay, directly mentioned building foundations for learning and one participant, Ashley, alluded to building foundational elements for learning. The post-assessment theme, "Built Foundational Elements for Learning" emerged in response to questions one, two, and ten with most responses being coded in the PK and UoL sections of the post-assessment. Prominent quotes for this theme are listed in Table 139.

Table 139

Prominent Quotes from Post-assessment Theme – "Built Foundational Elements for Learning"

Class Participants	Prominent Quotes
Ashley	I feel like this class, unlike all the other core classes that I've taken this semester, has really opened up my perspectives on what learning actually is.
Coreen	Yes. I have a solid foundation now. Before it was like a great property, and this class has built the foundation, and now I'm putting in investments to bring in the lumber kind of stuff.
Coreen	I call it (my approach to learning) more sophisticated because I understand it more, I know how to approach it.
Coreen	[Discussing the foundation for learning.] Yes, it's not just improved how I learn, it's improved my accessibility to learn in the future.
Dalisay	But this class helped me learn the foundation to what I'm supposed to be thinking. Like how I'm supposed to be thinking, going forth with my other classes.

As illustrated in Table 139, focal participants reported building knowledge for their learning, including how they should approach their learning and thinking going forward. For instance, Coreen referenced a metaphor for the knowledge she developed while in the ASC – a "foundation," similar to a home's foundation. Coreen stated in the post-assessment, "In the first interview, it was really hard to identify how I learned or how I studied," because I had "no words" for the strategies I used...". But the ASC, "...gave me all the definitions to my strategies." Having that knowledge gave Coreen new ways to utilize learning strategies when needing "extra assistance" based on strategies she had previously applied. Focal participants reports of incorporating and developing more strategies for learning is discussed next.

Incorporating More Strategies for Learning. Four focal participants reported they've incorporated more strategies for learning or new elements to previous strategies because of what they learned in the ASC. The post-assessment theme, "Incorporating More Strategies for Learning" emerged in response to questions one, two, three, and ten with most responses being coded in the PK and UoL sections of the post-assessment. Prominent quotes for this theme are listed in Table 140.

Table 140

Prominent Quotes from Post-assessment Theme – "Incorporating More Strategies for Learning"

Class Participants	Prominent Quotes
Coreen	Also, just if it isn't working, I can ramp it up a little bit. Especially the writing in your own notes strategy for example - it's like I did that kind of but learning about it made me know what it was and that I was already using it and then if I want to improve on it, now I can go search this up and I can learn more about it even on my own time and then I can use that more."

Daniel	I've started thinking outside of that box I put myself in and I start applying more strategies.
Daniel	I decided not to stay stuck in the same strategy of learning and I started experimenting.
Daniel	You always want to be aware of that. And so, if all of that hadn't just lined up, I don't think I would be here to say, "Experimenting with different learning strategies is what I got out of this class." I think I would still be just, Mr. Keep writing it down, writing it down, writing it down, reading it over, maybe writing it down more.
Dalisay	And so, at the beginning, I was more worried about if I'm going to understand material or how I'm going to tackle this material... now I adapted to that, and now I'm implementing it more. I personalize it more to where I could better understand what I'm learning.
Lilly	I'd definitely say (the ASC) did validate it, a lot of what I was doing before but then it also encouraged me to incorporate more.

As illustrated in Table 140, focal participants discussed applying more strategies and/or adding new approaches to their learning, often in reference to what they previously used (at the beginning of the semester). Two focal participants, Lilly and Coreen, reported they developed more knowledge for learning strategies they previously used, which allowed them to, a) go into more depth with their strategies and/or, b) add new elements to their learning when needed. Abby did not discuss incorporating more strategies for learning but did develop understanding for the strategies she currently used, "I don't necessarily think my strategies have changed, but maybe my approach to those strategies, and my understandings of those strategies have changed." Focal participants reports of physically written notes being helpful to learning is discussed next.

Physically Written Notes Help Learning. Four focal participants reported that writing their notes (as opposed to typing) helped them learn. Two participants in the pre-assessment reported a similar understanding. The post-assessment theme, “Physically Written Notes Help Learning” may indicate that the physical hand movements and visual stimulus (i.e., visual-motor movements) when writing supported participants thinking. The post-assessment theme, “Physically Written Notes Help Learning” emerged in response to questions three, seven, eight, and nine with most responses being coded in the S&S section of the post-assessment. Prominent quotes for this theme are listed in Table 141.

Table 141

Prominent Quotes from Post-assessment Theme – “Physically Written Notes Help Learning”

Class Participants	Prominent Quotes
Coreen	...like I love writing down notes with hands, it helps my learning...
Ashley	I feel like writing down what she says or what she's writing down helps me learn better because I'm the one who's physically writing it.
Ashley	I also realize that even if it's not in my own words, as long as I'm writing it down, physically writing it down, like what I do for my stats notes, I pick it up better than when I'm just typing it.
Daniel	Think writing helps with my memory of it and then seeing it on a paper helps with the visual just part of it, feeding that information in my brain.
Dalisay	I realize writing has been more efficient than typing for me because I tried taking notes while typing. I realized it doesn't process through my head that much because I'm so focused on trying to type it correctly on my keyboard. Like that's another distraction for me - trying to make sure I don't misspell things

	but when it comes to writing, actually handwriting in my notes, it has helped me think.

As illustrated in Table 141, focal participants reported that physically writing notes helped their learning; though, participants did not elaborate why it was helpful to their learning. Coreen and Ashley reported that written notes were helpful, but primarily typed their notes because of the flexibility and efficiency digital notes offered. Reports of improved academic performance is discussed next.

Improved Academic Performance. Four focal participants reported that what they learned in the ASC helped them to improve an aspect of academic performance in college courses. The post-assessment theme, "Improved Academic Performance" emerged in response to questions two, three, and ten with most responses being coded in the PK and UoL sections of the post-assessment. Prominent quotes for this theme are listed in Table 141.

Table 142

Prominent Quotes from Post-assessment Theme – "Improved Academic Performance"

Class Participants	Prominent Quotes
Coreen	...focusing on my own learning has made it so my grades aren't lower than what they've already dropped...if you look at my understanding which is really hard to measure but I know it. My understanding how I learn is way better than it used to be and I can guarantee that without this my grades would have stooped a lot lower than they have.
Daniel	And then seeing that perfect A was crazy to me. Because that was my first perfect score on a test I had gotten in college, and you always want to frame your first dollar bill that you make off your business and so - like your first success - and so like first big success like that, no matter how small you always want to make

	sure like, "Hey, doing this (drawing strategy) is what got me here.
Dalisay	And just use the knowledge and the skills that I was presented in class, and I applied that with my other classes, which I've done, and it has been very successful. So, yeah.
Lilly	Like on one of my last tests, it was one of the bests I've done in a while because I've tried to actively draw pictures, word things in my own way, and just try to put it into terms that I can understand when I go back or even just thinking about it when I'm writing it down

As illustrated in Table 142, focal participants reported their grades improved or were better than they would have been had they not learned about their own learning or applied specific strategies which they learned in the ASC. Dalisay confirmed in the member check that when she said “very successful” she was referring to her academic performance. This post-assessment theme lends credibility to the change theme, “Understand More About the Ways I Learn Best.” Verification of the previously discussed post-assessment themes and summation of the change theme are discussed next.

Verification and Summation of Change Theme 6 – “Understand More About the Ways I Learn Best.” The researcher drafted case summaries from post-assessment transcripts and further developed the case summaries with focal participants in member checks approximately eleven weeks after the post-assessment interview. Participants’ statements from member checks were used to verify, modify, and/or provide depth to the themes that developed during language analysis.

“Understand More About the Ways I Learn Best” is a change theme that relates to developing knowledge for one’s learning, particularly through the incorporation of strategies for learning. Table 143 lists sections of focal participants' conversations with the researcher in the member check that correspond with the post-assessment themes previously discussed. All paraphrased statements were developed from focal participants responses and were confirmed with them as being accurate in the member check. Any direct statements are listed in quotation marks.

Table 143

Conversations in Second Member Check Relevant to Change Theme – "Understand More About the Ways I Learn Best"

Focal Participant Name	Chris (Questions/Interpretations)	Focal Participant Answering
Abby	You find yourself paying attention more when learning something new because you feel you know more about yourself as a learner – primarily that you need visual stimuli to learn at your best.	Yes.
Ashley	Do you feel that your understanding of yourself as a learner has grown because of your participation in this study?	Yes. Both the class and study helped.
Coreen	As a result of (the ASC), and your own learning, you feel that you better understand how you learn best. The (ASC) helped to validate strategies you were doing in high school.	Yes, that's accurate.
Coreen	You feel you now have more ways to develop your learning strategies which may help when you face challenging coursework.	It helps with all coursework not just challenging coursework. Even with easy material I use these strategies.
Coreen	You are working on building on that foundation by thinking about, applying, and adapting strategies to help your overall learning in college.	Yes. "Those strategies being directly from (the ASC)."

Dalisay	You feel that the (ASC) helped you develop a foundation for learning and thinking, which will support you while in college and beyond.	Yes.
Lilly	The (ASC) class, and your work within the class, helped you understand more about the strategies you implemented in high school and why they still work for you.	That is correct. Looking back at it now, I never understood why I did it that way. I just did it in a way that made sense to me, that helped me in a way that I could process it.
Lilly	Though, you are engaging in similar strategies/activities, you are engaging in these strategies/activities more often and more situational to the curriculum you are learning. Meaning that you are matching specific learning strategies/activities to specific types of curriculums to understand the material at your best.	Yes, that's right.

Sections from the case summaries in Table 143 provided verification and in some cases depth to participants' responses in the post-assessment. Focal participants reported understanding more about their learning and/or the ways they learned best. These statements were often explicit and related to the application or development of strategies presented in the ASC. In some cases, the knowledge learned and/or applied in the ASC helped focal participants improve their academic performance.

In the post-assessment, focal participants reported, 1) understanding more about their learning, 2) building foundational elements for learning, 3) paying more attention to their learning, 4) incorporating more strategies for learning, and/or 5) developing the strategies they previously used. In the member check, five focal participants verified they learned more about their learning and one focal participant, Daniel, implied he learned more about learning when discussing strategies that were helpful to his academic performance. Two participants, Lilly and Abby, verified in the member check that they paid more attention to their learning, because they felt they knew more about how they learned.

In the class activities, sixteen class participants affirmed that they felt empowered from learning about their learning (e.g., "Learning about My Learning Makes Me Feel Empowered"), and seven class participants reported/indicated that they felt more 'in control' of their own learning (e.g., "Feel in Control of My Learning). Four class participants reported feeling more confident about their learning (e.g., "What I've Learned Helps Me Feel Confident in My Learning"). The latter two themes were provisionally coded as "MK" and "MC."

Class participants additionally reported that they had an ability to improve their learning because of what they learned during the last semester (e.g., "Ability to Improve Learning). Five class participants also reported being visual learners, three of which indicated learning they were visual learners because of participation in the ASC. Lastly, seven class participants reported they did not know how to study in high school (e.g., "Did Not Know How to Study") and four class participants reported they did not study regularly in high school (e.g., "Did Not Study Regularly in High School"). Class activities themes provide rationale and credibility that a change occurred during the last semester.

Template analysis and provisional coding indicate that focal and class participants learned about their own learning primarily by applying strategies discussed in the ASC and reflecting on those experiences during/after learning scenarios (e.g., reflective journal entries). As a result, most focal participants made several outcome-based responses that amounted to *understanding more about their learning* in the PK and UoL sections of the post-assessment. All focal participants explicitly or implicitly reported during the study that they learned best 'visually' by, 1) seeing and creating visual stimuli, 2) visualizing (picturing) ideas, and/or 3) structuring notes as a visual system. Focal and class participants also reported learning best when using language as a strategy for learning, but they did not connect using language to being a visual learner. The researcher deduced that focal participants gained personal knowledge for learning and thinking 'visually' and for using language strategically, e.g., 1) taking notes in one's own words, 2) discussing ideas with peers, and 3) using internal dialogue and/or reflecting on new ideas.

Template analysis, longitudinal analysis and provisional coding reveal that focal participants gained metacognitive knowledge and metacognitive confidence for their learning, particularly because they learned about, 1) their visual thinking (e.g., visualizing ideas in learning scenarios) in learning scenarios, 2) how they 'processed' or understood new ideas best (e.g., physically writing notes and structuring notes as a visual system), 3) the effects of reflective/metacognitive thinking, and/or 4) the effects of strategic language use (e.g., discussing ideas with peers). As a result, all focal participants became more aware of their own thinking/learning, and some focal and class participants, a) improved academic performance and/or learning, and b) developed and/or became aware of positive dispositions towards learning (e.g., "Feel in Control of My Learning"). The previously discussed themes, when placed in a visual matrix amount to a 'change' in the ways participants understood how they learned effectively (or best). Three class participants reported they did not implement any new strategies in the ASC, so a change unlikely occurred for all class participants.

In summation, focal participants learned about themselves as learners, which is reflected in the change themes previously discussed, and the emergence of class activities and post-assessment themes (listed in Table 137) that show participants learned more about the ways they learn best, primarily by applying/developing strategies for learning. This 'change' is supported by participants reports of improved academic performance and dispositions such as empowerment and feeling in control of their learning. Other post-assessment themes, not mentioned in this section, that overlap with the change theme are "More Attention to Thinking When Learning," "Asks More Questions about Understanding," "Visualizing Ideas to Understand Speakers Words," and "Structures Notes as a Visual (Semantic based) System to Understand Ideas." The next section will synthesize the results from RQ1, RQ2, and RQ3, including sub-questions.

Summary of Research Question 3

Results of RQ1 indicated all six participants' functioned using visual cognition to process auditory concepts. Results of RQ3, showed that class participants made gains in metacognitive awareness (RecCog and KnowCog) during their first semester in college, likely because of participation in the ASC. Results of RQ3a showed that five out of six focal participants had few or no experiences where a teacher or counselor had helped them with their learning and/or thinking, coinciding with themes that emerged in JE6 for class participants who did not know (or never learned) how to study and/or they did not study regularly. Results of RQ3b showed that more than half of focal participants had metacognitive knowledge for their visual thinking and/or understood themselves to be visual learners. Results of RQ3c showed that focal participants predominantly sought, focused on, created and/or adapted visual input to better process and/or understand new ideas. Three focal participants also "visualized" context-based situations to support thinking about new ideas. Lastly, focal participants relied on communication with peers to support thinking and learning before and during college. Results of RQ3d showed that more than half of class participants integrated strategies for learning into their lives, including, 1) taking notes in their own words, 2) drawing to represent academic ideas, and/or 3) using visualization to support themselves in academics. Class participants also reported meta-learnings, including 1) how drawing could support learning, 2) how visual thinking could support strategies for learning, and 3) how language supports thinking/understanding, including how using one's one words in notes supports learning. The triangulation of the TEMPro analysis, quantitative analysis, and qualitative analysis shows that focal participants were visual learners, most of whom had a degree of metacognitive knowledge for their visual thinking (in relation to learning) in the pre-assessment and who made metacognitive gains during their first semester in college.

Research question 3 asks, *what themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?* In RQ3, the researcher deduced through template analysis, provisional coding, and longitudinal analysis, that six change themes occurred for the majority of (at least four) focal participants over the course of their first semester in college. The six change themes are listed in Table 144.

Table 144

Change Themes Deduced from all Analysis over the Course of the Semester

Category	Change Themes
Knowledge and Dispositional Change Theme	Understand More About the Ways I Learn Best
Strategy and/or Behavior-based Change Themes	Reflecting on Visual Thoughts in Learning Scenarios
	Monitoring "Understanding" when Learning More
	Using My Own Words to Create Understanding
	Developing Visual Systems to Support Understanding
	"Visualizing" in Learning Scenarios to better Understand New Ideas

Quantitative and qualitative analysis revealed focal participants became more metacognitive in learning situations, tuning into their own attention, understanding, visual thinking, and learning more from the pre-assessment to the post-assessment.

Monitoring “Understanding” when Learning More. Notably, focal participants monitored their thoughts more in learning situations by the end of the semester. The change theme, “Monitoring “Understanding” when Learning More” was the primary change that occurred for focal participants during the semester and the central finding of the study. All focal participants confirmed a change occurred in the post-assessment, provided rationale for how they monitored their thinking more, and verified they monitored their understanding more in member checks. In the post-assessment, participants engaged in monitoring by, 1) purposefully thinking about their own understanding inside and outside class, 2) monitoring their attention while teachers presented information in class, and 3) asking questions about their own understanding when engaging with new academic ideas.

Understand More About the Ways I Learn Best. Focal and class participants learned more about themselves as learners. The five strategy/behavior-based change themes in Table 143 impacted the change theme "Understand More About the Ways I Learn Best." The change theme, “Understand More about the Ways I Learn Best,” is a result of knowledge gained from 1) learning about learning in the ASC, 2) learning about learning strategies in the ASC, 3) application of physical and mental strategies, and 4) reflection on strategies used in the course of learning. Qualitative analysis reveals that the application of learning strategies was critical for facilitating meta-learning and change in the context of the ASC. The primary strategies that students applied to understand how they learned were, 1) use of mental images (visualization) to 'see' (understand), 2) visual note-taking strategies that supported students visual processing and thinking, 3) use of natural language (i.e., words) internally/externally, and 4) reflective/metacognitive thinking. As a result, focal participants gained metacognitive knowledge and metacognitive confidence for their learning. Additionally, some focal and class participants reported, a) improved academic performance and/or learning, and b) developed and/or became aware of positive dispositions towards learning (e.g., "Feel in Control of My Learning").

Visual Thinking Changes. Focal participants assigned more meaning to their visual thoughts and for control-based behaviors related to their visual thoughts (i.e., mental images, visualizations) in the post-assessment as compared to the pre-assessment. This indicates participants developed metacognitive knowledge and (metacognitive) regulation for their visual thinking in learning situations. Qualitative analysis suggests all six interview participants understood, by the post-assessment, that they thought about and/or understood ideas through their mental images (e.g., "visualizations). Focal participants became more reflective toward their own visual thinking in learning situations than they did at the beginning of the semester (i.e., "Reflecting on Visual Thoughts More in Learning Scenarios"). The researcher concluded that focal participants reflective thinking for new academic ideas, combined with the knowledge students gained about visual thinking led to more reflection/awareness of their visual thinking in learning scenarios.

Most focal participants also reported creating context and/or additional meaning through their visual-mental thoughts, represented by the themes "Creating Context Through Visual Thinking" and "Actively Relating / Connecting Visual Ideas." Participants engaged in these behaviors by, 1) purposefully thinking about story-based scenarios, 2) organizing their thoughts into structures that held meaning to them, and/or 3) connecting/relating new ideas to previous knowledge. Additionally, at least four focal participants showed a connection between the physical act of taking notes and the mental act of picturing ideas in one’s notes by the post-assessment/second member check. This connection existed for one focal participant in the pre-assessment.

Using My Own Words to Create Understanding. Focal and class participants utilization of language was another important finding. Focal participants reported behaviors indicating they regulated their use of language more during their first semester in college. Focal and class participants integrated writing ideas in their own words and embraced using language as a ‘tool’ to support learning. In the post-assessment, participants engaged in using language by, 1) writing meaning in their own words, 2) discussing ideas with peers, and 3) using internal (or mental) dialogue when engaging with academic ideas.

Developing Visual Systems to Support Understanding. All focal participants took notes in their classes, and all reported changing how they visually formatted and/or represented academic ideas in their notes to support their understanding. The majority of focal participants reported and/or indicated they developed unique "systems" over the course of the semester to better represent/format academic ideas.

As a change theme, “Developing Visual Systems to Support Understanding” brings together post-assessment themes provisionally coded as, metacognitive knowledge, “MK,” metacognitive regulation, “MR,” and metacognitive strategies, “MetStrat,” which indicates focal participants learned about and engaged in more behaviors/strategies for capturing their notes in ways that supported their ability to mentally ‘see’ and/or understand academic ideas. In the post-assessment, focal participants reported more 1) drawings (e.g., “Drawing Icons and Diagrams in Notes”), and 2) formatting with bullet points and color-coding (e.g., “Structures Notes as a Visual System to Understand Ideas”).

Considerations. Focal participants overall assigned more meaning to physical and mental strategies provisionally coded as "MR," indicating that participants regulated their learning more by the end of the semester. Overlap existed between change themes in many cases suggesting change themes were not as broad as they might appear, and that cohesiveness existed in terms of what participants' learned. For instance, focal participants use of, a) reflection for thinking about new ideas, b) monitoring of understanding, c) internal dialogue to think about new ideas, and d) visualization to understand spoken words, overlapped in many focal participants statements. Thus, some cohesiveness existed between what was learned (in relation to strategies) in the context of the ASC. However, the extent to which participants used multiple strategies cohesively is not clear.

Because visual thinking and other changes were primarily reported by class and focal participants in semi-structured interviews, and not observed in this study, the researcher approaches 'changes' with caution. The researcher suggests the reported change themes be thought of as strong evidence for change; a likelihood that many FYFG students enrolled in the ASC became more metacognitive and in control of their thinking and learning during their first semester in college. Observations of students in learning situations (e.g., think aloud methods) would need to be conducted to make more definitive statements. Therefore, the degree or magnitude of change for focal participants is unknown without further observation. However, quantitative analysis suggests moderate metacognitive gains occurred during the study. Changes for individual participants is discussed next.

Individual Changes. Individual changes for focal participants occurred that were not discussed in Chapter 4. For example, in the post-assessment Daniel stated that the ASC helped him realize that he needed "to be more open-minded to try new things" for his learning. He additionally stated, “I've become more open to the idea of trying new things in terms of helping myself learn.” However, the post-assessment theme, “Open-mindedness to New Ways of Learning” was only present in the data for two focal participants. Focal participants reported challenges is discussed next.

Challenges. In a follow-up to Q10 of the post-assessment, the researcher directly asked “What challenges do you still face as a learner? Focal participants in the post-assessment reported they experienced two primary challenges in relation to learning. Four focal participants reported that being motivated was still a challenge to their learning (reflected by the post-assessment theme, “Being Motivated as a Challenge to Learning”). Additionally, two focal participants reported they still struggled to understand some challenging academic concepts, (reflected by the post-assessment theme, “Still Struggling to Understand Some Challenging Ideas”). Criteria from longitudinal analysis that was not discussed in RQ**3** will be briefly discussed next.

Turning Points. “Turning points” is a criterium of longitudinal analysis (Saldaña, 2003; 2021) related to *turning points that occur through time*. There were no turning points for focal participants as a group. Participants had unique turning points, such as declining academic performance, which supported a change event. However, a theme did not materialize that would support a change event. Some turning points were mentioned in Chapter 4 and are discussed in Chapter 5.

Constance in Themes. “Constant” is a criterium of longitudinal analysis (Saldaña, 2003; 2021) in this study related to *what remained constant through time*. Participants mentioned *re-reading the text* and/or *slowing down to read text as a way to understand the words on the page* in both the pre- and post-assessment. While there was a class in the ASC (in the learning and thinking block) that focused on how to skim read and mentally pull main ideas off the page, this mental activity was never discussed among participants. No other themes remained constant.

Decrease in Themes. “Decrease” is a criterium of longitudinal analysis (Saldaña, 2003; 2021) in this study *related to what decreases through time*. The primary themes that decreased or did not show up in the post-assessment that were present in the pre-assessment were “Searching in Google for Help with Class Material” and “Focusing on Visual Movements of Speaker to Understand Their Words.” The researcher assumes that focal participants developed an expectation of what the researcher was looking for, particularly, when asked how they mentally construct ideas (i.e., what happens inside their minds) in learning situations in the post-assessment. For example, the theme, “Searching in Google for Help with Class Material,” which emerged in the pre-assessment, was absent in the post-assessment. Understanding that the ASC focused on physical and mental strategies to support conceptual learning, participants may have believed Google searches to not be an optimal answer to post-assessment interview questions.

Additionally, in the pre-assessment focal participants had challenges answering some of the ‘mental’ questions in the AoC section, but by the post-assessment participants did not have challenges answering these questions. They often explained how they thought visually and/or what they did to create meaning for themselves. It’s assumed by the researcher that based on what focal participants learned and likely what they determined to be the researchers’ focus; they answered the questions in the post-assessment more directly, particularly in the AoC section. For example, focal participants no longer mentioned watching the speaker to see their movements to makes sense of ideas, as that was never discussed in the ASC. More participants focused on the things they did mentally to make sense of the ideas (e.g., “Visualizing Ideas to Understand Speakers Words”). Therefore, the “decreases” in longitudinal analysis primarily related to strategies that participants could have still utilized but, a) decided were not optimal answers, and/or b) decided that newer strategies/behaviors related to the ASC were more effective answers.

Chapter 5: Discussion

The purpose of this mixed-methods case study was to investigate how first-year, first-generation college students assessed the way they visually thought and learned when entering college, and what changes occurred to their visual thinking and learning in the context of a course that facilitated meta-learning. One may ask, why explore changes to visual thinking and learning? The researcher became interested in this subject after his own meta-learning experiences. The researcher never fully understood his own learning until taking doctorate courses in neuroeducation. Learning about the curriculum because a dual process of learning disciplinary content and learning his own learning.

One might also ask, how could the researcher not fully understand his own thinking and learning, even though he had made it that far in his education? The answer to this question, spurred this research. In short, the researcher had not developed metacognitive awareness for his own visual thinking and learning. As Kazemi & Ghoraishi (2012) explained, “metacognition is a self-awareness ability,” however “students are often not conscious about their knowledge and skills in the learning process (Kazemi & Ghoraishi, 2012).” The researcher was not aware that he could learn more deeply through his own visual-mental thoughts and language. He had used visual thinking and language throughout his life to learn but was mostly unaware of it. In reflecting on these experiences and speaking with others in the neuroeducation program that experienced something similar, the process of understanding how one learns, can begin to help a person understand what they are capable of, and that can be empowering.

The researcher became curious what it would it be like to immerse first-year students in a curriculum that helped them learn and develop metacognition for their visual thinking and learning. Might that be impactful to students that are facing so many new academic challenges?

An opportunity became available to study and work with first-generation students because of a pilot initiative that was being developed. In the process of working with first-generation students the researcher learned as much as he could about the first-generation population, so that he was not only serving his own needs. The researcher came to understand that supporting first-generation students' learning is a matter of *equity* because the population consists of demographics (e.g., racial minorities, females, lower-income families) that regularly experience oppression, marginalization, and inequity in college (Choy, 2001; Ives & Castillo-Montoya, 2020; Lohfink & Paulsen; Rodini et al., 2018). In studying the first-gen population, the researcher found something greater than visual thinking and learning – by the end, the researcher understood more about what it meant for a group of underrepresented students to learn about themselves and others, develop a sense of control for their learning, and a sense of belonging in a classroom.

Overview of the Research

To study changes to first-generation students visual thinking and learning during their first semester in college the researcher designed and developed a study involving two primary components. The first component involved an extensive review of literature that discussed, 1) first-generation college students and their academic learning, 2) the relationship between, metacognition, meta-learning, and first-generation students, 3) the connection between language, cognition, and metacognition, and 4) the conceptual framework for visual thinking and learning from a neuroeducation theoretical framework (see Chapter 2). This review of literature was necessary to frame constructs such as metacognition, meta-learning, as well as visual thinking and learning to analyze these constructs effectively.

The second component involved the methodological framework for collecting and analyzing data which investigated first-generation students' visual thinking and learning during a 15-week academic success course that hosted a 'learning and thinking' block of classes. The 'learning and thinking' block (or meta-learning block) spanned five weeks and focused on helping students explore their own thinking and learning within a neuroeducation framework. The researcher, acting in a separate academic capacity, helped to co-design the curriculum, co-teach the curriculum, and provide student feedback. The primary goal for the researcher in the role of 'guest instructor' and 'co-curriculum designer,' was to help first-year, first-generation students gain an understanding/awareness for their own thinking and learning to develop strategies that support the ways they learned best. The primary goal for the researcher in the context of the study then, was to explore how meta-learning within a neuroeducation framework, which specifically views language as the vehicle to learning, impacted first-generation students visual thinking and learning, if at all.

The researcher conducted semi-structured interviews with six focal participants near the beginning of the learning and thinking block and near the end of the ASC to assess changes to visual thinking and learning. The researcher also collected class activities and artifacts near the mid-point of the study from 23 class participants to assess and corroborate changes over the span of the semester. "Change" in this study was operationalized as cumulative, consistent, and/or emergent themes that appeared in focal participants' responses over time, which indicated positive difference and/or growth of said themes (Saldaña, 2021).

To interpret changes to visual thinking and learning the researcher analyzed participants' transcripts and written assignments for cognitive, metacognitive, and meta-learning phenomenon. Member checks were used to verify, clarify, and elaborate on these themes. The researcher specifically assessed the development of *valid knowledge*, which refers to language (or personal discourse) that develops *attention* for seeing, embracing, and correcting the ways which an individual acts into the world (Bamber, 2008; Meyer, 2003; Torbert, 1999). Meta-learning was conceptualized as a process by which one comes to understand and control their thinking and learning processes including behaviors and attitudes that support growth (Colthorpe et al., 2018; Maudsley, 1979; Jackson, 2004).

The researcher used a combination of qualitative methods to analyze participants' interview transcripts and class activities (i.e., a written journal entry and learning strategy assignment) to develop themes and interpret changes over the span of one semester (see Chapter 3 or Chapter 4 for an abridged explanation). Additionally, 23 students completed the metacognitive awareness inventory (MAI) during weeks five and week 14 of the ASC. MAI pretest and posttest scores were quantitatively compared using a paired samples t-test (see Chapter 3 for explanation).

Using mixed-methods in this capacity helped the researcher to validate metacognitive gains among class and focal participants. Therefore, semi-structured interviews and class activities collected during the ASC, in addition to statistical analysis of the MAI, allowed the researcher to assess whether meta-learning had meaningful changes to students' visual thinking and learning. Chapter 4 thoroughly discusses the quantitative and qualitative analysis and findings.

The researcher details in this chapter how the methodological approach extended the researcher's understanding of the qualitative data and led to the identification and interpretation of participants experiences. This final chapter will, 1) summarize the findings, 2) compare the findings to the literature, 3) list the limitations of the study, 4) discuss future directions for research on meta-learning and metacognition, 5) discuss the practical implications of this research, and 6) conclude with recommendations for how to properly implement a meta-learning curriculum in a college setting. This study was guided by the following research questions, the findings of which, will be discussed next:

1. What does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition?
2. What changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fifteen of an academic success course?
3. What themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students' knowledge, strategies, and dispositions for visual thinking and learning?
    a. What do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course?
    b. What do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course?
    c. What do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course?

d. What meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students' visual thinking and learning?

Interpretation of Findings

The following section and subsections provides findings related to who FGCS participants are as learners and how they changed their visual thinking and learning during their first semester in college. To date, there were no known studies that investigated changes to FGCS as they engaged in a process of learning about their own learning during their first semester in college. More research was needed to understand first generation college students as academic learners and the changes they experience when engaging in courses designed to support their academic success (Ives and Castillo-Montoya, 2020).

The Arwood Neuroeducation Model (Arwood & Merideth, 2017) was applied to the ASC and in the research to conceptualize visual thinking, learning, metacognition, and meta-learning among other concepts. In connecting the findings from qualitative and quantitative data sources, the researcher found that moderate-to-strong gains were made in metacognition (including knowledge and regulation) for learning over the course of the semester. Collectively, the analysis supports the positive impact the meta-learning context had on focal participants' meta-learning processes, as well as the development of metacognition (knowledge and skills) for their visual thinking and learning. Meta-learning processes and themes were identified primarily through the application and implementation of metacognitive strategies. The following subsections summarize the findings from each research question.

Research Question 1 - Temporal Analysis Interpretations

The first research question asked what does functional language analysis of language samples of first year, first-generation students', suggest about participants' auditory or visual cognition? To answer this question a TEMPro analysis (Arwood & Beggs, 1992) was conducted on interview participants' responses to an auditory prompt – "What do you do on a typical day"?

No participants produced an auditory proposition during the pre-assessment of this study. This suggests that none of the six students used auditory thinking to connect ideas in time. As a result, all six participants who responded to the TEMPro indicated having a visual learning system. In other words, they use a visual cognition to process and represent auditory concepts, such as 'typical day'. The six participants do not possess a linguistic level of language function for auditory concepts, which is now typical for students. Rather, results indicate that focal participants' use visual thinking to represent and learn concepts.

Research Question 2 - Metacognitive Awareness within the Academic Success Course

The second research question asked what changes occur to first year, first-generation students' metacognitive awareness as measured by the metacognitive awareness inventory (MAI) taken in weeks five and fourteen of an academic success course? Running statistical analysis on MAI pretest and posttest scores revealed there was an increase in mean score by 19.75 points that was statistically significant. There was a moderate effect size (d = .78), which means practical significance for the ASC curriculum likely exists. When segmenting the overall MAI score into two factors, knowledge of cognition (metacognitive knowledge) and regulation of cognition (metacognitive regulation), there was a statistically significant increase in both knowledge of cognition and regulation of cognition scores, $\alpha < 0.05$.

Furthermore, a metacognitive gain formula showed a mean metacognitive gain (MG) of 0.21 (21%) during FYFG students' first semester in college. This formula, termed the "average normalized gain," was a measure of class effectiveness in promoting conceptual understanding, based on what was possible (a maximum score of 260) (Hake, 1998, p. 64). Twenty-one out of 24 students experienced positive metacognitive gains, while three participants experienced declines in average gain scores.

Cumulatively, these results reveal that most class participants made gains in metacognitive awareness during their first semester in college, likely because of participation in the ASC. Thus, changes occurred to first year, first-generation students' metacognitive awareness in terms of gains for both knowledge of cognition in relation to learning (i.e., knowledge of one's learning and learning strategies) and the regulation of cognition (i.e., monitoring/control of metacognitive strategies and skills for learning).

One consideration about the MAI as an instrument should be mentioned. The MAI comes primarily from cognitive psychology research. Because the ASC curriculum and this study used an interdisciplinary framework (that includes cognitive psychology) some of the items were not a good fit. Four items showed decreases in collective means scores, such as item 52, "I stop and reread when I get confused" (*MD* = -.08); item 3, "I try to use strategies that have worked in the past" (*MD* = -.25); item 29, "I use my intellectual strengths to compensate for my weaknesses" (*MD* = -.29); and item 46, "I learn more when I am interested in a topic" (*MD* = -.04). None of these four items were a focus of the ASC curriculum and do not fit the neuroeducation framework used in this study. For instance, "I stop and reread when I get confused" was not supported in the ASC, even though this may be needed at times. The ASC curriculum taught students how to read so they wouldn't have to reread several times. So, item 52 could have been interpreted as an insufficient strategy or been thought of adversely by class participants.

Another item, was “I use my intellectual strengths to compensate for my weaknesses.” This is a vague statement that does not make explicit what is an intellectual strength and weakness. The Arwood Neuroeducation Model (ANM) promotes that most all students can develop intellectually through strategies/techniques that support their learning system. Therefore, the ASC was centered on strengths not weaknesses. Graduates of the neuroeducation program rarely if ever talk about student weaknesses and would advise against this practice.

Additionally, as it relates to item 3 the class taught primarily visual, mental, and language strategies that students were unlikely to encounter in their previous education, so falling back on old strategies may have also been interpreted negatively. Lastly, as it relates to item 46, the professors in the ASC taught students how to engage with all ideas not just ideas they are interested in. Although, it was acknowledged that students tend to learn more when information is meaningful. Therefore, it’s hard to interpret how some students might have perceived this item.

In sum, it’s not surprising, and perhaps beneficial that these scores saw decreases from pretest to posttest. Metacognitive gains along with other quantitative measures may have been greater if replaced with items that were a better fit. Alternatively, not all items that had positive increases were a perfect fit for the neuroeducation framework using in this study. Overall, these findings provide support for the quality of the ASC's efficacy for promoting metacognitive awareness and serve as a benchmark for future development of meta-learning approaches.

Research Question 3a - First-Year First Generation Students’ Previous Experiences with Learning

Research question 3a asked what do participants in a first year, first-generation student cohort report as previous experiences with learning in an academic success course? The twenty-three class participants, and six focal participants were the focus of this question. Template analysis on focal participants interview transcripts and class participants written journal entries, among other qualitative methods, helped to answer this research question. The following subsections will discuss the prominent themes found. See Appendix N for full list of pre-assessment themes and Appendix O for full list of class activities' themes.

Few to No Experiences Learning about Learning. Five out of six focal participants affirmed that they had few or no experiences where a teacher or counselor had helped them with their learning and/or thinking. Additionally, three focal participants indicated that their previous experiences learning about their own learning and thinking were lacking. In other words, participants indicated that any experiences they might have had learning about their own learning were not substantial. For instance, Daniel stated "I would say there's at least been three times in my life where I've taken those tests that determine whether or not you're like a physical, like hands on learner or if you're an auditory learner or whatever learning styles suits you. And I've always just like, I've always taken those tests and I thought to myself, 'I wish I could have more to go into this.' I wish there was like something more to offer than just like, 'oh, this is what I got.'" Additionally, in a follow-up question the researcher asked Ashley, "Okay, so were there many in-class experiences where (teachers) talked specifically about learning and thinking?" Ashley, responded, "Not really, and if they did, it would be a brief discussion maybe one to two sentences exchanged, like it wasn't a whole ordeal."

Did Not Know How to Study in High School. Seven class participants mentioned that they didn't know and/or had never learned how to study prior to college. This was a prominent theme in the study overall. Several class participants related 'not knowing how to study' to negative impacts on learning or performance in high school. Ana conveyed that not learning how to study in high school was negatively impacting her academic performance in college. Ana stated, "Some challenges I faced in the past in high school were mostly taking exams. We never really learned proper ways to study which is majorly affecting my grades in college."

Additionally, four class participants indicated that they did not study regularly for their classes in high school. For example, Renzo stated, "Outside of class one of the hardest things for me was just simply starting the learning process. I would struggle so much to force myself into my desk every day after school, and now in college it's even worse when I have only myself keeping track of myself." Additionally, two class participants mentioned periodically looking over notes quickly, possibly for the purpose of test-taking. For example, Valeria stated, "My study habits consisted of memorizing as much information as possible the night before a test so that it is fresh in my memory when actually taking the test." Lastly, María mentioned not studying for tests at all, "A problem I had in high school was that I would never study for test(s). Memorizing things for tests was never really my thing and I would go into my exams blind. I would take the tests with what I had learned from in class and nothing else." Lack of motivation was interpreted as an implied obstacle for all participants coded for this theme. This could be because studying in high school often takes the form of memorization of material for the purposes of test-taking, rather than studying to think and learn. If this was the case, as it seems to be, then there was little-to-no semantic and semiotic basis for studying academic material.

Four class participants also indicated that their high school education was not challenging. For instance, one of the focal participants' Daniel stated, "I don't think I experienced a challenge in learning until college." Additionally, two class participants Ana and Valentina, related 'not being challenged in high school' to negative results in college. For instance, Valentina stated, "In high school it felt like I really had to try to fail but here I really have to try in order to get a decent passing grade and it can be really frustrating at times."

Communication in Groups Helps with Challenging Ideas. Three focal participants discussed previous experiences (before college) in which they worked in group settings, primarily with peers, to help resolve confusion. For instance, Ashley responded that she hadn't any experiences where she figured out things on her own because she usually worked with peers or a teacher. When asked to explain how working with a friend helped her, Ashley stated, "I think it would be the two of us talking back and forth because again me, coming up with one question could be completely different from a question that my friend had. So, like if we both put our heads together, we tackle the problem at different angles." Additionally, Dalisay stated, "I tend to work with other people to help me figure out because, I don't know, for some reason I feel more comfortable reaching out to students than my own teachers."

Watching Educational Videos to Learn Better. Three focal participants explained that they watched educational videos, particularly Khan Academy videos, as a strategy to help learn confusing academic material. For instance, Dalisay stated, "I personally go to Khan Academy and some YouTube professors or teachers online, not professors, but AP Calculus YouTube videos… because they give you practice problems after the short videos. And you can look back in the videos, and if you do get it wrong, they'll show you what you did wrong and explain to you why you got it wrong, so you would understand." Additionally, Daniel stated that he actively sought out videos to learn material that might not be as easy to grasp, such as in math, "I like to seek out more resources. I think having the Internet available to me has been a real big help… because I've always been able to just YouTube. By going to YouTube or I can just search for the concept and keep looking until I find someone (that) has an explanation that I can help break down for myself." The three participants, coded for the theme "Watching Educational Videos to Learn Better" explained how videos helped their understanding in some facet, which indicates metacognitive knowledge (MK). For instance, the term "break down for myself" in Daniel's previous response, indicates that Daniel uses educational videos to break down bigger ideas into smaller concepts to help him understand the whole process. For Dalisay, watching videos helped her correct her thinking (i.e., know what she did wrong) so she could understand or better understand calculus problems. For example, Dalisay stated, "…Khan Academy like gave me that chance to actually sit down and actually learn things. I think it's just the format and the multiple possibilities of practicing. They give you a lot of practice. It's very specific to their curriculum. Every step it shows you-- especially for math, it helps me understand where I went wrong and stuff."

Other Prominent Themes. Other prominent themes that emerged from focal participants responses were "Taught to Use Cornell Notes" and "Teachers Supporting Students Learning" Regarding the support of learning - three participants mentioned previous experiences (before college) that teachers supported their learning of academic material. These responses were not related to learning about learning.

Summary of Findings for RQ3a. Again, five out of six focal participants affirmed that they had few or no experiences where a teacher or counselor had helped them with their learning and/or thinking. This finding coincides with themes that emerged in JE6 for class participants, notably that several did not know (or never learned) how to study and/or they did not study regularly. If participants were never taught about learning and/or learning strategies, it follows that they would mention not knowing how to study properly, and potentially have limited interest in studying consistently.

Focal participants were asked about how they cleared up confusion on their own before college. Participants primarily discussed either experiences working with others, particularly peers to figure out challenging ideas, or they mentioned watching educational videos to help their learning. Regarding the former theme, focal participants often did not clearly discuss how experiences working with others supported their learning, notably how language might support their thinking or learning. Regarding the latter theme, focal participants clearly acknowledged that videos supported their understanding. Interestingly, each individual had unique reasons as to why videos supported their understanding. For instance, watching educational videos allowed Abby to pause and rewind to gain access to more content; while videos helped Lilly see step-by-step processes, and helped Daniel gain access to more content so that he could then break down ideas into smaller chunks.

Research Question 3b - First-Year First Generation Students Understanding of their Learning

Research question 3b asked what do focal participants in a first year, first-generation student cohort report about how they learn, in a pre-assessment interview, the first five weeks of an academic success course? The six focal participants were the focus of this question. Template analysis on focal participants interview transcripts among other qualitative methods were used to answer this research question. The following subsections will discuss the most prominent and relevant themes that were identified. While many themes emerged in the pre-assessment, there were elements of each students learning that are not captured in this chapter.

Each focal participants' understanding of their learning was unique. This section draws overarching conclusions from the group of focal participants. It's important to understand that when participants use the term "visualization" or "visualizing" it's because this is the general term used for using or seeing mental images. Participants' and the researchers' general use of the word 'visualization' and its adjuncts in the context of this study implies they are using a visual cognition or their visual thinking to make sense of and 'see' ideas in various contexts when learning. See Chapter 4 for detailed analysis of each participants understanding of their learning when entering college. Also see Appendix N for all the pre-assessment themes and hierarchical relationships that were identified by the researcher.

Mid-Range Understanding of Learning (Rating). Question two of the pre-assessment asked focal participants, "how would you rate how well you understand your learning? On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best?" Participants were asked to rate understanding of their learning at the beginning and end of both the pre- and post-assessment. In the pre-assessment, four participants rated themselves between a five and seven, which the researcher subjectively labeled as "mid-range." One, focal participant Abby, rated themselves high, between an "eight, nine" and Lilly rated themselves low, at a "four and a half." At the end of the pre-assessment, all six participants again rated their understanding of learning. Four participants rated themselves the same as the beginning of the interview and therefore, had no change in their understanding of learning rating. Two participants, Lilly and Daniel, gave themselves a higher score at the end of the interview than the beginning. Notably, Lilly's score jumped from a "four and a half" at the beginning of the interview to an "eight" at the end of the interview. The boost in metacognitive confidence could indicate that the interview itself acted as an intervention.

Still Figuring **out What Works Best for My Learning.** Four focal participants indicated that they were unsure of specific aspects of their learning. Lilly for instance, explained,

"…some methods work for me, but it doesn't work for me in every subject. For example, in science like drawing pictures and more visual learning tools are very helpful to me, but then at the same time, for Math that wouldn't be helpful for me. It would just depend on the subject and I'm still trying to figure out what works best for me." Another participant, Coreen, contrasted her current feelings about learning with how she learned in high school, "I don't feel very confident in how I learn. I never really had to try in high school or middle school for that matter. I would take the notes and take the test and boom, there's an A. It was just really the only study strategy I had was pay attention in class. Now that I'm in college, I'm realizing-- I already knew going into this…that wasn't going to be enough."

Two participants also indicated that they were sometimes unsure of the best way to learn academic ideas. For instance, Ashley stated, "…sometimes I know I learn a certain way. Like I'm a visual learner, but at other times, I'm like, "Oh, I need someone to walk me through step-by-step" instead of just showing me one way through. So, sometimes I get confused on what's the best way for me to understand something."

Being a Visual Learner. Two focal participants, Ashley and Abby, mentioned they believed that most of their peers were visual learners. Ashley referred to the challenges of visual learners in virtual classrooms during the pandemic, "I think lately, everybody's been more of a visual learner because when we went on Zoom and stuff, we found that learning just by listening wasn't the best option. Then going back into in-person, you see everybody like just trying so hard to get that visual side of learning. I think most of us are all visual learners." Ashley and Abby both indicated their peers needed visual stimuli in the learning environment, e.g., being led by example or having diagrams/graphs available in the learning environment. Based on a priori criteria, these responses indicated theory of mind (ToM), as participants ascribe a way of learning to other people.

In a follow-up to question three of the pre-assessment, the researcher asked focal participants to *explain how they think they learn best*. Three focal participants, including Abby and Ashley labeled themselves as visual learners. This theme was coded as “I am a Visual Learner [MK].” Focal participants primarily related this label to needing visual examples (i.e., materials) to understand the ideas presented to them in a classroom. For instance, Abby stated, “…I'm also a visual learner, we like to learn by example. So, for example, we would ask questions to clarify, we'd like clarification.” Shortly thereafter Abby stated, “So yeah, we like to see other people do it to know and to assure ourselves that we're doing what's right.”

Additionally, Ashley stated, “I think I learned best visually, I would say, yeah.” The researcher then asked, “what can somebody do in class to help you?” Ashley responded, “For example, in math, instead of just saying, "Oh, this is the formula, try it out," if (teachers) could just go through it once, and then go through it again with us following what they're doing to make it make more sense…”. Thus, both Abby and Ashley ascribed being a visual learner to needing to see visual, step-by-step examples to support their learning.

Coreen was also coded for the theme “I am a Visual Learner. ”The researcher asked Coreen, “In general, is there anything that you know about yourself and your own thinking that helps you understand other people when they're talking?” Coreen responded, “I know that I do not learn auditorily. I've always accepted that for the longest time. She stated shortly after, “If I'm hearing them talk, I turn and I look at them if I can. I need to.” This response indicates that Coreen needs visual stimuli, (e.g., to see the person’s movements) to be able to understand the (auditory) words that people are saying.

Finally, Lilly indicated she was a visual learner, equating the way she represented ideas (on paper), thought, and communicated with being "visual". For instance, Lilly stated, "Like I had said before, I'm very visual, just the way I communicate in general. When I communicate, even with my friends, like I'll draw pictures, or I show them videos or pictures to better explain myself." Lilly attributed aspects of her communication with peers and family members to her thinking and learning overall. In other words, she was aware of how she thought about ideas, and how others might think of those ideas, and as a result she used/created visual examples (e.g., videos, drawings) to help others understand her best. In the same response, Lilly continued to support the "visual" label, by discussing how she color coded notes to help separate and identify ideas (mentally).

Focusing on Visual Movements of Speaker to Understand. Four participants indicated they look at and/or focus on the visual movements of the speaker to understand the words they are saying. This theme was coded as "Focusing on Visual Movements of Speaker to Understand Their Words [MR (Control), VP]." Three of the four participants coded for this theme indicated focusing on lips (i.e., mouth movements) to understand people when they are speaking. For instance, Coreen responded, "I focus on their lips, which has become very difficult in quarantine and stuff." Correspondingly, Ashley stated "Also, I like to look at lips, just see the words coming out I guess that helps me process better."

Additionally, two participants mentioned having to transition from reading lips to paying attention to body language (e.g., hand and body movements) to understand speakers, because people often wore face masks (due to Covid precautions) when speaking. Coreen explained, "…I've moved to looking more at their body language and not just their lips, but their hands, and their shoulders, and that's helped a little bit… (with) how to understand what they're saying, and

I have to pay so much more attention than I used to…”. Correspondingly, Abby stated, “Having people with face masks, it constrained me to look at other behaviors and aspects like body language and stuff like that. It forces me to be more aware of other things that normally, I would just pay attention to the face or facial expressions and stuff like that.” This indicates that focal participants were metacognitively aware that they needed visual stimuli to help them understand spoken words, and actively engaged in attention-based behaviors to support their understanding.

Seeing with Mental Images and Visualizing Ideas. Four focal participants showed knowledge that they ‘see’ (or understand) ideas through mental images. The theme, “Seeing (Understanding) with Mental Images [MK, VT]” (SwMI) was structured within the category, “Awareness of Cognition,” as it represented participants’ metacognitive awareness in a learning task. The SwMI theme represents metacognitive knowledge for the focal participants visual thinking. For instance, in response to question seven in the pre-assessment, both Ashley and Daniel were metacognitively aware that they understood ideas through mental images (i.e., visualizations) when watching a video or reading. For example, Daniel stated, “when I understand all the parts of something I can visualize it in my head and that's when I would say, I like, that's the moment of understanding.”

Additionally, Lilly, Daniel, and Dalisay were all metacognitively aware that they understood speakers by ‘visualizing’ (i.e., visually thinking about) their spoken ideas. Dalisay stated that she understood spoken words, by ‘picturing’ ideas, and if she didn’t ‘picture’ an image (i.e., concept), or if her image was “cloudy” it was a sign that she was confused. Dalisay stated, “So, I would picture myself as the scientist doing this, and doing that. Then, if I don’t see myself- or I don’t picture it, or I don’t understand what pouring the beaker is to this, that’s like, “Okay.” I got confused, my image is all cloudy and stuff.” This indicates that Dalisay had a level of metacognitive access to her ways of visually processing ideas. It's unclear however, if focal participants saw and used the movement of ideas (i.e., mental shapes and graphics) or whether they saw and used the mental image itself as the source of their understanding. Some evidence suggests that students use the movement of mental ideas in space to process meaning more often than they use the mental image itself (Arwood & Merideth, 2017).

Creating Context through Visual Thinking. Lilly, Dalisay, and Daniel also discussed 'picturing' or 'visualizing' story-based contexts for ideas being spoken about. This theme was coded as "Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills]." Daniel, Lilly, and Dalisay discuss 'visualizations' deliberately, as if they control the behavior (to a degree) and use it to understand or create meaning for what others are saying. For instance, the researcher asked Daniel if he could explain what he meant by 'visualization'. Daniel explained - "Seeing the thing happen in my head. Like, if we're talking about a movie scene, once that scene is described to me, I will try and visualize it in my head and watch it over." Daniel was aware that mentally "seeing" ideas (what he termed 'visualizations') was a source of his understanding and gave examples in which he actively visualized events to understand other people's spoken thoughts. Daniel created story-based contexts for his visual thinking, explaining that he mentally places himself (or other ideas) into situations from different perspectives (e.g., third person) to create more meaning for the ideas he is thinking about.

Furthermore, Dalisay suggested she places herself in various events, even historical contexts to create more meaning to understand spoken ideas. Dalisay stated, "Yeah, if I could see it. If I can see me doing it, or if I can see me understanding it or talking about (a) history event, like the bombing of Pearl Harbor. If they're talking about that, I would picture myself in that situation and see for myself." Lastly, Lilly's quote depicted how she visualizes contexts that she's familiar with and have meaning to her. "Like, I have pet ducks and (my mom) [laughs] will tell me funny stories about them and just having a basic understanding of them and understanding the way my mom is, I can visualize little things that my mom tells me." All three participants show knowledge in these responses that they 1) understand spoken ideas with visual-mental thoughts (or visualizations), 2) that they can mentally see events that have meaning to them (e.g., stories), and 3) that they create story-based situations (i.e., context) to help think about the ideas that are being spoken about.

Summary of Findings for RQ3b. For a thorough review of each focal participants' understanding of their learning see Chapter 4. All students were unique in the way they understood their learning and how they supported their learning. Overlap in participants' meanings, particularly those that related to learning were most prevalent for themes which indicated participants sought, focused on and/or created visual input to better understand new ideas. For instance, several focal participants explained that seeing ideas represented and/or broken down visually supported their understanding. Some participants did mention that auditory information or learning in a kinesthetic style was a factor in their learning, but these assigned meanings were mostly anecdotal.

Three focal participants labeled themselves as being "visual" or being a "visual learner." Another participant, Coreen, indicated that she needed visual stimuli as opposed to auditory stimuli to understand ideas, so she was also included in the theme "I am a Visual Learner". All participants coded for this theme discuss needing to see or create visual stimuli in the learning environment to better understand or 'know' academic ideas. Two of those participants, Abby and Ashley, believe that most of their peers are visual learners and that they also need visual stimuli (i.e., perceivable visual elements) in the learning environment to better understand academic material. Thus far, a pattern has emerged in the first two research questions that indicates many FYFG students believe themselves and most of their peers to be visual learners, but indicate not knowing how to learn, in some contexts. As reported in RQ3a, many class participants have not learned how to utilize effective study strategies and it's apparent from the pre-assessment that focal participants have not learned strategies (from educators) that take advantage of being a visual thinker/learner. Thus, a contributing factor to participants' 'not knowing how to learn in some contexts' is conceivably that they haven't learned how to take advantage of their visual thinking and learning through application of research-based strategies for learning.

Knowledge-based themes that related to visual input included, "Visual Shapes Support Understanding," "Hand-written Ideas Support Understanding," and strategy based-themes that related to students creating/seeking visual input included, "Focusing on Visual Movements of Speaker to Understand Their Words," "Creating (Meaningful) Visual Formats for Learning," "Color-coding Notes to Organize Ideas," "Watching Educational Videos to Learn Better," and "Breaking Down Ideas on Paper to Understand." All themes listed above were provisionally coded as being metacognitive, in that participants referred to an element of their cognition (e.g., processing or understanding). These 'visual' themes aligned with focal participants' statements that they and their peers were visual learners.

Additionally, four of six focal participants mentioned they make sense and/or understand ideas by picturing those ideas mentally. Three focal participants, Daniel, Lilly, and Dalisay explained in depth how visualizing ideas helped them better understand ideas in learning situations, primarily those situations in which a person is speaking to them, i.e., when auditory words are the primary stimulus. Several visual thinking themes were provisionally coded as metacognitive knowledge (MK) and metacognitive regulation (MR) suggesting at least half of focal participants were metacognitively aware of their visual thinking and controlled aspects of their visual thinking to support understanding. For instance, half the focal participants discussed using 'visualizations' deliberately to create context (more meaning) for their learning. This deliberate use of visual thinking indicates half of the focal participants had a degree of metacognitive control over elements of their visual thinking and could use it in a strategic way. However, the majority of focal participants did not show ways in which visual ideas could be connected to language to raise the level of thinking for higher levels of conceptualization.

These results show that more than half of focal participants, at the outset of their first semester in college, had a degree of metacognitive knowledge for their visual thinking. Most notable to this study, that they would 'see' or 'picture' images in learning situations, and their ability to 'see' or 'visualize' ideas was a source of understanding. Provisional coding criteria revealed that half of focal participants had a degree of metacognitive control over their ability to "visualize" context-based situations to support thinking about new ideas. It's important to note that references to visual thinking and language for each participant were intermittent, and sometimes required follow-up questions. Overall, focal participants explicitly stated they were "visual learners," although this was primarily attached to the conception of needing visual inputs, but explained why visual inputs helped them metacognitively. Additionally, more than half of students explained their visual thoughts were a source of their understanding. These findings offer more support to the findings of RQ1, in so far as focal participants likely use a visual cognition to represent and learn language-based concepts. Lastly, participants reported learning or having realizations about their thinking and learning during the interview, which suggests the pre-assessment (and the member check) were meta-learning interventions in themselves.

Research Question 3c - First-Year First Generation Students Align Strategies with Thinking

Research question 3c asked what do focal participants in a first year, first-generation student cohort report as strategies that support thinking and learning, as recorded in a pre-assessment interview, during the first five weeks of an academic success course? The six focal participants were the focus of this question. Template analysis on focal participants interview transcripts among other qualitative methods were used to answer this research question. The following subsections will discuss prominent and relevant themes that were identified. This section draws overarching conclusions from the group of focal participants. See Appendix N for all the pre-assessment themes and hierarchical relationships that were identified by the researcher.

Creating Visual Formats for Learning. "Creating (Meaningful) Visual Formats for Learning" was the primary theme that emerged from the pre-assessment, in terms of 1) number of quotes coded overall, 2) number of participants who reported a strategy that fell under this theme, and 3) depth of metacognitive knowledge, i.e., explanations for why participants engaged in strategies that fell under this theme. 'Creating visual formats' relates to the ways in which students captured/formatted ideas, primarily on paper but also digitally. This is an overarching theme which encompasses the sub-themes, "Color-coding Notes to Organize Ideas" and "Breaking Down Ideas on Paper to Understand." The through line between these strategies is that students developed visual formats, based on what made sense to them, and often referenced an ability to see the ideas, which supported their understanding, and in some cases their thinking. Students reported that such formats/structures supported their ability to identify, separate, organize, and/or connect ideas.

For example, Abby stated, "…and I have a set format especially if it's on paper or something that I can see, that helps guide my thinking and my learning. (cont'd) I like to outline the processes of thinking or of an assignment or steps that I would have to go through in order to complete something." Additionally, Lilly stated, "…I wrote down every chemical formula…because we're going over amino acids and how to identify if it's hydrophobic, hydrophilic all of that stuff. Just writing it all out and just looking at it color coded; it helped me create that separation and the visualization which part to look at." Here Lilly is connecting the process of developing a visual format for new scientific ideas with mentally identifying what's important in her notes.

Some focal participants also utilized their language to capture ideas and/or break down ideas on physical/digital pages. For instance, three participants, (Daniel, Abby, and Ashley) used elements of their own language to break down ideas (i.e., create smaller ideas) or write out steps to understand challenging ideas. Cumulatively, the theme "Creating Visual Formats for Learning" indicates some focal participants, a) adapted their notetaking over time to include more visual formats, which varied based upon subject matter, and b) learned to break down ideas or write out steps to an idea/process on paper or digitally. In few cases, where these strategies were used together, such as Abby and Lilly described, notetaking likely supported their ability to understand and think with ideas, which would raise their level of conceptualization (i.e., thinking). It's important to note that color-coding is not considered a conceptual strategy but it's possible that developing a meaningful system for color-coding key terms or thoughts, supported other conceptual strategies (e.g., breaking down ideas on paper with one's language). Interview responses (from the pre-assessment and member check) and artifacts showed that five focal participants created meaningful visual formats (e.g., shapes, colors, and/or spaces), which reportedly helped to better identify, organize, and/or create relationships between ideas. Thus, participants had some awareness for ways they could process, understand, and think with academic ideas, although the researcher would hesitate to relate this theme to visual thinking as participants rarely discussed ways they could raise their thinking or mentally picture ideas in relation to this theme.

Using Language to Support Thinking/Learning. Five focal participants reported using language to support thinking/learning of new ideas, represented by the themes “Using Dialogue to Support their Thinking/Learning” and “Writing Ideas in My Own Words to Understand.” Using one’s natural language internally and externally was something that was taught in the ASC starting in week one of the learning and thinking block. Dalisay and Coreen immediately reported they had begun to write ideas in their own words (when taking notes) and it had been effective thus far. This shows that Dalisay and Coreen had begun their own meta-learning processes before the pre-assessment occurred. For instance, Dalisay stated “Actually, ever since you talked about writing notes in your own words, I’ve been doing that ever since. (cont’d) …it forces me to really understand what I’m learning, because my goal now, is to try and write things in my own words. It pushes me to actually listen and understand, and then, think about it and then write it my own words, but yes. Additionally Coreen stated, “I write down what (the teacher) says and then when she's like pausing to take a breath and drink of water, go to the next slide, I think about it in my head. If I think of a better way to say that makes sense to me, then I write it down.”

Pre-assessment themes that relate to utilization of language/communication indicate focal participants largely relied (before college) and continued to rely (early in college) on their language, particularly communication with peers, to support thinking and learning. Participants used their own words (i.e., natural language) to varying degrees when speaking, thinking, and writing (taking notes), to support their conceptual understanding of new and sometimes challenging ideas. Participants referenced using their language in connection with other strategies or behaviors (e.g., taking notes), with a few exceptions. Notably, Lilly integrated language with visual thinking (in moments of reflection) to support her ability to connect ideas and develop logic.

Visualizing Ideas. Focal participants engaged in visual thinking strategies, particularly "Visualizing Ideas to Understand Speakers' Words," and "Creating Context through Visual Thinking." Four focal participants referenced their visual thinking as a source of their understanding (e.g., "Seeing Ideas with Mental Images") and those four also indicated (through provisional coding) they used their visual thinking or "visualizations" strategically at times. For example, when asked about how he understands someone (he knows) when they are talking to him, Daniel stated, "When they're talking to me, I like to take the story and I like trying to like place myself into that third person like view of their story and try to visualize every element. (cont'd)… if I can first hear it, like everything described, and then take the parts that I've heard, and then put it all together into one little scene that I can visualize, that's where I think my understanding and learning is."

As discussed in the previous research question, three focal participants (Daniel, Dalisay, and Lilly) used "visualizations" to create context (meaning) for their thinking, sometimes from different perspectives, which helped them understand spoken ideas. Three focal participants (Ashley, Daniel, and Lilly) also referenced visual thinking to understand or remember new ideas when engaged with visual input, e.g., writing notes and flashcards and when reading. Thus, focal participants metacognitively assigned meaning to their visual thinking when presented with predominantly auditory and visual input in learning situations. However, there was a predilection for mentioning visual thinking in relation to understanding spoken ideas, which likely means that these focal participants use visual cognition to process auditory concepts and are metacognitively aware of some aspects of this process.

Summary of Findings for RQ3c. Four participants showed an awareness of their visual thinking and/or visual thinking strategies, three of which also showed some regulatory and (metacognitively) skilled visual thinking behaviors to support learning. Therefore, more than half of focal participants, at the outset of their first semester in college, had a degree of metacognitive knowledge for their visual thinking and three participants indicated having a degree of metacognitive control over their ability to "visualize" context-based situations to support thinking about new ideas. Some participants also utilized their language skillfully in terms of deliberate and consistent use of strategies to support learning.

References to visual thinking and language for each participant were intermittent, and sometimes required follow-up questions. The extent to which participants controlled visual thinking in terms of how active or skillful they were at picturing events in various learning scenarios is unclear and is not the focus of this research. It's possible those aware of their visual thinking when prompted with a learning task might explain their visual thinking in terms of control, but in actuality they are only aware of these ideas. Cumulatively, this suggests all students had metacognitive knowledge for aspects of their learning, specifically how they visually process and/or visually understand new academic ideas. More than half of focal participants had metacognitive knowledge for strategic aspects of their visual thinking and learning and half of focal participants used strategic behaviors in relation to their mental imagery.

Lastly, four participants indicated they (metacognitively) monitored their own thinking/understanding in the process of a learning task. This was a broader theme, that incorporated different types of monitoring behaviors in various learning tasks. **Additionally, a**ll focal participants indicated that they searched for materials online **(e.g., Google)**, particularly when faced with challenging ideas. Participants discussed utilizing online tools in high school and also during their short time in college.

Research Question 3d - Meta-Learning Themes That Emerged at the Mid-Point of the ASC

Research question 3d asked what meta-learning themes become apparent in two class activities, during an academic success course, that relates to first year, first-generation students' visual thinking and learning? Several prominent and notable themes emerged from the class activities (LSA and JE6), which answered research question 3d and provided evidence to answer the primary research question, RQ3. Template analysis on twenty-three class participants' written class activities (JE6 and LSA), among other qualitative methods, helped to answer this research question. The following subsections will discuss the prominent themes found. Most themes that related to meta-learning emerged in response to class participants applied and/or integrated strategies. See Appendix O for full list of class activities' themes.

Using Drawing as a Strategy for Learning. In total, 16/23 class participants applied and/or integrated drawing as a strategy for learning between the class activities (LSA and JE6). Eight of those sixteen participants reported utilizing drawing as a strategy for their learning in both the LSA and JE6. Ten of 23 students learned that drawing supported their learning/understanding (coded as "Drawing Supports Aspects of My Learning" in the LSA and "Drawing Helps to Better Understand Material" in JE6). There were various other learnings from drawings, captured in the themes "Various Learnings from Applying Drawing" in the LSA and "Various Learnings from Drawing" in JE6. Thus, over half of class participants (12/23) reported knowledge they had attained (in most cases, meta-learnings) from utilizing drawing as a strategy for learning. Commonly mentioned challenges to drawing were that it was time consuming and that it was difficult to think about what to draw.

Using Visual Thinking. Eight class participants understood aspects of the connection between drawing and visual thinking (coded as "Drawing and Seeing Thoughts" in the LSA, and "Connection between Drawing and Mental Images" in JE6), which means more than one-third of total class participants, including one half of those who applied and/or integrated drawing as a strategy, had knowledge of using visual (mental) thoughts with drawing to represent ideas. Additionally, seven of 23 class participants indicated applying and/or integrating visualization as a strategy to support themselves in academics and/or to support their learning.

Five class participants reported that their mental imagery when used as a strategy (i.e., visualization) supported an aspect of their learning, (captured by the theme "Mental Imagery Supports My Thinking/Learning" in JE6). Thus, eleven class participants assigned meaning to knowledge related to visual thinking (in the context of visualization and drawing), which was captured by the meta-learning theme "Learned about Visual Thinking." For example, Ana wrote, "I think drawing things in ways I imagine them helps me understand them better because then I can imagine it in my head when a question asking that on the test or the homework comes up which is super helpful in terms of remembering how one thing affects the other etc." Additionally Chea wrote, "After I finished (applying the strategy), I realized that adding drawing to imagination really helped me to really understand the concept of the lesson...".

Between the cumulative themes "Learned about Visual Thinking" and "Using Visualization to Support Self in Academics," 14/23 class participants were coded for at least one theme that related to visual thinking. Thus, at least half the class had a degree of metacognitive knowledge for their visual thoughts (i.e., mental images) in direct or indirect support of learning at the end of the learning and thinking block.

Using Language and Metacognition for Learning. Twelve of 23 class participants applied and/or integrated notes in their own words as a strategy for learning between the class activities (LSA and JE6). Five students applied “Taking Notes in My Own Words” in the LSA and affirmed they integrated the strategy into their daily life in JE6. Additionally, eight class participants discussed how writing notes in their own words supported aspects of their learning (captured by the meta-learning theme “Notes in My Own Words Supports Learning”). For example, Cathleen stated, “But I now have figured out how to take effective notes in my own voice so that I am able to get the information that I need down, and I’m able to understand what is written down in my own ‘language’/voice.” Furthermore, four of the twelve participants who took notes in their own words knew to utilize their thinking (i.e., metacognition) to reflect on and/or translate information into their own words before taking notes. Metacognitive behavior primarily related to monitoring understanding and/or creating understanding with one’s own words (i.e., thoughts) during notetaking. For example, Alena stated, “...multitasking both what my professor was going more into depth about the subject and the summarization of that subject in my head in my own words was something that helped me better retain information in my class.”

Additionally, between the LSA and JE6, seven class participants explained how using their language supported their thinking and/or understanding. These class participants understood that using language (i.e., their own words) was beneficial to their thinking and/or understanding during the learning process. For example, Chea indicated that she used her language to metacognitively think about what she was reading, “At first, I read the important concept in the text, then I processed the information in my mind and tried to understand what it really meant.” Similar statements were captured by the (cumulative) meta-learning theme, “Language Supports Thinking /Understanding.” Similar to what was discussed in the ASC, class participants reported using language in the following ways: 1) teaching academic material, 2) discussing ideas with others (teachers and peers), 3) writing ideas in their own words (e.g., rewording or summarizing information), and 4) metacognitively reflecting on (or translating) academic material.

Some participants utilized language with other strategies, drawing being the most mentioned. Dalisay, Coreen and Chea specifically discussed using language in connection with visual thinking, but not in the context of their language being a supportive mechanism or tool for visual thinking. Between the cumulative themes “Metacognitively Reflecting on Ideas,” “Notes in My Own Words Supports Learning,” and “Language Supports Thinking / Understanding,” 14 of 23 class participants were coded for at least one meta-learning theme that related to use of one’s own natural language to support thinking. Thus, half the class if not more had a degree of metacognitive knowledge of how to use language strategically to support learning at the mid-point of the study.

Gaining Knowledge of Self as a Learner. In response to the question five of JE6, 16/23 class participants answered affirmatively that they felt empowered from learning about their own learning. These responses were captured by the theme, “Learning about My Learning Makes Me Feel Empowered.” Four other participants mentioned that they felt more confident in their learning. These responses were captured by the theme, “What I've Learned Helps Me Feel Confident in My Learning.” The latter two themes from JE6 were not provisionally coded as “ML” but because they have strong correlations with the meta-learning theme, “Feel in Control of My Learning," the researcher felt it important to mention. Template analysis revealed that learning about one's learning in the context of the ASC was connected to feeling empowered, which related to feeling in control of one's learning, as well as feeling that one had improved or had the ability to improve learning through the application of learning strategies. For instance, Emanuel stated, "I feel that understanding my own learning helps me feel empowered in the sense that I am able to understand that I don't work the same way as everyone else and I know what to look for and what I need to give myself in order to succeed...". Several class participants reported feeling more in control of their learning because they understood more about themselves as learners and could apply specific strategies that supported thinking and learning when needed. Therefore, the meta-learning process helped many class participants understand they had more control over their learning.

Class participants mentioned a variety of challenges they faced in college, e.g., finding motivation, understanding academic material, difficulty paying attention, and less than satisfactory academic performance (see Appendix O for themes). These challenges, along with the reports of not previously learning how to study often framed the reasons why class participants chose to apply and/or integrate specific strategies for learning. Lastly, five class participants mentioned they were visual learners and/or learned best through visual learning. Being a visual learner or learning that one was a visual learner during their time in the ASC, was not discussed by class participants in the context of feeling in control of one's learning.

Summary of Findings for RQ3d. Class participants' 'meta-learnings' came primarily in response to applied and/or implemented metacognitive strategies intended to match their learning systems. These strategies were primarily drawing with mental imagery and using one's natural language to take notes. For example, Renzo who tried both drawing and taking notes in his own words had this to say about using his own natural language, “While taking notes in my own voice I found that I understood the information so much better. I gained a much richer picture of what I was learning, and the ideas became much more clear and concrete in my mind.” Later Renzo stated, “...I found that after giving these learning strategies a longer shot they were actually incredibly helpful to me. They made learning and notetaking and reading notes so much more enjoyable. I found it was easier to stay focused when I could doodle or translate crazy information into my own thoughts.” Several class participants echoed similar statements, referencing how the metacognitive strategies they chose supported how they learn. For example, Dalisay stated, “Taking notes using my own words helps me understand my thoughts better and drawing visual concepts helps me “see” my thoughts which both are ways I believe works best for me.” Additionally, Efrain stated, “I think I learn best by writing down notes in my own words instead of just copying down what the professor has on the board or on the projector. I noticed that if I am able to write those concepts in my own words onto my notes, it means that I know and understand the concepts being taught.” Lastly, Alena stated, “...and it made me feel so much better as a student because I was understanding what was being taught by catching up on every slide that was being explained without feeling left behind.” It should also be mentioned that a few students did not implement any strategies in the ASC. Those that did not implement strategies felt they had a system that worked well for them or that the strategies would only work in specific situations.

Research Question 3 – Change Themes That Emerged at the End of the ASC

Research question 3 asked what themes emerge during an academic success course, at a private liberal arts university in the pacific northwest, that relate to changes to first year, first-generation students’ knowledge, strategies, and dispositions for visual thinking and learning?

The six focal participants were the focus of this question, and the twenty-three class participants' class activities' themes supported 'changes' that were occurring at the mid-point of the study. Template and longitudinal analysis of focal participants interview transcripts and class participants written journal entries and artifacts, among other qualitative methods, helped to answer this research question. The researcher incorporated deduced themes over the course of the semester into a time ordered matrix and used the criteria from longitudinal analysis to reach determinations on participants' 'changes.' Qualitative methods provided a way to analyze metacognition in depth, particularly as it relates to alternative cognitive phenomena that may not be factored into quantitative protocols.

A multi-tiered and thorough qualitative analysis led to the identification of six overarching change themes that most focal participants experienced. Overall the data support the presence of these 'change themes' and their role in supporting focal participants' visual thinking and learning, 1) monitoring "understanding" when learning more, 2) reflecting on visual thoughts in learning scenarios, 3) "visualizing" in learning scenarios to better understand new ideas, 4) using my own words to create understanding, 5) developing visual systems to support understanding, and 6) understand more about the ways I learn best. Focal participants made changes (i.e., progress) in the areas of visual processing (for their notetaking), language use (both external and internal), knowledge of visual thinking, and control of visual thinking behaviors, as well as monitoring understanding. The following subsections will discuss the changes found. See Appendix P for full list of post-assessment themes and Appendix O for full list of class activities' themes.

Reflecting on Visual Thoughts in Learning Scenarios.

"Reflecting on Visual Thoughts in Learning Scenarios" is a change theme that was deduced from various themes that emerged over the course of the ASC that relates to being more metacognitive in relation to one's visual thinking (i.e., mental imagery). Focal participants *reflected more* on their visual thoughts over the course of the semester because they learned that using mental imagery (i.e., "visualization") was beneficial for learning and for factors related to learning (i.e., anxiety, attaining goals). Learning about mental imagery and applying visual thinking in the ASC helped the majority of focal participants become more aware of their mental images in learning scenarios. Application of visual thinking (i.e., mental images) also occurred in connection with metacognitive (learning) strategies, such as drawing. For example, when the researcher asked Lilly to give an example of strategies that have worked for her Lilly stated, "So, the visual, creating visual imagery and something to associate that with, we talked about the dictionary where you write a term and draw a picture to associate with that, I've started doing that a lot more, and I've definitely noticed how it's helped."

As a result of using "visualizations" strategically, participants started to explain their visual thinking in vivid detail, often using metaphors to explain what they saw. For example, Daniel equated his mind to a movie theater, "I think about the words and just pictures within the video or whatever I was reading. And I just start visualizing them in my mind, and I really kind of blow them up on the big screen in my at home mind movie theater, and I just see them. And they feel more clear, I guess." Additionally, Dalisay discussed in detail what she saw in her mind's eye when confronted with a verbal learning task, "So, it's like in this corner of my site, is what they're saying but then while they're thinking I'm building on my own site on this corner, but it's slowly overtaking theirs, but it's taking some others to inspire my thinking." Coreen also explained her visual thinking vividly and metaphorically when confronted with a verbal learning task, "...just as the words flow in, they come in like a text. It's like a typewriter, but each button is a word that comes in, and they just like they filter in, it's like a flow from -- You know how soundwaves work, so it's like they flow towards me, and they go into my brain, and they start writing out on this page." Such language indicates semantic knowledge has been developed for participants' visual thinking. It should be noted the researcher did not ever ask about participants' visual thinking directly unless the participant discussed their visual thinking first. The vast majority of statements about visual thinking came about naturally in response to learning prompts. The researcher verified statements about visual thinking with participants to ensure their accuracy during the first and second member checks.

The researcher concluded that focal participants reflective thinking for new academic ideas, combined with the knowledge students gained about visual thinking led to more reflection/awareness of their visual thinking in learning scenarios. Therefore, this change theme relates to becoming more reflective towards one's own visual thoughts in learning scenarios. The majority of focal participants thus, underwent knowledge-based changes to their visual thinking. Several focal participants showed metacognitive awareness (e.g., knowledge) for their visual thinking in learning situations in the pre-assessment and came to experience more developed knowledge for their visual thinking capacities in learning situations by the end of the semester. Two participants who had shown only partial awareness of their visual thinking during the pre-assessment developed metacognitive knowledge for their visual thinking over the course of the semester. 'New' knowledge came about as a result of focal participants using their visual thinking, often in strategic ways in learning situations and reflecting on these scenarios. This change theme overlaps with the post-assessment theme, "Learned about Metacognition, Visualization, Mental Imagery in ASC," and post-assessment themes which comprise the change theme, *“Visualizing” in Learning Scenarios to better Understand New Ideas,* which is discussed next.

“Visualizing” in Learning Scenarios to better Understand New Ideas. “‘Visualizing’ *in* Learning Scenarios to better Understand New Ideas” is a change theme that was deduced from various themes that emerged over the course of the ASC that related to focal participants’ statements about “visualization,” “imagination,” and other terms denoting control for one’s mental imagery. This change theme specifically relates to developing (metacognitive) regulation and skills for one’s visual thinking in learning situations for the purpose of understanding new academic ideas. Focal participants reported using mental images - what they often termed “visualizations” or “imagination” - to understand new academic ideas in various learning situations, e.g., when teachers or peers were speaking, and when reading or watching videos. For example, when showing the researcher her English notes Abby stated she would ‘visualize’ and organize ideas on paper when reading– “This is my English class where I would visualize things to help me. Like this is when we're analyzing a book, reading it, I would make a timeline of what's going on, and try to organize my ideas.” Abby explained a similar mental behavior when listening to the teacher in class, “I'll definitely try to visualize the basic subject and concept and, listen for certain keywords that would fall under that concept, kind of like an outline.” Abby and Coreen did not assign meaning to visual thinking as it directly related to learning in the pre-assessment but did assign meaning to visual thinking themes as a result of what they learned in the ASC, e.g., both coded for “Actively Relating / Connecting Visual Ideas.” Abby stated during the post-assessment, “When I think about what people are discussing and learning, or talking about, I definitely try to visualize it in my mind, from what we've learned in class.”

Most focal participants reported creating context and/or additional meaning through their visual-mental thoughts, represented by the themes "Creating Context Through Visual Thinking" and "Actively Relating / Connecting Visual Ideas." The latter theme did not emerge until the post-assessment. Metacognitive regulation or control for "visualization" (i.e., using mental images) was reported more (i.e., more themes, more responses, and more themes in more learning situations coded as "MR" and "MetStrat") in the post-assessment than in the pre-assessment. All six focal participants indicated using (i.e., controlling) aspects of their mental imagery to understand new academic ideas. Participants engaged in these mental behaviors by, 1) purposefully thinking about story-based scenarios, 2) organizing their thoughts into structures that held meaning to them, and/or 3) connecting/relating new ideas to previous knowledge. For example, Dalisay confirmed in the member check that she created mental relationships between her reasoning of what classmates were discussing and previous knowledge to develop understanding of the spoken words. "When given a word and definition, I picture that meaning in my head through actions or visual representations which helps me understand the definition." When asked if her 'relation building' "was based in mental images or something else," Dalisay stated "I guess mental images and prior knowledge." Dalisay also created these relations when engaged in verbal learning tasks, *"*…when they're saying something, I try to visualize it through pictures of their sentences. So, if it's like a sentence about having empathy for others, I like picture like a leader being empathetic towards their people." Additionally, Lilly discussed visually thinking about specific relational scenarios to help her new ideas, "I recently had to do a presentation on a nurse. And so, just thinking about that nurse, like what was going on during that time - just kind of like imagining things. Not necessarily imagining an entire story, *but just trying to think*, "Okay, this was the nurse's life, this is how she chose to take her life and go into nursing." And how does she emulate the concepts of being a nurse?" Overall, Lilly reported using her visual thinking in a more reflective manner to understand new academic ideas in the post-assessment as compared to the pre-assessment. She confirmed in the member check that she often put new ideas in a story-based form which gave her thoughts more structure and meaning.

There are numerous other statements such as these in the post-assessment and second member check that show application of strategic behaviors for visual thinking. In summation, visual thinking expanded in both breadth and depth for the interview group. More focal participants, by the post-assessment, *engaged in more metacognitive strategies related to visual thinking* to understand the ideas they were learning - indicating more metacognitive regulation (or control) for visual thinking in learning situations.

Monitoring "Understanding" when Learning More. "Monitoring "Understanding" when Learning More" is a change theme that relates to developing regulation (or control) for one's metacognitive monitoring in learning situations for the primary purpose of understanding new academic ideas. This change theme incorporates the themes provisionally coded as "MK" and "MR," for metacognitive monitoring in the pre- and post-assessments as well as the cumulative theme, "Metacognitively Reflecting on New Ideas" in the class activities. It's important to note that other themes, particularly strategy-based themes in the class activities and post-assessment templates, which were provisionally coded as being metacognitive (e.g., Taking Notes in My Own Words), also influenced this change theme, as they required metacognitive monitoring to be successful.

Overall, focal participants reported monitoring their attention/understanding more frequently in learning situations and monitored their thinking in more strategic ways (i.e., deliberate mental activities to achieve a goal) over the course of the semester. All six focal participants in the post-assessment confirmed that they paid more attention to their understanding when learning than they did at the start of the semester. For example, when prompted about whether she pays more attention to her thinking now than at the beginning of the semester, Ashley stated "I focus on how well I'm taking in what the professor is saying now because I feel like in the beginning (before the ASC), I would just let it go in through one ear out the other." She later followed up saying, "…in my psych class, (the teacher) posts the slides, then we just take notes off of that, while she's also going through it. But I felt that before (the ASC) I was more focused on trying to write down notes or type them, rather than listening to the other additions to the notes that she's giving verbally. Now I've been more aware of what she's saying than I am of the notes."

All focal participants provided examples, similar to the quote above, of how they monitored their understanding during the last semester. Focal participants specifically gained personal (valid) knowledge and regulatory capabilities for applying their thinking towards their attention and/or understanding to better understand new academic ideas (over the course of the ASC). This was the most substantial finding of this study in terms of evidence and had connections to participants' strategic use of natural language (discussed next). For example, Dalisay stated, "When I'm learning something new that's where I talk to myself a lot in my head. Because I try to make it clear within myself first." Another example of monitoring understanding comes from Abby - **"**Probably just try to listen until I hear something that I do understand. Mostly listen to keywords, key concepts, and then I'll try to drawback onto that." Lastly, Coreen indicated she recently started monitoring her understanding, "This one's recent…when the teacher pauses, I use that time to search back and make sure I heard what they were saying...".

Thus, participants reported using more attention-based and understanding-based monitoring activities that support learning than they did during the pre-assessment.

Using My Own Words to Create Understanding. “Using My Own Words to Create Understanding” is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants’ statements of using their own words, voice, and/or language (i.e., natural language) to better think about and/or understand academic material. This is a change theme that relates to developing metacognitive regulation (or control) for using language internally (e.g., mental dialogue) and externally (e.g., discussing ideas with peers) to clear up areas of confusion and/or develop understanding. Focal and class participants were taught in the ASC that their natural language (also termed "own words" and "own voice"), when used to think about academic concepts, supports higher thinking (e.g., critical thinking) and development of neurosemantic brain networks. Participants were presented with several strategies (in the ASC) to try, such as, a) teaching academic material, b) discussing ideas with others (e.g., peers), c) writing notes in their own words, and d) asking questions of their own understanding to support higher thinking about academic concepts. For example, when prompted about using her own natural language to understand new ideas, Coreen stated, “It's something I've always tried to do, but this class has helped me stress importance on realizing…how important that actually is, because that's the part that you actually learn from. Not just getting that text in your head, but the understanding of it, that's the actual part where you learn, and that is what I learned from (the ASC). Definitely one of the most important things I've learned.”

The majority of focal participants reported using their own words (or language) more than they did at the start of the semester to better think about and understand academic concepts. In the post-assessment, participants engaged in using language by, 1) writing meaning in their own words, 2) discussing ideas with peers, and 3) using internal (or mental) dialogue when engaging with academic ideas. In the member check, focal participants verified they used language in these ways. For example, Daniel talked about the strategy of explaining ideas to other people to develop his understanding, “I felt like the information you brought to the table really helped me think like, "Oh, that's how my brain is going to start moving about these things." When you said that the brain learns something better and can verify its own understanding of something when you're repeating it to somebody else - that wasn't something I really attempted before, and as I started doing it, I was thinking, "Wow, this is crazy, this works.” Additionally, Dalisay discussed taking notes in her own words when her professor was speaking, “It tends to click way better than trying to understand what our professor is saying because it's his own thinking. This is my thinking. And then when I go back to it, it helps explain why I wrote it that way - because I knew what I wrote - so it made me click into more information that's easier for me to understand.”

The change theme, “Using My Own Words to Create Understanding” incorporates the themes provisionally coded as “MK” and “MR,” for using one’s words in the pre- and post-assessments as well as the cumulative theme, “Taking Notes in My Own Words,” and meta-learning themes - “Notes in My Own Words Supports Learning," and “Language Supports Thinking/Understanding” in the class activities. Focal (and class) participants learned about using language and began to apply/integrate language strategies to verify, clarify, and develop their understanding. As they did, focal participants recorded more responses provisionally coded as “MR,” particularly in the post-assessment. Four participants (Coreen, Daniel, Dalisay, and Lilly) verified they used their language (externally and/or internally) more at the end of the semester than the beginning because of what they learned in the ASC. The same focal participants verified that using their language helped them develop and/or verify their understanding of academic ideas. Cumulatively, all six focal participants reported using a strategy related to their natural language, in the post-assessment and second member check, compared to four participants in the pre-assessment and first member check.

While focal participants utilized their language, particularly among peers more than any strategy reported in the pre-assessment, learning about how language can be used as a 'tool' or strategy for learning, helped several focal participants use language more strategically for their learning during their first semester in college, which likely raised their level of thinking about academic ideas in specific cases. Using their language seemed to come natural to many participants, more so than any other strategy used. For instance, Coreen and Dalisay reported in the pre-assessment that they had immediately begun to take notes using their own words because of what they learned in the ASC. In the post-assessment, Coreen and Dalisay reported that they had continued to take notes in their own words, and that it was helpful to their understanding/learning. Additionally, Lilly and Ashley reported behaviors (e.g., annotating) indicating they also took some notes in their own words. Thus, at least four participants reported a new strategy related to writing meaning in their own words, since the beginning of the semester.

Developing Visual Systems to Support Understanding. "Developing Visual Systems to Support Understanding" is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants' statements of formatting their notes by color-coding, bullet pointing, and arranging ideas, as well as representing ideas by drawing, writing key ideas to learn later, and writing ideas in their own words. "Systems" references the strategic ways participants captured and organized ideas on paper/screens. “Formatting” in this sense references a meaningful way to organize/arrange ideas. The change theme, “Developing Visual Systems to Support Understanding” incorporates the themes provisionally coded as “MK” and “MR,” for representing ideas and formatting notes (in visual ways) in the pre- and post-assessments as well as the cumulative theme, “Drawing as an Adapted Strategy for Learning,” and the meta-learning themes, “Drawing Supports My Learning" and “Diverse Learnings from Drawing” in the class activities. Focal and class participants were not taught in the ASC how to format their notes but were taught how to draw concepts to learn conceptually (e.g., flowcharting).

Cumulatively, this change theme relates to developing knowledge and regulation for notetaking strategies that support processing (recognition) and understanding of academic ideas. Most focal participants reported developing a system for notetaking that enhanced their ability to understand or mentally ‘see’ ideas. Participants developed visual systems to represent/organize (primarily auditory) ideas in a way that allowed them to process and understand the ideas in their notes. By the post-assessment, participants developed systems through one or more of the following strategies: 1) representing ideas with drawings, 2) writing meaning in their own words, 3) color-coding ideas, 4) arranging/outlining sections of text, 5) connecting ideas with arrows/lines, 6) writing ideas to learn later, and/or 7) bullet pointing sections of text to separate and connect ideas. The majority of focal participants by the second member check reported and/or indicated they developed unique "systems" over the course of the semester to represent/format academic ideas, which supported their recognition (e.g., identification, separation, organization, and/or connection) of ideas and understanding. Three focal participants verified they developed a “system” for notetaking, while all six participants, verified they made visual changes to their notetaking including, 1) drawing or diagramming more, 2) flowcharting, 3) writing ideas in their own words, and/or 4) breaking down ideas into sections.

Focal participants developed the system (or systems) primarily in response to lecture-based notes/slides. Although, focal participants engaged in various strategies, the common theme among participants is they *developed unique systems allowing them to 'see' (or understand) the ideas on the page (or screen)*. Although, five focal participants formatted their notes in the pre-assessment, at least four of those focal participants made adaptations to their formats over the course of the semester, and one focal participant, Coreen, who hadn't previously reported formatting notes in way she could understand reported creating a bullet-point structure for her notes in the post-assessment. "This bullet point stuff was I had thought about it because of the visualization and the drawing class because it was like, "You know there's probably a reason I don't understand all (these) uniform (bullet points). If I go out and I structure this like an artwork, it will make more sense."

All focal participants gained personal (or valid) knowledge for visually representing and/or formatting academic ideas to best support their understanding over the course of the ASC. For example, Ashley stated, "We've learned about visual maps and creating those flow charts. Before, I didn't really think I needed it specifically, but I've definitely adapted to it when it comes to certain subjects that it's helpful in." Additionally, Dalisay stated how she began to connect ideas in her notes using a system of visual features, "So, I guess that ties into using diagrams, drawing pictures, drawing tables and -- it's kind of like mind mapping, like the steps - like I need to see it, not just write words. I have to go step by step, like use arrows to like "Okay, this goes there and then" -- yeah."

More metacognitive strategies were applied toward note-taking over the course of the semester that capitalized on the way students visually processed and understood new ideas. Participants reflected on their notes, thought more metacognitively about their notes, and engaged in more strategic, note-taking behaviors to support their understanding. Overall, focal participants reported behaviors indicating they regulated their notetaking more during their first semester in college. However, focal participants did not engage in this behavior for all their classes. It's unclear how consistently focal participants engaged in this behavior and to what degree they metacognitively controlled this strategy. In summation, focal participants visual notetaking strategies and systems expanded in both breadth and depth for the group as a whole. More focal participants, by the post-assessment, engaged in more note-taking strategies which supported their ability to, 1) identify ideas, 2) separate and make associations between ideas, and 3) mentally see and/or understand ideas. This theme relates to visual thinking and learning, in terms of participants' developing awareness for ways they could visually process and conceptualize new academic ideas. Several artifacts of participants' note-taking strategies also support this theme (see Chapter 4).

Understand More About the Ways I Learn Best. *"*Understand More About the Ways I Learn Best*"* is a change theme that was deduced from various themes that emerged over the course of the ASC that incorporated focal participants' statements of 1) understanding more about the ways they learn best, 2) building foundational elements for learning, 3) incorporating more effective learning strategies from the beginning of the semester, 4) improved academic performance, and 5) being more in control of learning. This change theme additionally incorporates themes related to participants' metacognitive confidence for their learning, including ratings of how well they understood their learning in the pre-assessment as compared to the post-assessment. The change theme, “Understand More About the Ways I Learn Best” incorporates themes provisionally coded as “MK,” “CK,” “ML,” and “MC,” in the pre- and post-assessments that relate to judgements of one’s understanding and/or development of their learning as well as the meta-learning themes, “Feel in Control of My Learning,” “Ability to Improve Learning," and “I am a Visual Learner” in the class activities. Additional themes in class activities were incorporated that provided context for growth in participants understanding of learning and outcomes related to meta-learning. In class activities sixteen class participants affirmed that they felt empowered from learning about their learning (e.g., “Learning about My Learning Makes Me Feel Empowered”), and seven class participants reported/indicated that they felt more ‘in control’ of their own learning (e.g., “Feel in Control of My Learning). Additionally, four class participants reported feeling more confident about their learning (e.g., “What I've Learned Helps Me Feel Confident in My Learning”).

Overall, focal participants reported understanding more about their own learning and supported these statements with confidence-based ratings, and outcome-based statements about how they felt as a result of learning about their own learning. For example, four of six focal participants in the pre-assessment reported they were “Still Figuring Out What Works Best for My Learning,” and seven class participants in JE6 reported they previously “Did Not Know How to Study.” In the post-assessment five focal participants reported the themes “Understand More About the Ways I Learn Best” and “Built Foundational Elements for Learning.” Furthermore, all focal participants by the end of the post-assessment rated their understanding of learning high (between 8 and 10) compared to a mid-range rating (between 5 and 7) at the beginning of the pre-assessment. Therefore, all focal participants gained confidence and personal (or valid) knowledge for their own learning over the course of the ASC. For example Ashley stated in the member check, “Through those concepts (mental imagery, visualization, and metacognition) I was able to grasp what I meant when I say, ‘I’m a visual learner.’ I knew how to explain what I needed to help me learn properly. These concepts helped me understand more about what I needed to learn and be a visual learner.” Not surprisingly, Ashley also reported greater metacognitive confidence in relation to her understanding of learning and a feeling of empowerment and control because of what she learned about her learning. Dalisay also equated her visual thinking to being a visual learner when responding to a verbal learning task, “While someone is speaking, I picture their words into actions in my head. While I do that, it makes me understand what they're saying more clearly. As a visual learner, I tend to picture images in my head more than words sometimes.”

Additionally, Abby mentioned that she’s more focused on her learning and what helps her learn that she was at the start of the ASC, “I would definitely say that I've been more aware of what makes me a better learner. What certain types of things catch my attention maybe or I'm more attentive to.” Several participants also mentioned that putting a word or a term to ideas such as mental imagery, visual thinking, and metacognition, helped put these concepts into action. For instance, Lilly stated in the member check (paraphrasing), “In this class, it was more just learning different methods and putting, I guess, a word or a term for what I've been doing, and I guess I just never really thought of it, it's just something that worked for me. Being able to go in-depth more on why I do that and how it helps was definitely very interesting for me.”, Coreen correspondingly stated, “When I sat in the (the ASC), I thought “I do that, just not that well.” So, I need to keep doing that, which was the most helpful thing I learned – the definitions for those ways to learn (metacognition, mental imagery, visualization). Cumulatively, the various change themes suggest the concepts discussed within the ASC (in class and among learning communities) and the strategies that focal participants applied/implemented helped them develop ways for understanding how they learn best. Focal participants' statements about the application or development of strategies presented in the ASC as factors that supported their learning were often clear and explicit. In some cases, the knowledge learned and/or applied in the ASC helped focal participants improve their academic performance.

Interpretations of Change within a Meta-learning Framework

There was previously little known about how first generation students change within environments that support their visual thinking and learning. Qualitative methods provided a way to analyze meta-learning and metacognition in depth, particularly as it related to alternative cognitive phenomena that could not be factored into quantitative measures. Analysis rendered copious findings that will hopefully progress the fields of first-generation students' academic learning, metacognition, meta-learning, and visual thinking forward. The previously discussed findings, including change themes, cumulatively suggest three related factors – 1) that focal participants used a visual system to learn previously but were not fully aware of how to take advantage of it, 2) that the ideas/strategies presented in the ASC, primarily for *using language, mental imagery, visualization, and/or metacognition* to support learning were meaningful to most first-generation participants, and 3) that facilitating access to ideas/strategies that supported the ways focal participants learned visually, helped them develop metacognitive knowledge and regulation for the ways they learn best, which positively influenced dispositional factors in some cases related to being a learner (e.g., motivation, confidence, empowerment, control). The degree and permanency of these changes is unknown but likely to be moderate (in degree), and continually shifting (permanency) based on one's experiences and learning dispositions (see Crick et al., 2015).

Focal and class participants learned about their own learning primarily by applying learning strategies discussed in the ASC and reflecting on those experiences during/after learning scenarios (e.g., reflective journal entries) and in learning communities. As a result, most focal participants made several outcome-based responses that amounted to *understanding more about their learning* in the post-assessment. All focal participants explicitly or implicitly reported during the study that they learned best 'visually' by, 1) seeing and creating visual stimuli, 2) visualizing (picturing) ideas, and/or 3) structuring notes as a visual system. Focal and class participants also reported learning best when using language as a strategy for learning, but they did not connect using language to being a visual learner. Nonetheless, focal participants seemed to be able to raise their level of thinking about academic ideas (in several cases) and simultaneously their own thinking and learning processes (see NsLLT in Chapter 2).

The researcher deduced that focal participants gained valid knowledge for learning and thinking 'visually' and for using language strategically, e.g., 1) taking notes in one's own words, 2) discussing ideas with peers, and 3) using internal dialogue and/or reflecting on new ideas. Focal participants gained metacognitive knowledge, metacognitive regulation, and metacognitive confidence for their learning, particularly because they learned about, i) their visual thinking (e.g., visualizing ideas) in learning scenarios, ii) how they 'processed' or understood new ideas best (e.g., physically writing notes and structuring notes as a visual system), iii) the effects of reflective/metacognitive thinking, and/or iv) the effects of strategic language use (e.g., discussing ideas with peers). All focal participants became more aware of their own thinking/learning, and some focal and class participants, a) improved academic performance and/or learning, and b) developed and/or became aware of positive dispositions towards learning (e.g., “Feel in Control of My Learning”).

The previous sections corroborate major themes from first generation and metacognitive research in higher education, while expanding our knowledge about how some first generation populations understand their learning and come to change in meta-learning environments that support the ways they visually think and learn. Research suggests FGCS tend to be less involved in academic environments (e.g., contribute less to class discussions), participate less in extracurricular activities and interact less with peers than continuing generation students – all factors which impact college retention (Carini et al., 2006; Filkins and Doyle, 2002; Pascarella and Terenzini, 2005; Pascarella et al., 2004; Kuh, et al., 2006; Pike & Kuh, 2005; Soria & Stebleton, 2012; Tinto, 2006). Tinto’s (1993; 1997) primary sources of first-year student departure are as follows: a) unresolved educational goals in relation to external commitments, b) academic and social challenges (e.g., poor academic performance and lack of peer/faculty involvement), and c) inability to integrate into the educational institution (academically or socially). First-year transitions can be critical for students’ retention and academic success (Barefoot, 2005). Interventions that facilitate academic and social involvement, specifically learning communities, have shown to positively impact a range of student outcomes, including those for first-generation students (Cerezo & McWhirter, 2012; Jehangir, 2009; 2010; 2012; Markle & Stelzriede, 2020; Siegesmund, 2016; Tinto, 1997). The academic success class (ASC) was designed with these challenges and opportunities in mind.

As meta-learning relates to students’ self-awareness regarding their learning processes, it is closely aligned to the self-regulation of learning (Zimmerman 2002; Winne 2010); that is, the thoughts, feelings and actions that students use to help them attain their academic goals

(Zimmerman 2000). Students' ability to develop meta-learning competencies therefore is intricately connected to the learning context (interview setting or classroom) and the activities/approaches students engage in to become self-aware learners (Biggs, 1987; Jackson, 2004). Copeland and Levesque-Bristol (2011) for example, suggested that positive learning climates foster motivation which in turn impact self-determining approaches that enhance learning outcomes, such as metacognition. Castillo-Montoya and Ives (2021) identified three practices, which aligned with this study to support first generation students' academic learning through a strengths-based approach: a) facilitating an interdependent learning culture, b) providing support for academic learning success, and c) building internal/external community. In response, the ASC utilized the following pedagogical practices with first-generation students, a) learning communities, b) dialogues which integrated previous cultural, ethnic and education experiences into learning, c) multicultural learning experiences, d) reflective journal writing, e) collaborative/active learning assignments, and f) class discussions to bolter students voice while cultivating a safe space to do so.

This study corroborates Bamber et al.'s (2005) findings that meta-learning can help non-traditional students form a different kind of relationship with academic learning that many may be seeking. This relationship is built upon discursive forms of personal and community meaning-making, that helps students develop a 'persuasive discourse' built upon what works best for them as active learners; particularly, as they grapple with challenges in their first semester in college (also see Lillis, 2001). Similar to the Jehangir (2010) study, the qualitative data in the form of reflective writings and semi-structured interviews showcased that first-generation students became validated as "knowers," in this specific case as *knowers of their own thinking and learning*. All of the focal participants came to develop a valid discourse over the course of the semester for their thinking, learning, and strategy use, which often reflected how they used their visual thinking and natural language to support their learning. Meta-learning, led to changes in personal knowledge and strategies that most focal participants integrated into their daily lives. The validity of such knowledge came from their experiences reflecting on their visual thinking and language learning in the context of learning tasks, in learning communities, and when writing reflectively. As suggested by Makarova et al. (2017), giving visualization (or visual thinking) a foundation in one's learning, develops the semanticity (i.e., personal meaning) of learning, helping the student turn inward to their own visual thoughts and how they might impact their environment – in this case their studying and learning.

The researcher discovered that metacognition, specifically metacognitive awareness for one's visual thinking develops through discourse (i.e., language) in meta-learning contexts, which in turn reflects a person's relationship with themselves. From in-class observational data, first-generation students seemed to feed (motivationally) off their learning communities. Many were often quiet and reserved in the classroom until they began to speak with their learning communities, and many times the dialogue/learning ramped up from there. Additionally, the cultivation of safe spaces in the classroom seemed to help first-generation participants feel like they mattered and belonged. These environmental factors, among others, likely drove affective and motivational elements that impelled students to participate in the meta-learning curriculum (Bamber et al., 2005).

Similar to the Wibrowski et al. (2017) and Conefrey (2021) interventions, it's likely that the learning environment fostered affective-motivation factors (e.g., sense of belonging), which compelled participation and experiences in which participants' thinking turned towards learning and strategies to support learning, which in turn reinforced learning dispositions (e.g., confidence, self-efficacy, and/or agency). For example, though sense of belonging was not studied directly in this study, in week 12 of the ASC a guest instructor discussed topics related to ethnicity, social histories, and cultural studies. At one point the guest instructor asked students where they felt like they belonged at the University. One student said she commuted to school and so it was difficult for her to join social groups but the ASC was where she felt included. The majority of other learning community groups then echoed a similar sentiment – that the ASC was where they felt like they belonged at the University. This lends support to Jehangir's (2009; 2010) research that first-generation students can cultivate a sense of belonging in learning contexts where their cultural wealth, in this case previous cultural, ethnic, and educational experiences are supported within learning communities.

This study provides some contextual evidence that first-generation students who've strengthened their metacognitive awareness for learning may be more capable of developing skilled-based behaviors which support their thinking/learning and other goal-setting behaviors, which in turn supports the students' beliefs in themselves (Conefrey, 2021). It should be stated, the focus of this research was not to study the constructs of self-efficacy nor agency, so the researcher cannot say with certainty these factors were impacted. Given available research and this study's findings, it's quite likely that the learning environment, which includes social interactions with peers/faculty, as well as students' learning dispositions (Crick et al., 2015) influence engagement in the curriculum, which can be reinforced if the student begins to develop metacognitive and self-regulatory capabilities for their learning. Lastly, it should be noted that focal participants still experienced challenges with their learning. Some mentioned they still struggled to understand and learn some academic ideas and four focal participants stated they still struggled with being motivated to learn some subjects.

Meta-learning - Theory Affirming vs. Theory Building

As mentioned in Chapter 3, this case study provided an opportunity to be *theory affirming* and *theory building*. The research was theory affirming in the sense that all focal participants were identified by use of a visual cognition for processing auditory concepts, which supports neuroeducation findings that most students use a visual system for learning (Arwood, 2011). This study lends further evidence to the TEMPro analysis results (Arwood & Beggs, 1992), through qualitative analysis, which shows focal participants referred to their visual thinking to understand verbal concepts when prompted at times. This study also affirms the neuroeducation theoretical framework by illustrating, a) how language provided the conceptual vehicle or 'tool' that directed student's metacognition, learning, and meta-learning, b) how learning strategies that were metacognitive in nature provided opportunities for college students to learn academic material and simultaneously learn about themselves, and iii) how learning about how one learns can provide opportunities for students to develop positive affective states. This study also affirms the various impacts that metacognition interventions can have on first-generation students' thinking, academic learning, and factors related to their academic success.

This study was theory building in several interdisciplinary respects. First, there were no previous neuroeducation studies that explored meta-learning with first-generation college students, so the findings lend support for the efficacy of neuroeducation practices with underrepresented or non-traditional students. Second, there were no known first-generation studies that explored students' academic thinking and learning in this kind of detail and breadth. Therefore, this research provides progress in how educators can understand first-generation students as learners, and how they change in meta-learning environments that support the way they learn neurobiologically. This study provides evidence that meta-learning can be integrated into other high impact practices such as learning communities, multicultural learning, and reflective writing formats to great effect.

In attempting to "create constructs" and "midrange theory" as discussed in Chapter 3 (Eisenhardt & Graebner, 2007, p. 25), the researcher provides empirical evidence that substantiates meta-learning as a dual learning process that can be highly impactful to the self-directed thinking and learning capacities of non-traditional students. Per the researchers' previous operationalization of meta-learning in Chapter 2, as *learning about one's thinking and learning processes to become aware and take control of one's thinking and learning*, the researcher would amend that statement to represent meta-learning as being more personal and meaningful. Additionally, the researcher believes meta-learning should hold true to Biggs (1985) original meaning while reflecting the ways in which teachers can facilitate meta-learning for underrepresented students. In reflecting on the experiences and findings of this study, the researcher concludes that *meta-learning in the context of this study was a process of learning about the ways one thinks and learns best, that develops more strategic awareness and control of one's thinking and learning processes.*

The word "best" is carefully chosen to reflect the meta-learning process as being personal and meaningful to the student, (i.e., based on how they come to understand how they learn) and not based solely on a teachers' conception. The word "strategic" reflects the cultivation of cognitive skills for one's learning much like one would seek expert knowledge in a discipline if motivated to do so. The word "process" is meant to show that any type of learning represents what Arwood (2011) calls a 'spiraling process,' akin to Vygotsky's Zone of Proximal Development. This means learners reach certain challenges in the learning process, and must receive support from their own metacognitive thinking, from tools, and/or teachers to continue thinking and learning process. Meta-learning, in the same fashion is conceived of as a spiraling process of learning about oneself that is continual and comprises the learning task, the application of metacognitive strategies to meet the learning task, thinking, learning, thinking about one's thinking, thinking about the way one is learning, reflecting/reviewing, and evaluating/correcting, not necessarily in that order (see Carnell, 2007 for a similar model). The more students monitored their learning through the use of metacognitive learning strategies, the more they facilitated their own metacognitive experiences, which were opportunities to build metacognitive knowledge and metacognitive skills for their learning. In this study, cognitive and metacognitive processes of learning interacted with dispositional factors (e.g., attitudes, beliefs, motivation, and confidence), in terms of what students believed they were capable of and should be doing, which seemed to influence engagement in meta-learning processes. Monitoring one's attention and understanding was the most reported mental behavior in this study, which may mean that it's an initial and essential meta-learning process that students engage in to begin developing metacognitive awareness which supports raising one's level of thinking.

In summation, meta-learning in the context of this case study was a process by which students developed valid (and metacognitive) knowledge about the ways they learned best with language through discovery and departure from the ideas/strategies discussed in the meta-learning environment in an effort to build practical knowledge for their learning. In this sense, meta-learning was not based on someone else's conception of the way they learned but rather the students' discerning and developing awareness (cultivated in learning situations) that directed their learning at times. The researcher provides evidence that prolonged experiences with metacognitive strategies may attune the mind to its own visual thoughts and language, thereby changing conceptions of what learning entails.

Implications for Practitioners

There are several implications for practitioners who would like to engage first-generation or underrepresented students in a process of meta-learning that yields similar results as this study. It's likely that meta-learning would be best supported by 'change agents' that seek to sustain long-term, culturally inclusive interventions that support positive and meaningful changes to students' learning (see Henderson et al., 2011). These change agents must form positive social relationships with students and seek to continually work toward supporting their interests at the institution while helping students develop socially and academically (Rendon, 1995). Implementation of meta-learning and metacognitive strategies is a goal for practitioners who want to change students' conceptions of learning and behaviors toward deep learning approaches that fulfill lifelong learning capacities. This will usually require the change agent or agents to make institutional changes that adopt more inclusive methods (White & Gunston, 1989).

The rest of this section will focus on contextual factors of the ASC learning environment that may be helpful to practitioners. Based on observations, reflections, and interviews, many first-generation students were immediately engaged and interested in learning about their own learning, specifically the neuroscience of learning, visual thinking, and the utilization of language for learning. The researcher, acting as guest instructor gave practical strategies in the first week of the 'learning and thinking block' and continued to build the theory behind those strategies (with guest instructors) as the class progressed. Additionally, the researcher as guest instructor helped students more fully develop their metacognitive (learning) strategies, giving them opportunities to utilize these strategies outside of class (e.g., when studying) and to reflect on challenges, efficacy, and improvements to these strategies in journal entries and class assignments. Several students were science majors (e.g., nursing) so the scientific process of learning about their learning, may have interested them.

There were several forces during this research which pulled the meta-learning process in opposing directions which practitioners should be mindful of. One force that pulled the meta-learning process was students’ perceptions of what might work for them based on naïve or previously taught misconceptions of learning (e.g., learning styles). Another force was college learning environments and what they asked of students. Some environments asked students to engage in shallow learning practices (e.g., rote memorization), which the researcher perceived as being especially damaging to implementing a deep learning approach. As previous research has illustrated, students, like all people are outcome-driven and often will take the path of least resistance if it still leads to success. For instance, some participants in this study continued to use memorization because they believed it was the best way to earn a good grade. If the learning environment is merely asking students to memorize information, students will likely continue to engage in strategies commensurate with that type of environment which may lead to reinforcement of coping mechanisms (e.g., memorization techniques) for test-taking and grade amplification. This occurred to some degree during this study.

There are also social forces (e.g., peers, faculty) at play which may negatively or positively impact the students’ conceptions of learning or how to approach learning. The final influencing force on participants’ meta-learning in the context of this study comprised the ASC instructors who attempted to support first-generation student’s meta-learning using a neurobiological and sociocognitive approach to learning. Meta-learning is likely composed of these various, turbulent forces at most universities which pulls the meta-learning process in opposing directions. If pulled too far in any one direction, the meta-learning process may unravel, failing to provide impactful results to the student. It’s, therefore, critical the meta-learning process be meaningful to the student while simultaneously imparting a deep approach to learning based on empirical evidence.

In this study, the meta-learning process seemingly progressed in and outside the classroom by, a) developing a safe space (Schapiro, 2016) for students to discuss ideas with learning communities, b) facilitating agency in the classroom so students could decide what worked best for them, and c) providing supportive, iterative feedback that was acknowledging of students’ work and which attempted to nudge students in the right direction when students’ had misconceptions about thinking and learning processes. Additionally, in this study it was vital that meta-learning was not based in mechanical conceptions of learning but in the way students represented their thinking, understood ideas, and developed their thinking, which provided a strong semantic basis about learning. For example, using one’s natural language (e.g., discussing ideas with peers) as a strategy to support thinking, understanding, and learning seemed to come natural to many first-generation students in the study, more so than any other strategy utilized. This is likely because, of the foundation language had in each students’ conceptual thinking and learning and because participants seemed to thrive in small group discussions. The themes identified in qualitative analysis highlighted the impact of developing language for one’s learning and thinking processes particularly when supported by reflective writing practices and discussion in learning communities. These educational practices likely provided a semiotic basis for meaning construction in relation to one’s thinking and learning processes, particularly as students applied new metacognitive learning strategies. Students’ meaningful exchanges between these various meta-learning activities likely explains changes to students’ visual thinking and learning processes.

Some focal participants mentioned that engaging with the ASC helped them feel more motivated to learn and/or more open to trying new things to support their learning. For instance, Lilly stated that learning about her learning helped her to feel more motivated to try new strategies. Daniel also mentioned being more open-minded to trying new things to support his learning. Based on what Lilly had stated in the post-assessment the researcher attempted to confirm with Lilly during the member check that she was more motivated to engage with new strategies. In response Lilly stated (paraphrasing),

> Yes, that's accurate. And it also, it reignited that excitement to learn. I've always liked learning. I can't study for long periods of time. I like 30-minute blocks. So, for me it's "how do I make the most of my short attention span." There was an expectation that college students always need to be studying that set up some anxiety for me. The (ASC), and my work within the class with other students, helped to validate why I was in college. Certain family members aren't as supportive of an education. And so, meeting people that have the same motivations and going through the same experiences helped to rekindle some of my enjoyment around learning.

This suggests programs for first-generation students should be designed holistically to foster community and care within and outside the classroom. During this study, the researcher learned that helping first-generation students' learning is not merely a cognitive enterprise. The whole person must be supported so they can come to believe in their capabilities and have the motivation to expend enough effort to cultivate those capabilities. Aligning students' short term and long term goals may be a fruitful approach to implementing meta-learning properly, so students find initial practices meaningful. (White & Gunstone, 1989).

Revisiting Foreshadowed Problems

The following subsections revisit the foreshadowed problems listed in Chapter 3. Foreshadowing potential problems, allows the researcher to concentrate on specific topics drawn from the literature, to add further understanding to the case outside of the research questions.

Learning Styles vs. Meta-learning

The use of learning styles were previously mentioned in Chapters 1, 2, and 3. The researcher foreshadowed that if participants used learning styles, they might represent these ideas as being helpful to their learning. The researcher foreshadowed these perceptions may interfere with ideas of visual thinking and learning from a neuroeducation approach.

In short, the potential for interference was difficult to ascertain. The researcher can say with confidence that during the pre-assessment some participants were guided by conceptions of learning styles, particularly being a visual learner. When asked about being a visual learner or speaking about being a visual learner during the pre-assessment focal participants discussed needing ideas broken down step-by-step for them to understand a whole idea or process and auditory information being difficult to process.

The learning strategies used in the ASC were intended to provide access to students' semantic circuitry so they could better think with ideas. As focal participants engaged in these strategies they seemed to raise their level of thinking about academic ideas in specific cases as well as their conceptualization of their own learning. On the other hand, focal and class participants did not regularly discuss integrating visual thinking and language to develop their thinking and/or learning. This is not a surprise in an intervention with such a short time frame and likely suggests a longer intervention is needed to layer students' thinking about how to integrate these cognitive tools. But the researcher did get the sense, particularly in class activities, that previous conceptions of needing visual stimuli to understand and memorize ideas for tests, may have hindered some participants adoption of deeper learning strategies. Alternatively, it did not seem overly challenging for those focal participants who mentioned learning styles approaches, such as memorization of key concepts, to build onto some of their initial conceptions what constituted learning.

How FYFG Students Reacted to Drawing for Conceptual Learning

Drawing can be a rewarding but time-intensive process. Another foreshadowed problem made by the researcher was whether FYFG students would find drawing to be too time-consuming for practical use. This turned out to be a relevant challenge but not one that was insurmountable.

One of the primary challenges that class participants reported was the time-consuming nature of drawing. Many students made alterations to drawing from the way it was discussed in class, to be more meaningful, and time-sensitive. The researcher believes all participants needed more practice and training to implement drawing effectively but overall the rationale and process seemed to make sense to focal and class participants, and some found the strategy effective for their learning. Over half of class participants (12/23) reported knowledge they had attained (in most cases, meta-learnings) from utilizing drawing as a strategy for learning.

Impacts of COVID-19 on ASC and Study

The researcher also foreshadowed problems related to COVID-19. Because the instructor, students, and researcher wore facemasks in class to ensure safety in response to COVID-19, it was a point of emphasis to revisit whether any issues presented themselves that contributed to difficulties in learning or any other socioemotional implications. It’s important to note that students were returning to in-person classes after a 1-year or more hiatus from in-person classes due to the pandemic. In the ASC, instructors and students wore face masks. This meant students were not able to focus on each other's lip movements. Interviews were also done with face masks. The majority of focal participants indicated in the pre-assessment they had been directing their attention to the visual movements of a speaker to understand their words. These visual movements were primarily composed of lip movements but because face masks were regularly worn, some participants mentioned transitioning to focusing on body movements.

In the context of the study the researcher always tried to provide visual elements to support the students' understanding, such as printed copies of the interview questions, and visual, story-based prompts to help students picture what the researcher was asking. Focal participants often referred to the printed interview questions when the researcher asked the question, and some mentioned the printed questions were helpful for their understanding. Additionally, at least one participant found the visual prompts in the interview questions to be helpful. Overall, it's hard to know the impacts COVID-19 had on students in the ASC and the context of this study, as there were no clear issues that presented themselves. Several students I spoke with or observed were happy to be in a class environment again. However, socioemotional and learning challenges almost certainly played a role in this study, though they were unobservable.

Metacognition for Visual Thinking Upon Entry into College

The researcher foreshadowed that it would be a focus of this research to investigate whether there are connections to participants' meta-learning and visual thinking. The researcher stated in Chapter 3 that "Students with limited metacognition for their visual thinking may need forms of meta-learning (i.e., learning about one's learning processes) to make use of their visual thinking." This was an astute observation ahead of the research as there was a clear connection between meta-learning, metacognition, and visual thinking. The process of learning about the way one thinks and learns visually seemed to be meaningful to participants as it explained ways they may have known they learned but never heard explained explicitly. All focal participants made changes to their visual thinking as a result of the meta-learning process which suggests teaching first-generation students about their visual thinking and learning through language (in the context of this study) was impactful to helping them develop metacognition for their visual thinking. It will be interesting to see if these results can be duplicated in additional research.

Limitations of the Study

There were several inherent limitations to this study that need to be considered. First, there was a focal participant who learned English as a second language which could have impacted the TEMPro results. Second, during the 15 weeks of learning in the ASC, FYFG students were likely exposed to a variety of reflective and dialogic activities outside of the five-week meta-learning block that contributed to their metacognitive gains in knowledge and regulation. Practices which occurred within and also outside the constraints of the case study, such as learning communities, career development, reflective thinking, multicultural learning, and social/peer relationships may have impacted factors such as agency, belonging, and self-efficacy, contributing to student changes. However, these factors should also be considered a strength, as the researcher was able to show that meta-learning seamlessly interacts with other known high-impact and effective practices contributing to metacognitive changes.

In the context of this analysis, it was difficult to put parameters on where 'visual thinking' in the context of neuroeducation and 'visualization' in the context of cognitive psychology and neuroscience begins and ends. It was helpful to think of all such responses as language that metacognitively assigns meanings to one's visual cognition and thus (as reported), helps focal participants visually think about (or visualize) contextual scenarios to build meaning, relate and connect ideas, understand and 'see' new ideas, and/or layer their thinking when learning. Participants used the term visualizations on most occasions to refer to their mental thinking of visual images (i.e., mental pictures) when engaged in a learning task. Some researchers may point out specific granular differences in visual behaviors based on their field of study, but in educational practice such differences, the researcher would argue, are trivial.

It's also hard to say or measure the degree and consistency of qualitative changes. For instance, focal participants indicated they regulated their use of language more over the course of their semester in college. However, it's unclear if focal participants recurringly engaged in this behavior, for how many subjects, and to what degree they controlled this strategy. The quantitative analysis conducted with the MAI indicated moderate metacognitive gains occurred, which when compared to qualitative themes provides legitimacy that metacognitive gains in knowledge and regulation for learning occurred. But because the quantitative and qualitative measures do not both assess visual thinking and learning from the same theoretical framework it's hard to draw more definitive conclusions about students' visual thinking and learning.

Lastly, the transferability of this study is constrained, given the limited number of participants, the focus on their individual experiences, and the nature of the researchers' role in the study. Bias plays a factor in the analysis of these results, as the researcher was actively involved in students' meta-learning processes. However, the researcher took great strides to improve the trustworthiness of this study by utilizing interactive member checks, a mixed-methods approach, analytic memos, and bracketing within a research journal (see Chapter 3).

Recommendations for Future Research

The results of this study could be the basis for a number of future studies. Exploring interdisciplinary connections between visual thinking, metacognition, and meta-learning is an untapped field of research that could pay dividends to underrepresented student populations. To that end, the researcher suggests that a quantitative self-report questionnaire be developed that assesses metacognitive changes to students visual thinking and learning based on deep learning approaches. This is needed to assess changes more accurately to student's metacognition for learning over time. The MAI while practical strikes the researcher as an outdated model that does not capture how students learn neurobiologically.

Additionally, the researcher believes that fostering a sense of belonging and a sense of empowerment in the ASC may have been two of the most impactful environmental factors that supported students' meta-learning, although these were ancillary findings/observations in this study. More research is needed that explores environments that promote belonging and empowerment in relation to students learning/meta-learning, so appropriate curricular designs can be made.

Lastly, more research is needed that examines visual thinking in education. Visual thinking is currently not widely considered a metacognitive skill for learning. In the researchers' view, using one's visual thinking strategically, as in using one's language, metacognition, and mental imagery in tandem to learn is the most important metacognitive skill to have in the 21st century and subsumes other metacognitive behaviors such as planning, orientation, and evaluation, as all of these strategies could plausibly be carried out through one's visual thinking.

Concluding Remarks

This study found that the meta-learning intervention within the ASC helped focal participants develop visual thinking and learning capacities that provided a means by which participants enacted changes to support their visual thinking and learning processes. Participants integrated a number of metacognitive strategies into their learning, such as writing notes in their own words (e.g., voice), discussing ideas with peers, monitoring their understanding, drawing ideas in their notes, and visualizing new ideas, among others. As focal participants applied these strategies more over the course of the semester they began to develop metacognitive knowledge and skills for their thinking and learning processes. As a result, focal participants learned about themselves as visual thinkers and learners, specifically how they learned best. These ‘changes’ were marked by participants reports of improved academic performance and learning, as well as feelings of empowerment, confidence, and control over their learning. While some focal participants made connections between language and visual thinking as an integrated process for learning, more often participants discussed these cognitive aspects separately.

This study corroborates recent studies that have utilized metacognitive interventions with first-generation and underrepresented students and reported more developed metacognitive strategies and self-regulatory skills, which in turn impacted dispositional factors (e.g., empowerment) (Conefrey, 2021; Sermon, 2018; Wibrowski et al., 2017). Research suggests that pictures of students’ *possible selves* – that is, visions of their future selves is a motivating factor in self-regulation (Oyserman et al., 2004; Oyserman, 2019). Frazier et al., (2021) posits however, that students need access to metacognitive strategies, to make changes to their thinking and learning to realize these future selves. In other words, metacognitive strategies are the tools that help students develop capacities to actualize their goals. Students need to ‘see’ the destination and ways to reach that destination to enact changes (Oyserman et al., 2004). Strong visual thinking capacities then, are not only important to supporting learning but to empowering students to see and realize their potential. Connecting students to their thinking and learning processes is thus, a matter of equity and should be a fundamental aspect of all education as it can occur simultaneously with disciplinary learning.

If higher education administrators and practitioners want to place first-generation college students in positions that give them opportunities to enact agency and succeed in college they must rethink the way they oversee, develop, and implement curricular designs (Ives & Castillo-Montoya, 2020). In keeping with Ives & Castillo Montoya's (2020) view that we should understand how to support FGCS as academic learners by supporting their experiences and seek to change those practices which disadvantage students, this study has shown that metacognitive, reflective, and social practices in tandem can empower FGCS to become stronger academic thinkers and learners. Fostering metacognitive growth can be a tool to achieve equity at universities because it helps underrepresented and racial minority students become aware of and analyze thinking/learning approaches to better navigate academic environments (Tao, 2021; Horrell et al., 2019). Promoting metacognition for the way first-generation students learn best promotes equity, in that it helps FGCS become aware of and implement learning approaches (including mindsets) that contribute to academic and life-long success. If first-generation students are visual thinkers and learners and see themselves that way, then curriculum should be developed to match the way they think and learn, to provide them the best opportunities to succeed.

First-year programs are perfectly situated to be the foundation upon which educators provide academic success to students and internally conceptualize what academic success looks like in higher education. The primary goal of these programs should be teaching students how to think and learn effectively so they can be successful in classrooms, and the second goal should be exploring how educators can change classrooms to better suit how students think and learn. Jerome Bruner (1996), stated that, "education is a complex pursuit of fitting a culture to the needs of its members and their ways of knowing to the needs of the culture (p.42)" Thus, the researcher proposes that first-year programs act as a vehicle of academic scholarship and educational research, upon which universities learn from the incoming class and make necessary changes based upon students' feedback, and first-year students learn to develop life-long competencies that will help them succeed. For that to occur, however, first-year programs should be extended into students' second year to provide more opportunities for impactful research and scholarship to develop, and so the impacts of these programs endure. Upperclass students can also participate in these programs as mentors and researchers, helping to guide incoming classes and lobby for institutional changes. Curricular, extra-curricular and co-curricular goals as a university then, branch and are facilitated from this scholarship and students are empowered to help change institutional practices. It's a give and take, a balance, a moderation, between students, faculty, and university leadership that supports everyone's goals – and most importantly it is the realization of what many educators think of when we say "equity."

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Appendices

Appendix A - Academic Success Course Schedule and Key Takeaways

Week 1

Topic: What does it mean to be a first-generation college and/or low-income Student? (Focus on Person role)

Instructor Focus - Contextualizing student challenges and how the ASC can help

- Discuss most relevant portion of the syllabus.

Guest lecturer: Current first-year, first-generation student - What's good to know your first few weeks of school. What does it mean for the guest lecturer to be first-generation? Some of the guest's anxieties to begin school. Q&A afterward.

Key takeaways from class:

- The guest-speaker identified as black. The guest-speaker talked about feeling isolated; that there weren't many black people at the university. The student talked about almost dropping out of school.
    - The guest-speaker talked about the microaggressions and racism that the student had experienced on campus.
    - The student said it helped to have people at the university in their corner that worked with them and allowed the student flexibility and understood their concerns.
- The guest-speaker discussed a little bit about the hidden curriculum, and what helped them, such as checking the learning management system consistently and checking the physical syllabus.
    - There are people to reach out to who can help you and support you while in college.
    - Find a mentor to talk to that will support you and have their back if something goes wrong.
    - Reach out to faculty, and get to know them, so that they can eventually write you a recommendation letter.
    - Cultivate a network of relationships that will help you in your college career.
    - Find what works for you in terms of notetaking and strategies for engaging with the curriculum.
- This was a powerful conversation.

SELECTED READINGS/VIEWINGS (*Only specific readings and viewings from the ASC are added below*)

- (READING) Are you first Gen? Depends on who's asking
- (READING) Taking my parents to college
- (READING) 10 Things to Do in College Beyond Going to Class
- (PODCAST) FGEN Experience: Student Podcast

REFLECTIVE JOURNAL ENTRY #1

Reflective Prompts:

1. Read the syllabus, based on what we talked about today and the syllabus what do you want to learn about that will help in your learning/academic journey
2. Discuss the academic anxieties you have as you are starting college. What aspects of college make you nervous?
3. What parts of the guest speaker's thoughts and advice really hit home and resonated with you? How so?

Week 2

Topic: Cultivating a mindset: communities and diverse experiences – Part I (Focus on Person to Student role)

Guest Speakers: Three Current FGEN Coordinators

Prompts for discussion:

- Tell us how you first got involved with FGEN
- What does being in a 'community' mean to you? What does it provide you?
- How do you foster 'community' with others?
- As a first year FGEN, why might the FGEN community be beneficial to them?
- Besides FGEN, are their other clubs, offices or communities they are involved in?

Key takeaways from class:

- Participation in groups is critical to acceptance, growth, and development of a support system.
- Support systems help you grow by incorporating diverse perspectives into your lives.
- Learning isn't always academic, learning from each other is important as well.
- Walter asks what it means to be in 'a community'.
    - The second ambassador said, When I think of community that he thinks of trust. That you can share anything with them. He doesn't feel there are any bad apples in the first gen program at the university. Everybody is there to support you and keep your information safe.
    - The third ambassador said, it's a support system.
- After class, one of the students said she barely remembered what happened the week before. Walter said the first week of school is tough, there's a lot going on. Another student said she's struggled with her studies the first week of class. Walter said to try not

to associate constructive feedback with who you are as a person, but just understand it's something that you do. She said the main thing she learned all week was the discussion the first week of class with the first-generation speaker.

READINGS/VIEWINGS: (*Only specific readings and viewings from the ASC are added below*)

- (READING) How First-generation Students of Color Can Build Resilience in Higher Education through Mentorship
- (READING) 6 Things I learned here at University
- (READING) Advice for New Students from Older Students

REFLECTIVE JOURNAL ENTRY #2

Reflective Prompts:

1. What does being a "first-generation college student" mean to you, if anything at all, here at the university?
2. What communities do you want to join and why? How will this fit into your idea of your future-self in year-4 of college?
3. What did you take-away from the guest-speakers? How will this impact how you seek connection(s) in the coming weeks here on campus?
4. In this week's reading by Bianca Ramos, select the **most important** sentence to you in the entire reading. Explain why you selected this sentence to be the most important.

Week 3

Topic: Cultivating a mindset: communities and diverse experiences – Part II - (Focus on Person to Student role)

Exercise in Learning Communities:

- Each learning community answers questions (given by the instructor), on a poster sheet about their previous experiences with education, and then shares that with other learning communities. Students are encouraged to write and draw.

Key takeaways from class:

- Developing learning communities will help you throughout your first semester with the challenges you will face, and they can support your learning.
- One student said his perception of being college is "I'm an adult" and "I'm a student at the same time" and I'm trying to figure out how to do both things.
    - "What you heal within yourself, can heal your family" - is what one student said when presenting to another group.
    - Another student said that she's been more interested in school than most of her family. She's excited for herself and others to better themselves and learn.

- It's amazing how well some students just naturally get along with one another and seem comfortable talking with one another.
- Walter asked the class, 'what did you hear that was interesting?' What did you learn?
    - Their education is benefiting themselves but also their families, 'setting the standard for my nephews and siblings.'
    - Students seem excited to stray away from the norm, and discover themselves, and take new opportunities.
    - One student discussed pressure from families to graduate.
    - Walter acknowledges that the pressure to be a great student is hard
        - He says he's doing a study about success with first gen. And if you ask first-gen students what success is, you'll likely get 30 different answers and that's the beauty of it. Says success is *defined by you and not others*. One student nodded in acknowledgement. That was a great moment.
    - Walter said what's great is that you're teaching each other. That's what a learning community is. You learn from each other and that extends when you walk out the door and extends in your life. Class concluded on that note.

READINGS/VIEWINGS: (*Only specific readings and viewings from the ASC are added below*)

- (READING) *Poignant article by notable writer on his first day of college*
- (VIDEO) How drawing can set you free
- (VIDEO) Why people believe they can't draw

REFLECTIVE JOURNAL ENTRY #3

Reflective Prompts:

1. What is your mindset towards engaging in college academics based on what you previously experienced?
    - What are your current motivations?
    - What is your approach to learning based on previous experiences?
2. Becoming acquainted with drawing. Watch videos on drawing and draw something you want to do this week. Then write about the experience of drawing.

Week 4

Topic: Your College Experience and Time Management and Procrastination (Focus on Student role)

Instructor Focus: Time management and avoiding procrastination

Class Exercise: Planning out your schedule on a calendar

Assignment(s) for next class:

1. Learning Community Activity: Group must meet outside of class (virtual or in person).
2. Complete your remaining sheet on your own. Meet and discuss (LESS than 30 mins total):
    a. Which weeks look to be the most difficult or challenging, and what is "the plan" to attack these weeks? For example, with multiple papers, do you go to the writing center, office hours, have someone from your class or even your Learning Community read your draft? These types of ideas.
    b. Complete and upload a picture of your Fall, 2021 Semester Planning Sheet (take picture and upload file into Moodle for full credit)
    c. On BACK of your calendar, answer the following (individually) When, where/how did you meet? What was this experience like? What are the ways you can use this strategy, either by itself or with other time management strategies?

READINGS/VIEWINGS: (*Only specific readings and viewings from the ASC are added below*)

- (VIDEO) Time management and mindset TED Talk
- (VIDEO) Procrastination TED Talk

Week 5 (Class #1 in Learning & Thinking Block)

Topic: Learning and Thinking: Neuroscience for Learning (Focus on Learner and Student roles)

Beginning of Class Exercise: 2 min oral presentations from learning communities talking about what their learning community discussed, the semester planner assignment, and themes.

Topics for Guest Instructor/Lecturer:

- Discussing neuroscience for learning
- Strategies for learning in higher education

Key takeaways from class:

- Learning is meaningful
- Learning develops the brain (i.e., neuroplasticity)
- Neural networks are language-based
- Try to use strategies that help you learn and develop the brain at the same time. You can do this by using your own natural language.
- One of the questions from students related to what you do if you are learning something that you are not interested in. I said that was difficult; I said to try to make the material as meaningful as you can to yourself. I said that telling other people the information might help you to make it more meaningful. I mentioned that I would like to know what he does to make it more meaningful. After class, I thought I should have told him to make the material into stories to make it more meaningful.
- Some students mentioned that meeting outside class felt forced while some others said they chatted and got to know each other. Other groups said they saw the reason for meeting outside class.

- Walter mentioned the reason we have students meet outside of class, is to get to know each other and make connections, which may require the students to venture outside their comfort zone. Especially because students have been going through a pandemic and have been learning from home, both Walter and I believe it's important to nudge students a bit to meet and speak with each other. Also, students learn well in groups, and learn from each other in groups, which is important to cultivating positive experiences and communities for these students.

READINGS/VIEWINGS: (*Only specific readings and viewings from the ASC are added below*)

- (READING) Why the brain loves stories
- (READING) How Language Shapes the Brain
- (READING) Neuroplasticity: How to use it

REFLECTIVE JOURNAL ENTRY #4

Reflective Prompts:

1. What did you take away from this week's class on neuroscience for learning?
2. What knowledge, hobbies, and/or sports do you think are associated with strong (neural) networks in your brain?
3. Think of yourself as a learner. Is there anything from this week that you can apply to your own learning? Or maybe there's something that you've learned on your own that you'd like to apply. What is that and why?

Week 6 (Class #2 in Learning & Thinking Block)

Topic: Learning, Visual Learning Strategies, Note taking (intro), and Drawing (Focus on Student and Learner roles)

Discussion with Guest Instructor, Chris Long

- Review of last week's class and material. What do we remember about learning and the brain? What strategies do we remember and want to use?

Guest Speaker: Sarah (pseudonym), a neuroeducation specialist and kindergarten teacher, leads class via Zoom

Presentation Focus: Conceptual Drawing and Learning

- Sarah discusses and shows class how to draw and flowchart for conceptual learning. Sarah discusses why this strategy works to support conceptual learning by discussing how our neurobiological learning systems work.

Class Exercise: The class reads a short excerpt and draws with Sarah in real time. The instructor and guest instructor set up online cameras that synced Sarah and the classes drawing in real time. So, the class was able to follow along with Sarah as if she was physically present.

Key takeaways from class:

- Difference between short term memory and long-term memory is through visual learning – (e.g., seeing what you're thinking and creating connections between ideas with language)
- Walter asks a follow up and says it can be scary to try something new, especially when your previous education might have said take notes in a specific way. Sarah followed up with a positive response. She said she wasn't able to store most of the material she learned in high school in long term memory. With the neuroeducation strategies she has been able to remember concepts and use them consistently. Why not do what helps you, instead of what somebody is telling you to do.
- Scanning a text is important when reading, helps you pull meaningful information off the page to picture the ideas for drawing.
- Draw out the ideas that are in order in your mind.
    - Drawing helps adult students picture their learning and do something that is catered to their learning system
    - One drawback is the learning curve and the time it takes to begin conceptual drawing and getting your hand to move as fast as your mind.

READINGS/VIEWINGS:

- (READING) Reading, conceptual drawing and flowcharting (Arwood & Brown, 2001)
- (VIDEO) The powerful effects of drawing on learning

REFLECTIVE JOURNAL ENTRY #5

Reflective Prompts:

1. What was it like to draw and/or flowchart in class? Did your perceptions of drawing change? If so, how?
2. Is drawing and/or flow charting something you could use in class or outside of class to help you think about ideas presented in class? Why or why not.
3. If not, what else do you think might help you understand class material better?
4. What are the best ways that you learn? Identify at least one idea or strategy that helps you learn.

Week 7 (Class #3 in Learning & Thinking Block)

Topic: Visualizing Time and Studying (Focus on Student to Learner roles)

Guest Instructor: Chris Long reviews what we've discussed in the learning and thinking block and where we're headed.

Guest Speaker: Dr. Susan (pseudonym), a neuroeducation specialist, leads class via Zoom

Presentation focus: Being a natural learner, spatial thinking, studying, and visualizing time

- Susan discusses what it means to be a natural learner and points out that everyone in class is a natural learner. She then shows students how to read for conceptual drawing as well as how to engage in conceptual drawing. Lastly, she focuses on how to manage your schedule so you can visualize your schedule.

Class exercises:

- Students will draw the concepts that come to mind after reading a passage on how to cook a turkey.
- Students will work through strategies to plan out their schedules so they can visualize time.

Class discussion

- What are you an expert in? What helped you become an expert?

Key takeaways from class:

- We are all natural learners and finding out about our own learning can helps us study and perform better.
    - Searching for answers is a powerful form of long-term learning.
    - It's important to make connections between ideas. Flowcharting with images, icons, and words help to create connections.
- The beauty of drawing is that it doesn't necessarily matter if you're artistically inclined, as long as the drawing pertains to you or makes sense to you then it should work.
- The more you can visualize your plan (schedule) - the easier it is to act on it. So, write out exactly what you will work on then set a timer, and break out your studying/work into chunks across the days.
- A student said she has a sociology mid-term, she said this (the scheduling website and visualizing a schedule) helps in terms of what she could do each day before her mid-term. Susan said visualizing schedules this way helps to reduce anxiety. The headings from the website tell you what you can do each week.
    - Create systems for yourself in terms of drawing and time management that help you see what you're doing and learning.

READINGS/VIEWINGS:

- Visual Reading Strategies (Arwood & Brown, 2001)

Assignment(s) for next class:

- No Assignments or Reflective Journal Entries; a good time to do any make-up/missed assignments. Read the one article and test out the apps for time management/studying at some point during your break or the week after your break
- VIDEO: Try a Study with me video (Pomodoro Technique, 25 minutes with 5-minute breaks)

Week 8 [NO CLASS]

Week 9 (Class #4 in Learning & Thinking Block)

Topic: Metacognition, Visualization and Mental Images

Guest Instructor/Speaker: Chris Long

Presentation Focus:

- Tuning into our own thinking and mental pictures. The impact visualization has on understanding.
- What is metacognition? Building knowledge of our learning and thinking.
- Movies in your mind, the power of visualization for planning, learning, and well-being.

Class Exercise:

In their learning communities the class will read a case study or article about one of the three concepts discussed by the guest instructor (e.g., metacognition, visualization, and mental images). Based on what they learn they will share the ideas with the class and how they think the concept/strategy is relevant to learning. The class then can ask questions and provide comments.

Key takeaways from class:

- The concepts of metacognition, visualization, and mental images are what it means to be a visual thinker. How to use your thinking to plan into the future and to think creatively and critically.
- Our mental images are the source of our understanding.
  - Our language is the source of our thinking.
  - Together these concepts when used properly, help us become effective visual learners.
- The learning communities discussed the three high-level concepts clearly and were able to convey the ideas in the case study extremely well.
  - I mentioned they should all be proud of themselves because these are high-level concepts that many do not learn as first-year students.
- Students made the concepts relevant to teaching and learning in their discussions.

ASSIGNMENT

- Review the readings, viewings and graphics in Moodle
- Try one or two visual, metacognitive and/or language learning strategies this week that you think could be impactful. This can be visualization, drawing, note-taking in your own voice, teaching the material, etc.
- Try to use this strategy (or strategies) all week. Please do not use a strategy that we have not covered in class.
- Upload a visual example of the learning strategy that you used (notes, drawings, reflections, etc.)

On a separate document reflect on the strategy you used by answering the below prompts (**be descriptive at least 300 words):**

  - Tell us about the strategy or strategies that you used and how you used them.
  - How is this strategy helpful if you feel that it is helpful?
  - What are the challenges in using the strategy if there are any?
  - How can you overcome any challenges faced?

READINGS/VIEWINGS

- (READING) Getting Good at Mental Imagery – Strategies
- (VIDEO) Thinking About Thinking – It's Metacognition!
- (VIDEO) What is metacognition? (Exploring the metacognition cycle)
- (VIDEO) How visualization can change your life

Week 10 (Class #5 in Learning & Thinking Block)

Topic: Learning and Thinking (Part V): Learning Communities are Presented with Learning Challenges

Guest Instructor/Speaker: Chris Long

Presentation Topic: Wrapping up discussion on Metacognition, Visualization and Mental Images and how it relates to being a visual thinker and learner, and how we become critical thinkers and lifelong learners.

Class Exercise: Each learning community creates a character, who is a student at the university. Each learning community shares that characters' story and answers a series of prompts given by the guest instructor. These prompts include what are the characters' hobbies, goals, motivations, mindset, obstacles/challenges, and a plan to overcome these obstacles/challenges. Exercises are done on poster sheets and then shared with class (present in class, 2-3 mins). Hobbies, goals, mindset, obstacles/challenges, and a plan forward.

Key takeaways from class:

- Students were very engaged in the class exercise and came up with creative characters
- Their challenges ranged from dealing with misogyny, to dealing with pressure from parents, not having college preparation, being far from home, culture shock, and struggling with time management, among other challenges.
- Several learning communities drew pictures of their character and labeled them as a visual learner.
    - Some learning communities discussed investing in their learning and making their learning visual as plans to overcome obstacles.
    - Some other learning communities mentioned going to office hours as a way to overcome some challenges
- Not all learning communities came up with a plan for how to approach the challenges that faced their character

READINGS/VIEWINGS

- (READING) The role of metacognition in learning and achievement
- (VIDEO) What a brain like you doing in a classroom like this?
- (VIDEO) Improve learning by thinking about learning
- (VIDEO) Metacognition: The skill that promotes advanced learning.
- (VIDEO) Visualization for Students Benefits and Strategies

REFLECTIVE JOURNAL ENTRY #6
Take out a visual block of at least 20 mins and reflect on your experiences with learning and thinking for the past 6 weeks. Please answer all the prompts, minimum 350 words, for full credit.

1. What are some challenges that you faced in the past (like in high school) when learning?
2. Think for a minute about ideas or strategies you've learned in class so far. Which, if any, have you integrated into your own life?
3. Why have you integrated these new ideas or strategies?
4. How do you think you learn best?
5. Does learning about your own learning help you to feel empowered – as in you have power over the ways that you learn?
    a. If yes, what have you learned in this class thus far that has helped you to feel empowered?
    b. If not, please explain why you don't feel like you have power over your own learning? What do you think would help you to feel empowered in terms of your own learning?

Week 11 (Class #1 Identity, Community, and Society)

Topic: Cultivating our dispositions and skills in higher education to succeed in the 21st century workforce

Guest Instructor: Chris Long discusses what we'll be focusing on going forward – we've discussed how to learn and how to be a student - how to reflect on ourselves as a student and learner. Now it's time to turn our reflective thinking, our metacognition, on the issues that will impact us going forward, beyond college, and how we plan for living and living into the future.

Guest Speaker: Cameron (pseudonym) from the university's career department will take over and lead the class.

Presentation Topic: What are the skills and dispositions that the 21st century workforce is looking for? Cultivating strengths in higher education that lead to career success. How higher education is a place to learn how to learn, grow, develop and learn how to succeed.

Class discussion/exercises:

- What are your feelings when learning?
- Stop and explore what emotions you're feeling right now.
- How attuned to your emotions are you?
- Beyond just recognizing your emotions, how aware are you of the effect of your actions, moods, and emotions on other people?
- Share thoughts with your partner and your partner reflects back what you heard articulated.

Small group discussion: What is the career field you are currently most interested in? What are the skills and dispositions required to be successful in that career? What are your soft skills?

Key takeaways from class:

- EQ is the foundation for critical skills that have value in the real world and your career. Developing a growth mindset and soft skills are going to make you more employable.
- Adopt a "Growth Mindset"
    - Growth mindset is not about being positive. Growth mindset is about keeping an open mind and an open heart. He says that we can always be open to learning, experiencing and approaching new things/ideas.
    - We can grow in how we approach each situation, and we can adopt and learn a growth mindset.
- Cameron asks students to pay attention to your skill development. Employers are asking educators to have students reflect on these skills and help them develop them while in college.
    - Career and self-development, communication/interaction, critical thinking among other skills valued by employers.
    - Metacognition, self-awareness are other important skills for career readiness.
    - The soft skills and competence that you learn and develop in college are the things that career professionals and those that can create opportunities for you value.

READINGS/VIEWINGS

- (READ) What having a growth mindset actually means.

- (VIDEO) Angela Lee Duckworth: Grit: The power of passion and perseverance
- (VIDEO) Eduardo Briceño: How to get better at the things you care about
- (VIDEO) Aimée Eubanks Davis: How your unique story can get you hired.
- (PDF) Social Awareness Strategies

REFLECTIVE JOURNAL ENTRY #7

Given what we discussed about the value of emotional intelligence and growth mindset, and the critical skills they help to develop, how might you try to incorporate those competencies into your life in the coming weeks? There is a .pdf document with social awareness strategies (for developing EI) to give your ideas.

DIRECTIONS: Follow the RATE Model below and respond to each prompt. RATE is intended to help students develop and monitor core career competencies. Minimum 350 words.

- Reflect – Reflect on your experiences in the last class and discuss what you learned (including from your partner)
- Articulate – Articulate how you can develop career readiness competencies based on what you're learning.
- Translate – Translate how these competencies are valuable in the workplace.
- Evaluate – Evaluate your level of readiness in these competencies.

Week 12 (Class #2 Identity, Community, and Society)

Topic: Power, Privilege, and Class (Person role)

Guest Lecturer: Dr. Alex (pseudonym) professor/director from ethnic studies department, to lead the class.

Presentation and Discussion Focus:

- Introduction to Ethnic Studies
    - Ethnic studies' looks at things like racism, nationalism and patriarchy to think about belonging and not belonging,
- Topical issues through the lens of ethnicity, social histories, cultural studies.
    - Thinking about racial/cultural norms in America.
- What is our positionality? How do we understand our world through our position?
- What is one thing you would want someone to know about being a First Gen Student?
- Creating a sense of belonging. Where do we feel like we belong?

Learning community discussion:

- What is one thing you would want someone to know about being a First Gen Student?
- When have you felt like you belonged?

- When have you felt like you haven't belonged?
- When have you felt included at the University?
- When have you felt excluded at the University?

Key takeaways from class:

- "How do you feel who you are?"
    - Ethnic studies asks where we belong in the world and who we are and the institutions, and structures that make you feel a part and not a part of something.
        - These include formal and institutional structures, like clubs, universities, political parties and also cultural phenomenon - celebrity, pop culture and how that relates to feelings and emotions like sadness, happiness, exclusion, inclusion.
    - This is how power, class and privilege come into play, because these categories structure our sense of belonging and exclusion.
    - Language can create a sense of belonging and has strong cultural roots.
    - Alex asks a student which usually doesn't speak up. The student said she's a commuter student, so she doesn't join groups, so this class (the ASC) is where she feels included, this is what she has.
        - Several students echoed the same sentiment. That the ASC is where they feel like they belong, where they feel included.

REFLECTIVE JOURNAL ENTRY #8

Definition of Positionality:

Positionality is the social and political context that creates your identity in terms of race, class, gender, sexuality, and ability status. Positionality also describes how your identity influences, and potentially biases, your understanding of and outlook on the world.

Reflective Prompts:

a) What were your main takeaways from our class speaker, Dr. Alex, and her time with us?
b) How do you think your positionality has been shaped?
c) As a person and student, what does belonging mean to you? Where do you feel you belong? How can you cultivate a sense of belonging for others?

Week 13 (Class #3 Identity, Community, and Society)

Topic: Introduction to Authentic Storytelling - Knowing Your Story, Cultivating Your Voice, and the Power of FGEN

Guest Speaker: Dr. Anthony (pseudonym), Associate Professor, Theology

Presentation Focus:

- Finding yourself through telling your stories.
- Being mindful of your story and what do you want your story to be.
- Stories help us find ourselves and purpose in life.
    - The stories we tell about ourselves shapes us and become our reality.
    - Stories help us to build communities of life.
    - We become the stories we tell.
    - We are not a story but stories being told.
    - Our stories are connected to the stories of others.
- It's your story and you need to be the one telling it, because if you don't it won't be told, or worst it would be told the right way.
- When you share your story about being first gen it broadens the community - stories of the community creates space for new meaning.

Class Exercises:

1. Two students come to front of class and tell us your story.
2. What stories are you becoming?
3. How are you telling your stories in the space you occupy at university? What stories have you told to your friends on Campus.

Key takeaways from class:

- "Being first gen is a wonderful story, do you know why? Because it's a story of freedom." "You teach the community a different way of being." "You have a gift that you bring to the University."
    - We learn by telling stories.
- By knowing your story, the teacher can tailor their material to you. But you have to tell your story in class. If you are invisible the teacher can't teach you because they can't see you.
- "Remember the story that brought you here." When you feel failure, or you feel down, don't forget the stories that got you here.
- Reflect on how your story is leading you… and "leading you to greater heights."

Class Discussion:

1. What did you learn about your two classmates?
2. What did you learn about yourselves as you told your stories?
3. Why did you tell the stories you told of yourselves?
4. Are these the only stories you recall of yourselves?
5. What realities do you want for yourself.

READINGS/VIEWINGS

- (READING) Dr. Anthony's FGEN STORY
- No other readings or work

Week 14 [BREAK, NO CLASS]

EMAIL TO STUDENTS

I have two important announcements about the final week of the ASC.

1. For those who would be willing to have your recording (of letters to next first-gen class) shown to the next class of first-generation students, please submit those videos to me via email. It would be great for the next class to hear your stories and insights! Currently, we have a few videos to include as part of a highlight reel but need at least three more videos to complete this project. Thank you to those students who have submitted your videos to me!

    a. Also, please be sure to upload your videos to the LMS, if you have not done so already, as the second part of your final project. Again, if you've already uploaded your video to Moodle, you do not need to do so again but if you haven't, please do so as soon as possible. Then to have your video included in the highlight reel, please submit that to me via email at [email]. If the video is too big to send via email you can use a free service called WeTransfer to email it to me. WeTransfer is easy to use - you can drag and drop the files on the screen, type in my email, and send the files over. The file will take a little while to transfer so please don't exit out of the browser right away. If you have any questions about any of this, please reach out to me and we can talk.

2. The final assignment for the ASC is completing the Metacognitive Awareness Inventory (MAI). You will see this assignment in the LMS. The MAI measures aspects of your metacognition as a learner. You took this survey in class during the 5th week of class. This is a follow-up to that original survey to measure if any changes in metacognition (*thinking about thinking and learning*) have occurred.

You have until December 3rd to finish this survey but can knock it out quickly today. There are 52 multiple-choice questions which should take you 10 minutes or less to complete. No studying is required to take this survey but please answer the questions accurately and honestly. Next semester we will provide you with the results. This survey helps us assess aspects of the class, so I hope we can have a 100% response rate!

Week 15 (Class #4 Identity, Community, and Society)

Topic: Exploring how we use technology and social media

Instructor updates:

- Talked about this being last class
- Talked about the MAI
- I mentioned need the videos for the highlight videos

- Status of current grades
- Talked about finishing course evaluations

Guest Lecturer: Dr. Sam (pseudonym) professor in education department, to lead the class.

Presentation and Discussion Focus:

- Being mindful of our relationships with machines and technology
- Reflecting on how we feel during and after we use technology/social media
- Pointing out the need to capture everything on smart phones.
- Short history on emoticons and codes in online communication.
- Short history about the supply chain industry and making food available and cheap.
    - The technology industry created the smart phone and built an industry around it and if we're not careful we can become glutinous with our relationship to that industry
- Challenging your relationships with technology.
    - How do we cultivate a better future with social media?
    - Important to decode the relationships that we have to technology.

Learning Communities Discussion:

- What is your relationship with technology?
    - Are our relationships with technology unhealthy? Or are they creating an unhealthy environment for us?

Key takeaways from class:

- "There's a gluttony of engagement". Sam says he's afraid we've created this society, but now it's up to you, you have to be the one to model and figure it out.
- What I'm asking is that you challenge your relationships with technology.
- Coming full circle, and looking at our relationships, are we creating our relationships in a healthy way in a physical environment that helps build community here.

Appendix B – Academic Success Course Objectives

By the end of this class, the student will be able to:

1. Observe and discuss the issues that confront first-year, first-generation students.

2. Reflect and discuss what knowledge, beliefs, and experiences you bring into college that you want to preserve. These can be negative experiences or positive experiences.

3. Reflect and discuss what you want to build upon while in college - in terms of your thinking, skills, strategies, beliefs, and experiences.

4. Reflect and discuss how your identity will impact your education and career. This means how will your previous cultural and social experiences impact your education going forward? What is your story? What is important to you in terms of who you are as a person? How will you use this understanding to benefit your academic and professional growth? The instructors' goal is to help prioritize 'who' you are above 'what' you do. Your academic success is an offshoot of your well-being, you're learning, and your identity.

5. Use your voice as an opportunity for self-expression, self-reflection, and growth.

    a. There will be opportunities for open dialogue, between the whole class, small groups, and teacher-student one-on-ones. There will also be opportunities for written dialogue in reflective writing assignments. Use these opportunities to discuss your anxieties, worries, challenges, and how you plan to overcome these challenges. Embrace your voice in the class to learn from your peers, learn from the instructors and allow your peers and instructors to learn from you.

6. Develop a learning community among your assigned small group. This learning community is intended to support you and allow you to support others in your academic journeys. Lean on this group and other groups to cultivate positive experiences and overcome challenges in higher education.

7. Cultivate a metacognition for your learning and thinking processes. This is done by continually reflecting on your own thinking and learning processes (individually and in groups) as well as strategies that will help you make sense of what you are studying.

    a. Understanding your own thinking and learning processes can help you develop strategies for reading, taking notes, and creating learning materials that will help you understand academic topics more deeply. Ultimately, this class will try to help prepare you to think more reflectively, deeply and critically about topics in your other classes.
    b. Reflect and discuss how you will plan, monitor, strategize and evaluate your behaviors in higher education?

c. Reflect and discuss the differences between learning styles and learning strategies. This will be discussed in class.

8. Reflect and discuss the processes and expectations of higher education that you are beginning to understand. What do you think you should understand that will help you succeed academically and grow as a person? What is hidden in the curriculum and administrative processes in higher education that I understand that will help me succeed as a *person*, *student*, and *learner*?

Appendix C - Consent Form for Research

You are invited to participate in a research study conducted by Chris Long, as part of the University doctoral program. This research is focused on understanding the learning and thinking processes of first-year, first-generation students in educational contexts, and how their learning and thinking strategies change during their time in the [ASC].

You have been selected as a potential participant because you are enrolled in the [ASC], and your affiliation as a first-year, first-generation student. Participation in this research is voluntary. If you'd rather not participate in this study, there will be no penalty involved, and your grade in the [ASC] will not be impacted.

Involvement in this study will help educators gain a deeper understanding of first-year, first-generation students in higher education. This study is intended to support the academic success, critical thinking and life-long learning of first-generation students.

Following the completion of this consent form is a 'demographic form', for your review. The demographic form asks for information about your ethnicity, gender, spoken languages, and educational history. The demographic form is helpful to the researcher as it provides more cultural and educational context that will enrich the findings of this study. This information is confidential and will not be used for any generalizations to ethnicity or culture. This form is voluntary to fill out.

All information that you submit for this study will be kept confidential and will be stored in a password protected and encrypted location. Additionally, responses to this consent form, the demographic form, and the questionnaires you will fill out shortly will be stored in an online survey tool called Qualtrics.

As a preventative measure to your confidentiality the researcher will use pseudonyms in the study. These pseudonyms are fake names that will protect your identity. Information that identifies you will only be disclosed to others with your permission or as required by law.

This study has received IRB approval, which means there are currently few observed risks in participating in this study. There is an unlikely situation in which the Qualtrics platform could be breached, and the information you provide taken. Such, a breach of private information, could result in a subject being impacted emotionally. The researcher will delete all information from Qualtrics once this study is concluded to prevent such an occurrence.

The findings of this research may be used in reports, presentations, and publications but the researcher will keep all information pertaining to your identity confidential.

Full participation in this study involves two interviews spaced approximately 10 weeks a part, member checks, two questionnaires spaced approximately 10 weeks a part, reflective journal entries, in-class and out-of-class exercises, and any examples of learning that you would like to provide to the researcher.

Reflective journal entries are responses by students to two to four questions given by the instructor on a weekly basis. Journal entries are uploaded by the student to the Moodle learning management system, where they become available to the researcher. The researcher can only use these journal entries for inclusion in the study if you give consent in this form. Class exercises are in-class and out-of-class assignments that students work on, either individually or in their learning communities. These exercises are either handed in to the instructor in physical form (e.g., paper) or uploaded to the Moodle learning management system. The questionnaire refers to the "Metacognitive Awareness Inventory", which is an assessment composed of 52 questions that assesses the awareness of your own learning. The Metacognitive Awareness Inventory is given during the fifth week of class and during the last week of class (15th week). This information provides a richer account of what occurs in the classroom and a better understanding of your learning and thinking.

All data from these activities may be analyzed and used for publication by the researcher with your consent in this form. Signing this consent form, and indicating "Yes", in all the boxes means that you give the researcher permission to use the class activities and assignments that you have submitted and will submit in the [ASC] for the research that is being conducted.

Are you willing to allow the researcher access to the materials you submit in the [ASC] (the MAI questionnaire, reflection journal entries, class exercises, and voluntary learning examples) to be used in the study being conducted?

☐ Yes
☐ No

Please sign below if giving consent:

____

The interviews (and ensuing member checks) are the only activities that occur outside of class and are the only activities that requires the students' time that would not have already been spent in the context of the class. The interview responses will be recorded and analyzed by the researcher, along with any experts the research enlists to analyze the data. All-important analysis will be included in the researcher's final dissertation.

Only six participants will be chosen for the interviews along with one alternate, so, even if you give consent, you may not be chosen to participate in the interviews. Students who given consent here will be considered for the interviews. However, you have the option to opt out of the interviews by checking the "No" box at the bottom of this form, to the prompt, "I would like to be included in the interview portion of the study." To ensure fairness, if more than six students sign up for the interviews, the instructor and researcher will draw names from a hat to decide who participates in the study.

The interview questions will assess how you process information - either visually or auditorily, while seeking to understand more about your experiences with learning in education, learning strategies that you use, and perceptions of your own learning (among other topics related to learning). The researcher will inform participants of the interview findings after the study is concluded. The research will also work with interview participants, to develop strategies that take advantage of the way that you may learn and think best.

All interviews and member checks will be conducted through the Zoom teleconferencing platform. The first interview will take place between the fifth and sixth weeks of the ASC class. The second interview will take place the second-to-last week (week 14) of the ASC class. The first interview will take approximately 45-60 minutes to complete. The second interview will take approximately 45-60 minutes to complete. In both interviews, the researcher will ask a series of 10 to 13 questions, to which you can give responses.

The researcher will provide an opportunity for you to clarify any remarks that you've made during the interviews. These opportunities are called member checks. The researcher will engage in member checks by meeting with you after both interviews, allowing you to review the transcript of the conversations. At that time, you can clarify anything in the transcripts that you see as inaccurate. Member checks are estimated to take 30 to 45 minutes. The interview and member checks are estimated to take a total of three and a half hours.

Signing the consent form and not opting out of the 'interview portion' of the study, enrolls you in the opportunity to be included in the interview portion of the study. If included in the interview portion of the study, signing this consent form means you give the researcher permission to use your responses in the study.

If you have any questions about the research, please feel welcome to reach out to Chris Long at longc@up.edu, or my doctoral advisor, Dr. Eric Anctil at anctil@up.edu. If you have questions about your rights as a participant in this research, please contact the IRB (IRB@up.edu). The researcher will provide a copy of this form for your records.

Please read the informed consent below before continuing to the demographic and education history form online.

The signature below indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, that you will receive a copy of this form, and that you are not waiving any legal claims.

The signature below with a "Yes" checked next to "I would like to be included in the interview portion of the study" means that you are agreeing to participate in member checks and two interviews. Consent also gives permission for the researcher to use the information provided in the Demographic and Education History Form, although this form is voluntary to complete.

I would like to be included in the interview portion of the study:

Important Notes: Must be available to participate in a 45–60-minute interview over Zoom before the next class. Six students and one alternate to be selected for interviews. Approximate time dedicated to both interviews and member checks: three and half hours outside of class.

☐ Yes
☐ No

I understand the implications of this research project and agree to participate in one of the following: 1) interview portion of the study; 2) the class activities portion of the study, or 3) both the interview portion and class activities portion of the study, based on the information I have read in this Information-Consent letter.

☐ No
☐ Yes

Please sign below if giving consent:

____

Appendix D - Demographic and Education History Form (hosted online in Qualtrics)

Please review and answer the following questions if you feel comfortable answering them. You do not have to answer these questions to be included in the study. Answers to these questions are helpful to the researcher in developing more informed findings.

Any answer you provide will be kept confidential. Only the researcher will know the answer you disclose.

1. What is your full name?

2. What is the first language that you learned to speak?

3. What is the primary language that you use to communicate?

4. What is the second language that you learned to speak? If you speak one language, mark "N/A".

5. Please mark an "X" next to the box in which you identify ethnically or racially. You may choose more than one. If none of the categories match how you identify, please choose "Other" and write how you identify.

   __ African American
   __ Black
   __ Asian
   __ Asian American
   __ Pacific Islander and/or Native Hawai'ian
   __ Alaska Native
   __ Native American
   __ Latino or Latina
   __ Latinx
   __ Arab
   __ Caucasian or White
   __ Other

   If Other, please list: _______________

6. Please list how you identify in terms of gender?

7. Please list any learning designations (or disorders) that may have been ascribed to you while in K-12 education? If there are no designations, please list "none".

Appendix E - Pre-assessment, Interview Questions

Interviewer Directions: *So, I may write down some notes down if anything is confusing so I can alter the instructions or interview questions. If anything is confusing or unclear, please feel free to let me know, so I can make changes.*

This interview will be recorded on Zoom, and I'll be recording a backup on my phone, so it can be viewed later and transcribed for analysis. Do I have your permission to record this interview? Okay, I'm going to start recording now.

Hello, my name is Chris Long, I want to give you some background on me, this study, and my goals for this study.

I used to work in documentary film, and I loved interviewing people and understanding their insights. So much so, that I wanted to understand more about how people thought and learned, and so I decided to switch career fields and go into education. After receiving my master's degree in learning design, I started school here at the University in the School of Education doctorate program. My focus is neuroeducation. I'm extremely interested in how people learn and think and how we can help people learn at their best.

In the context of this interview, my goal is that we learn about your experiences. There are no right or wrong answers. The best answers are what's true for you and your experiences. That's how I can understand more about your learning and thinking. That's also how I can potentially help you understand your learning and thinking better after this study is conducted, and how this study can inform the field of education and future first-year, first-generation students. So, above all please know that these questions, are not meant in any way to be judgmental nor will they paint you in a negative light. Whatever you think, is the "right" answer to a question is the right response. All information is confidential, and I will not share your responses with anyone. Please, feel free to be open and honest if it's possible.

Now, there are 13 questions that I will ask you. There are no right or wrong answers to these questions. Please answer openly and honestly, if possible. Some of these questions may be confusing and that's okay. I can reread any question upon request, as many times as you need. I can also provide more information about the question when needed. Last, the question is provided on the document that I sent to you before the interview if you'd like to read it. Do you have access to that document? So, if the question is confusing or not completely clear you have three options; you can ask for more information, you can ask that I reread the question and you can read the question from the document that was sent over, so you have a visual. You can ask for any one of these three options as many times as you need. There is only so much information I can give you because I cannot lead you to an answer. Every answer must be voluntary and truthful to your own experience. But I hope you will try to answer, to the best of your ability, even if you're a little confused. Does all that make sense? Do you understand the three options you can choose from if a question is not clear?

Finally, some questions try to help put you in a specific place and time, to help you think about what I'm asking. That may be a different type of question than you are used to, but it is meant to *help you think about previous experiences. When I ask those sorts of questions, try to put yourself into that scenario if you can. Here's an example, and this is not a question you will answer, just an example. Please, think about yourself in a room you've studied in before and in this room, you're reading something you really enjoy. Can you think of yourself in this room? Okay, so, that's an example of asking you to think about yourself in a specific place and time. Do you have any questions about these types of scenarios? If you need more detail or context, please ask. If you feel uncomfortable at any time, we can pause the interview and take it up at a different time or cancel the interview altogether. Whatever you feel comfortable with, is how we will proceed. Does all that sound alright? Okay, are you ready to get started?*

TEMPro Analysis

1) What do you do on a typical day?

Interview questions assessing metacognition for learning

The first and last questions assess impact of interview as intervention:

Interview Directions: *Now the rest of these questions relate to your experiences before college, so in high school and earlier.*

2) How would you rate how well you understand your learning? On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best?

Not Sure - 1 2 3 4 5 6 7 8 9 10 - Extremely Well

   a. Follow-up: Tell me why you placed yourself at that point (what do you know about how you learn)

Previous knowledge (including beliefs)

3) As a student, looking at other students, what have you noticed about how other students in general, learn best?
   a. Prompt: Overall, how do you think students learn best?
   b. Follow-up: Can you explain how you think you learn best? This can be related to anything that helps you learn.

4) People have a variety of experiences in education. Some people have had teachers or counselors that talk about thinking and leaning specifically, and some people haven't had experiences like that, which is okay. Which one of those situations sounds more like you?

   You can answer as "Never," "Few experiences like that," "More than a few," or "A lot"

Never	Few experiences like that	More than a few	A lot

5) [IF response is "More than a few" or "A lot" on Question 3] Can you explain your experiences before college, if there were any, where a teacher, counselor or parent taught you about how people learn or think best?
    a. Prompt: Can you explain any occasions where somebody showed you how students can use learning or thinking to their advantage?
    b. For further context – Can you explain more about what you learned during these experiences?
    c. Potential follow-up: How did teachers involve you in your own learning if that did occur?
    d. If "Never" on Question 3 – How do you think you've learned about your own learning, if you feel you have, during your life?
    e. If "Few experiences like that" – Tell me about one of those experiences where an educator talked to you about thinking and learning. What do you remember about what that person shared?

6) Can you tell me about a time in school when you were confused about something, and you were able to figure it out on your own? How did you go about figuring it out?
    a. Prompt: Was there ever a time in school where something didn't make sense, and you figured out a way to understand it? Can you explain that?
    b. Second Prompt: Or did somebody help you understand something that was confusing? Can you explain that?

Awareness of cognition

7) I'd like for you to think about a time when you're either watching a video or reading something that you're super interested in. Can you see that happening in your mind? So, you're reading or watching a video and then something clicks as in you understand it, like the little bulb goes off, how do the ideas make sense to you?
    a. Prompt: So, when the light bulb goes off, how do the ideas from the video or what you're reading make sense to you?
    b. Prompt: I'd like for you to think about a time when you're watching a video or reading something that you're interested in. Do you have that event in your mind? So, when you're watching this video or reading these words, when you think you know something well, as in it clicks like "oh I understand this," why do you think that happens?

8) So, I'm going to ask you to pick out a friend, family member or someone you are close to, and place them in your mind. Do you have that person in your mind? Okay, let's say you're both at lunch, and you're outside and safely distanced, so no face masks. That person is telling you a story. Can you see this person telling you a story? As they are speaking how is it that you understand them best? So, what do you do, if anything, that helps you understand what they're saying?

a. Prompt: Is there anything that you know about yourself that helps you understand other people when they are talking?
b. Second Prompt – Is there anything you do when people are talking to you to better understand them.
c. Follow up: In general, is there anything that you know about yourself and your own thinking, that helps you understand other people when they are talking?

9) I'd like you to try to think about a place you've studied before and that you also feel comfortable in. Okay, do you have that place in your mind where you study sometimes? When reading a textbook for one of your classes; so, when reading the words on a page, how do you make sense of the words?
   a. Prompt: When you read a paragraph, and you are going over it in your mind, can you tell me about that process of trying to understand the words?
   b. Prompt: The author has written the words on a page. Those words represent ideas that the author is trying to tell us. How do you understand those words best?
   c. Potential follow up – 'How or why you do that'

Strategies and skills

10) Okay, I'd like you to try to think about that place again that you've studied before and that you also feel comfortable in. Do you have that place in your mind? When studying here, do you have strategies that you use to learn something new or learning something better?
   a. If yes - please explain what strategies, you use when studying.
   b. If yes - why are these strategies helpful?
   c. If no - next question

11) When a teacher is speaking about an idea in class, how do you make sense of what they're saying? As in, what is something 'you do' to create meaning for yourself, based on what the teacher is speaking about?
   a. Prompt: How do you make sense of what a teacher is speaking about? In other words, what do you do in class to understand things that are being talked about?
   b. Prompt: Are there any strategies that help make sense of what a teacher is speaking about?
   c. Potential Follow-ups: 'How or why do you do that'

12) Can you think about a specific in-person or online class, that has been challenging for you? We've all had those. Do you have that class in your mind? Okay, what is something you've done or usually do to help you understand the challenging ideas in this class, if that is something you have done?
   a. Prompt: Generally, when something doesn't make sense in class, it can be over Zoom too, what is something you might do to help you understand it.

Assessing impact of interview as intervention:

13) So, if it's alright, I'd really like to hear your thoughts about what participating in this interview was like?
    a. Follow-up: Can you name one thing that seemed easy about answering the questions?
    b. Follow-up: Can you name one thing that was on the harder side?
    c. Follow-up: I want you to imagine that you leave here, and a friend asks you, "What happened in that interview? What was it about? How might you answer?
    d. Okay, I'm going to ask you to write a quick e-mail while we're here on this Zoom call. Is that possible for you? Okay we're going to send the email to the instructor and tell him how you'd rate how well you understand your learning, now at the end of the interview. On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best? How would you rate yourself? We're doing this to limit any bias in the interview.

Interviewer Directions*: Thank you so much for your time. I will transcribe this audio and make sure it is correct. We will then set up a meeting to review the transcript to ensure that these are your own words. This meeting will also give you a chance to elaborate or correct any of your responses. Do you have any questions about that meeting?*

Also, at any time during the ASC class if there's anything that really make sense to you and is working, like a strategy or skill or just idea that's helping you please reach out and let me know what that is. If we can see what's helping you, like a note-taking strategy, or anything that I can show people in the study, it can help the research quite a bit… and it may be able to help other people. Visual examples are great because I can show a picture of the strategy to the reader. So, you can show me anything like that at any time in this class.

There's a second interview that we'll schedule between the 13th and 15th weeks of class, which acts as a post-assessment, to find any changes that have occurred since being in the class. Before that interview I'll ask you to bring something to the interview that maybe has helped with your studying or learning. You don't have to bring anything at all to the study. This is only if there has something that you've tried that you feel has helped or will help.

On the other hand, if there's something really challenging or even bothering you in your classes or in this class, please feel free to reach out to me or Walter and we'll try to help. Do you have any questions? Well, thank you so much for your time, and I look forward to speaking with you again soon.

Appendix F – Post-assessment, Interview Questions

Details: The interviewer asked participants to send artifacts to the interviewer ahead of time that showed their thinking or their learning, e.g., note-taking or drawing.

The post- assessment occurred the second-to-last week of the academic success course. The researcher/interviewer asked participants the following research questions to find what changes occurred to their visual thinking/learning during their enrolled in the ASC (i.e., first semester in college). Instructions are similar from the pre-metacognitive assessment.

Interviewer: Hello, my name is Chris Long as I imagine you are aware.

Interviewer Directions*: This interview will be recorded, so it can be viewed later and transcribed for analysis. Do I have your permission to record this interview?*

In the context of this interview, my goal is that we learn about your experiences. There are no right or wrong answers. The best answers are what's true for you and your experiences. That's also how I can potentially understand your learning and thinking better and then help you understand information about your thinking and learning after this study is conducted. Open and honest answers will help inform the field of education so we can provide better educational opportunities for future first-year, first-generation students. So, above all please know that these questions, are not meant in any way to be judgmental nor will they paint you in a negative light. Whatever you think, is the "right" answer to a question is the right response. All information provided in this interview is confidential, and I will not share your identity with anyone.

And this is just a side note. In the first interview, there was something right here that I should have reworded. It wasn't worded right. What I said in the original interview was I will not share your information as in your responses with anyone, but that's the point of the research. I should have been clearer and said, "I won't share your identity with anyone." That's the reason for the pseudonyms, the fake name. Your responses will be shared in the actual study, and I'll talk about your responses with people, but your identity will always be confidential.

There are 10 questions that I will ask you. Some of these questions may be confusing and that's okay. The 10 questions are the primary questions. There's a lot of follow-ups in there, so there'll be more than 10 questions. I can reread any question upon request, as many times as you need. I can also provide more information about the question when needed. I'll ask the question that's provided to you on the handout I gave.

If the question is confusing or not completely clear you have three options; you can ask for more information, you can ask that I reread the question, or you can view the handout to have a visual representation of the question. You can ask for any one of these three options as many times as you need. There is only so much information I can give you because I cannot lead you to an answer. Every answer must be voluntary and truthful to your own experience. But I hope you will try to answer, to the best of your ability, even if it's confusing. Does all that make sense? Do you understand the three options you can choose from if a question is not clear?

As our first interview, some questions try to help put you in a specific place and time, to help you think about what I am asking. That is meant to help you think about previous experiences, especially over the last semester. If you need more detail or context, please ask. If you feel uncomfortable at any time, we can pause the interview and take it up at a different time or cancel the interview altogether. Whatever you feel comfortable with, is how we will proceed. Does all that sound alright?

I'll ask you for the materials you brought to the interview if you did bring any which if you did or didn't is totally fine and we'll review those materials. That'll be a little bit later on in the strategy section of the interview. This interview looks at several things, but overall, as I talked about earlier, it will assess changes that may have happened since the beginning of the semester. Please don't feel obligated to express that you have changed in any way if that's not true for you. This study will best help the field of education if the experiences that you communicate to me are your true experiences. Does that make sense?

Are you ready to get started?

Interview questions

1) The ASC class was designed to help students have a better understanding of thinking and learning. Can you explain how you would rate how well you understand your learning. On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best?
    a) Follow-up: Why did you rate yourself at that number?
    b) Follow-up: How, if it all, has your understanding of your own learning changed since you started this class?
    c) If yes or no: Why do you think that is?

2) Please explain what, if anything, you learned in this class about your thinking and learning that helped you?
    a) Prompt: What did you learn in this class about your thinking and learning in general?
    b) If yes or no: Why do you think that is?
    c) Follow-up: What are the beliefs you have about your own thinking and learning?
    d) Prompt: This can relate to anything about thinking and learning. What comes to mind when I talk about thinking and learning?

3) Because of what you learned this semester, do you find yourself paying attention to your own thinking more when you're learning something new?
    a) Prompt: Has the level that you pay attention to your own thinking changed since starting this class?
    b) If more - Can you explain how that process occurs?
    c) Potential Follow-up: How has tuning into your thinking helped you learn?
    d) Potential Follow-up: Why do you think you've been paying attention to your own thinking more?
    e) If no or follow-up – What do you focus on when learning?

f) Prompt: When you're reading about something or watching a video for class what usually occurs in your mind?

4) Can you tell me about a time this semester when you were confused about something, and you were able to figure it out?
   a) Prompt: Was there ever a time in school over the last semester, a specific occurrence when something didn't make sense, and you figured out a way to understand it? Can you explain that?
   b) Second Prompt: Or did somebody help you understand something that was confusing? Can you explain that?

5) Okay, let's think about your life since beginning college. I'd like you to try to think about a time this last semester when you're watching a video or reading something in your dorm room or in the library or at home; whatever place feels comfortable. Do you have that event in your mind? Okay, so you're reading or watching a video in this place; and then you think you know something well, as in something makes perfect sense, what occurs inside your mind?
   a) Prompt: When you're watching a short video online or maybe reading something that you're super interested about, and you have the lightbulb effect, something clicks and you understand it, how does it make sense to you? Is it just a feeling or is it something else in your mind that helps you make sense of the idea?

6) Okay, I'm going to ask you to think about yourself sitting in one of your classes. So, just try to place yourself in your chair, and now you're listening to your classmates (maybe a specific group of your classmates) talk about something the class is learning. Are you in that place in your mind? How do you 'reflect on' or just 'think about' the ideas they're discussing? Meaning, how do you think about the ideas they are discussing internally?
   a) Prompt or potential follow-up: Is there anything that you know about yourself and your own thinking, that helps you understand what other people are saying when discussing new ideas?
   b) Prompt or potential follow-up: How would you say you think through ideas when they are being talked about?

7) Let's go back to a dorm room or to a place you've studied this last semester that you also feel comfortable in. Okay, are you there in that place in your mind? Let's say you're in this place and reading a textbook for one of your college classes, how do you make sense of what the author has written about? In other words, how do you make sense or think through the words on the page?
   a) Prompt or potential follow-up: When you read a paragraph, and you are going over it in your mind, can you tell me about that process of trying to understand the words?
   b) Prompt: The author has written the words on a page. Those words represent ideas that the author is trying to tell us. How do you understand those words best?
   c) Potential follow up – 'How or why you do that'

Strategies

Interviewer: In this section, I will ask for the things you brought to the interview that help you learn, or I'll give you an opportunity to show me something that helps you learn.

8) This last semester, when a professor is speaking in class, how do you understand what they are talking about? In other words, is there anything that you do, that helps you understand what the teacher is saying to you?
    a) Prompt - Is there anything that you know about yourself and your own thinking, that helps you understand what a teacher is talking about?
    b) Follow-up – Did you bring anything that shows how you take notes in class or anything that helps you understand in class?
    c) If yes – Can you tell me about these and how they help you? Challenges?
    d) If no, or as a follow-up – Can you explain how your notetaking has changed since taking this class?
    e) Follow-up: Is there anything else that you'd like to show me that helps you learn in class?
    f) If yes: Can you explain what you're doing and how it helps? Is this a new strategy or something you've always done? Challenges? How do you overcome challenges?
    g) Follow up: Is there anything you'd like to share about what helps you learn?
    h) If no: next question.

9) Okay, let's say you're still in a place where you study sometimes, or maybe a new place that you want to try. Are you in that place? When studying here, what new strategies if any, do you now use to understand the material you're learning?
    a) If yes - please explain what strategies, you use when studying.
    b) If yes - why are these strategies helpful?
    c) Follow-up – Did you bring anything that shows the strategies that you use to help you learn out of class? *Do I have everything that you brought? Is there anything that you would consider a strategy that helps you learn?*
    d) If yes – Can you tell me about these and how they help you learn? Challenges? Overcoming Challenges?
    e) Follow-up: Is there anything that you'd like to share about your own learning?
    f) If no: next question.

10) How do you feel like your approach to thinking and learning has changed after taking this class, that is, if you feel it has changed?
    a) If no, please explain why you feel your approach to learning is similar to when you began this class?
    b) Follow-up: How you would you now rate how well you understand your learning. On a scale of 10 being I understand extremely well to 1 being I don't really understand how I learn best?
    c) Follow-up: What challenges do you still face as a learner, if any?

Interviewer: *Thank you so much for your time. I'll transcribe this audio, and make sure it's correct, and then we can set up a meeting during the spring semester to review the transcript to* *ensure that everything is in your own words and that my interpretations of your own words are correct. That meeting is voluntary, but it does give you a chance to elaborate or correct any of your responses and then I get to learn more, and then hopefully you get to learn more as well. Then just as the study goes along, as I get closer to finishing, I'll send you updates. Do you have any questions?*

Appendix G - Member Check Protocol

Member checks will be used in this study to provide each participant an opportunity to clarify or elaborate on any remarks made in the original interview.

Once the researcher has finished transcribing the interviews, the researcher will schedule a 30–45-minute appointment with each to review a case summary, which contains segments of the transcript, as well as questions and interpretations that relate to the transcript. If the participant would like to review their transcript prior to the study and provide feedback they have that option.

The researcher will develop a case-summary document, which consists of the researchers' questions and interpretations to segments of the transcript, to provide verification, clarity, and depth to specific responses. Each case summary contains pertinent segments of the transcript for the participant to read, to gain context for each question and/or interpretation. The case summary document consists of the following format:

Case Summary Part I – Primary Questions

- Segments of transcript (with most important areas highlighted)
- Researchers' primary questions and/or interpretations of the transcript

Case Summary Part II – Key Takeaways

- Researchers' key takeaways (summarization and synthesis of the transcript)
- Additional questions about transcript or researchers' interpretations to the transcript
- Segments of transcript (with most important areas highlighted)

When conducting member checks in-person or online: The researcher will give the participant time to read segments of the transcript that relate to each question/interpretation. Sections of the transcript that are most relevant to the question/interpretation are highlighted, so the reader may focus their attention to that section when forming a response. Once the participant signals they have read the segment of transcript, the researcher will read the question aloud.

During this process the participant is given an opportunity to edit, delete or add comments to the case summary. Any changes that a participant would like to make to their remarks without jeopardizing the usability of the original sample will be allowed. The participant is told the goal of this process is to represent the participants thoughts and intentions accurately.

The researcher will write the participants responses on the case summary document, either by paraphrasing their words or through direct quotes. Direct quotes are listed in quotation marks. Every statement added to the case summary will be verified as accurate with the participant before moving on.

If the member check is conducted on Zoom, the researcher will share their screen over Zoom. If the member check is conducted in-person, the researcher will share a hard copy of the case summary document with the participant. Additionally, any changes made to the document will be shown to the participant, by allowing the participant access to the document through Google Docs or by allowing the participant to view the researchers' laptop screen. This allows the participant to see and verify their responses during the member check.

The interview session will be recorded, so the researcher can review participants' comments to ensure all changes have been made accurately. Participants will be informed that they are being recorded.

The member checks will follow the subsequent protocol:

1. The researcher gives the participant time to read their response silently. The researcher informs participants to signal when they are done reading.
2. The researcher reads the question or interpretation aloud.
3. The participant can then state something that they'd like to add or change, and the researcher will record those additions/changes into the case summary using Microsoft Word.
4. The researcher will verify with the student that their quote or paraphrased statement is accurate. If the quote/paraphrased statement is accurate the researcher will move on. If the quote/statement is not accurate, the participant will have an opportunity to clarify until the statement is accurate. All quotes/statements must be accurate before moving on.
5. The researcher will record all changes into the case summary document using Microsoft Word.
6. Changes to the transcripts will then be made. Notations will be inserted to signify a change has been from the original transcript.
7. The case summary will be sent to participants for a final review, if they choose to review. The participant will have two weeks to review the case summary document.

When conducting member checks offline: Students will have two weeks to make any adjustments to their transcript. The participant can use the comments section in Microsoft Word to ask for changes to be made to the transcript OR the participant can list the changes in an email. The researcher will review the changes and make all necessary adjustments. The researcher will then send the transcript back to the student for a final review. The participant will have one week to review the revised transcript.

Appendix H - Email to Potential Interview Participants

Hi (student name),

I'm writing because you expressed interest in being a part of the interview portion of the study that's being conducted in connection with the academic success class.

My name is Chris Long. I was the one who talked in class yesterday.

I'm so excited that you decided to be a part of the study!

More than six students expressed interest in the interview portion of the study, so Walter and I drew names from a hat to see who would participate. Your name was drawn to be one of the six participants!

I wanted to see if you have any current questions or concerns?

If you're still interested in the interview portion of the study it would be great if we could schedule a time before next class to conduct the interview. The interview will take approximately 45 - 60 minutes to complete and can be done over Zoom. If you'd rather the interview be conducted in-person that can be arranged as well... whatever you feel most comfortable with. Can you list three times that are best for you, when we could conduct the interview?

Appendix I - Email to Participants Who Were Not Selected for the Study

Hi (student name),

I'm writing because you expressed interest in being a part of the interview portion of the study that's being conducted in connection with the [ASC] class.

My name is Chris Long. I was the one who talked in class yesterday.

More than six students expressed interest in the interview portion of the study, so Walter and I drew names from a hat to see who would participate. Unfortunately, your name was not drawn to be one of the six participants. I limited the interview participants to six, so that there'd be enough time to review everybody's responses before the study is scheduled to close. I wish there was time to include everyone.

On the other hand, it would be great if you agreed to be an alternate in the study, in case somebody has to drop out. If somebody did drop out you'd be on the list of students who could replace them.

Also, there's the ability to pilot test the study, which is kind of a practice run, to make sure that the interview questions make sense and to get your impression of what the interview was like. Based on your responses, I may make changes to parts of the interview. The pilot testing will be conducted tomorrow if you have time.

If you'd be interested in pilot testing the study or being an alternate please let me know. Also, if you have any questions or concerns, please let me know, I'd be happy to answer them.

Appendix J – Learning Strategies Assignment with Infographic

Try one or two visual, metacognitive, and/or language learning strategies this week that you think could be impactful. This can be visualization, drawing, note-taking in your own voice, teaching the material, etc. Try to use this strategy (or strategies) all week. Please do not use a strategy that we have not covered in class.

Upload a visual example of the learning strategy that you used (notes, drawings, reflections, etc.)

In addition to the upload above, attach a word document answering all of the prompts below (be descriptive at least 300 words):

- Tell us about the strategy or strategies that you used and how you used them.
- How is this strategy helpful if you feel that it is helpful?
- What are the challenges in using the strategy if there are any?
- How can you overcome any challenges faced?

The Learning Strategies Infographic is included below.

STRATEGIES TO SUPPORT THINKING & LEARNING

THOUGHT COMES BEFORE CREATION

People's understandings can be represented as mental pictures. Research indicates that's because concepts are processed visually (in most people). Engaging in the below strategies can make stronger connections between those concepts (and neural circuits) allowing you to learn and think more deeply.

LANGUAGE STRATEGIES

Strengthen thinking and build knowledge.

- Teach others what you have learned
- Communicate understandings to peers
- Create quizzes or tests for yourself
- Take notes in your own voice (own understanding)
- Write/type thoughts on paper when studying
- Develop stories with the concepts you are learning
- Regularly reflect on your learning and thinking about ideas

VISUAL AND MENTAL PICTURES - STRATEGIES

Thinking with your pictures

- Practice being aware of your mental pictures when somebody is speaking
- Draw out ideas and how they connect during class or when reading - tag them with your language
- Create diagrams, concepts maps other visual elements that have meaning to you - tag them with your language
- Time management - Create a system that allows you to see what you need to do in the amount of time you have

METACOGNITIVE STRATEGIES

Thinking about Thinking & Learning with Inner Voice

- Regularly ask yourself questions about your learning
- Regularly ask yourself questions about your understanding
- Reflect on performance and what actions could improve performance
- METACOGNITIVE STEPS - *Analyze Task, Plan Strategy, Monitor Progress, Make Adjustments, Reflect, Revise*
- Consistently reflect on your beliefs, actions, and goals and how they align

VISUALIZATION STRATEGIES

Reading, Planning, and Creative Thinking

- Visualize yourself doing any number of tasks to achieve a goal
    - Create and adapt images or events in your mind - ask reflective questions about your understanding, comfort level, and any challenges you should prepare for
- Imagine academic ideas interacting or play them out in story form in your mind
- Reading - Scan page with attention on headers, pull out main ideas from text, visualize them, add your language, make predictions, re-read, flowchart ideas on paper, reflect on ideas

Appendix K – Journal Entry #6

Take out a visual block of at least 20 mins and reflect on your experiences with learning and thinking for the past 6 weeks. Please answer <u>all</u> the prompts, minimum 350 words, for full credit.

6. What are some challenges that you faced in the past (like in high school) when learning?

7. Think for a minute about ideas or strategies you've learned in class so far. Which, if any, have you integrated into your own life?

8. Why have you integrated these new ideas or strategies?

9. How do you think you learn best?

10. Does learning about your own learning help you to feel empowered – as in you have power over the ways that you learn?

    a) If yes, what have you learned in this class thus far that has helped you to feel empowered?
    b) If not, please explain why you don't feel like you have power over your own learning? What do you think would help you to feel empowered in terms of your own learning?

Appendix L – Codebook I: Key Terms for Provisional Coding

Note about Key Terms / Criteria: Much of the criteria are based on direct quotes taken from research articles. Sections in italics are important to how the researcher utilized criteria to assess participants statements.

Key Terms:

- **Awareness of Cognition** - Participants' awareness of their thought processes, particularly their (mental) construction of meaning within a learning task or situation.

- **Cognitive Knowledge –** knowledge, beliefs, perceptions and/or memories outside the metacognitive domain. Also, a) *dispositions towards learning*, an umbrella term for sociocognitive aspects of self-regulation, such as affect, motivation, volition, feelings, self-efficacy, and self-concept; and b) *behaviors*, such as strategy-use, forethought, and self-reflection (Bandura, 1986, 2001; Efklides; 2011)..

- **Metacognitive Skills** - *Deliberate learning and/or thinking strategies* (e.g., orienting, planning, monitoring, and evaluation) that can be used to regulate cognition (Efklides, 2011, Veenman & Elshout, 1999; Versteeg et al., 2021). Consists of procedural knowledge (Efklides, 2018). Metacognitive skills – "concern(s) the *procedural knowledge that is required for the actual regulation of, and control over one's learning activities* (Brown, 1978; Brown & DeLoache, 1978; Flavell, 1992; Kluwe, 1987; via Veenman, et al., 2004, p. 90)."

- **Metacognitive Regulation** - *Corresponds to knowledge about the way students plan, implement strategies, monitor, correct comprehension errors, and evaluate their learning* (Saricoban, 2015, p.665). *In other words, the actions we take in order to learn* (Sandi-Urenaet al., 2011; direct quote form Stanton et al., 2015). *Metacognitive regulation involves how people control their thinking to facilitate their learning***.** Effective metacognitive-regulation skills allow a student to appropriately select learning strategies for a task and modify their approaches based on outcome (Stanton et al., 2015).

- **Self-Regulation** - "Refers to the self-directive process through which learners transform their mental abilities into task related skills" for learning (Zimmerman, 2001). Self-regulation is the ***process of continuously monitoring progress toward a goal, checking outcomes, and redirecting unsuccessful efforts*** (Berk, 2003), *taken from Nebraska website*)." "Self-regulation can be broadly defined as ***goal-directed behavior***, typically within at least a minimum temporal perspective. Common examples include achievement-related behaviors, personal strivings, and the regulation of shared goals in close relationships (Hofmann, 2012)." This is the method or procedure that learners use to manage and organize their thoughts and convert them into skills used for learning.

    - ***Difference in Metacognition and Self-regulation*** - metacognition is monitoring and controlling what's in your head; self-regulation is monitoring and controlling how you interact with your environment.

- **Metacognitive Confidence -** A subjective belief and/or judgement (rating) regarding the validity of any primary cognition (e.g., understanding of learning). These primary cognitions can be focused on oneself, other people, the environment, or at any object (Moreno et al., 2022, p.140). Therefore, metacognitive confidence responses are reflections that pertain to the validity of cognition (e.g., understanding) in various contexts. So, rather than a belief in one's learning (i.e., primary cognitions), these are statements of validity of one's beliefs in their learning (secondary cognitions).

- **Metacognitive Experiences** - Conscious feelings or judgements that arise "any time before, after, or during a cognitive enterprise" potentially in learning situations that require "highly conscious thinking (Flavell, 1979, p.908)." Can be prospective (e.g., judgment of learning or confidence that one will do well on the task), concurrent (e.g. feeling of difficulty), or postdictive (e.g. confidence about the response produced; Efklides; 2006,2008).

- **Metacognitive Knowledge** - *is a product of learning about cognitive processes, primarily as it relates to one's own previous learning experiences (Wenden, 1998).* Metacognitive knowledge *refers to the information that individuals hold about their own cognition and about strategies which impact it.* This knowledge provides a plan or guide for processing, the rules of which may be more (explicit) or less (implicit) amenable to conscious awareness and verbal expression (Spada, 2013).
  Brown (1987) classifies MK as declarative, procedural, and conditional knowledge. Metacognitive knowledge also encompasses an ***understanding of strategies for learning*** (Brown, 1987; Jacobs and Paris, 1987; Schraw and Moshman, 1995).

- Other info on Metacognitive Knowledge:
  - Ability to identify what we do and do not know (Stanton et al., 2015).
  - Corresponds to what students know about themselves, strategies, and conditions under which strategies are most useful (to learning). Acquired Knowledge in terms of Person, Task and strategy (Flavell, 1979).
  - Metacognitive knowledge refers to acquired knowledge about cognitive processes; knowledge that can then be used to control cognitive processes. Knowledge is considered to be metacognitive (rather than cognitive) if it is actively used in a strategic manner to ensure a goal is met (Flavell, 1979; Jackson, 2004).

- **Metacognitive Strategies** - Metacognitive strategies relate to students' knowledge of the cognitive processes they have and include the planning, monitoring, and regulation strategies that students use for these processes (Pintrich, 1999, from Yilman & Baydas, 107). Are ways in which to teach people how to think about their thinking, which can be empowering and lead to problem-solving mindsets. So, *metacognitive strategies are strategies that we use to be more metacognitive that leads to more refined thinking and learning.* Students who've employed metacognitive strategies well have been shown to manage their learning process, consciously integrate new information with existing information (Baten et al., 2017) and evaluate their performance (Zhang & Goh,2006).

- **Metacognitive Monitoring** – Monitoring and awareness of one's own cognitive processes, or a lack thereof (Anne M. Cleary, 2017) *to oversee regulatory behavior*. Also, refers to the monitoring of cognitive-affective change and proximity to goals (cognitive-affective regulation) … (Spada, 2013).

- **Metacognitive Control** - Metacognitive control can be generally defined as the volitional direction of one's own thought and memory retrieval processes. Metacognitive control processes that readers use to regulate their reading to the demands of the task and engage with the comprehension process. "Top-down control refers to the manner in which thoughts and knowledge control lower levels of analysis. In one view of top-down processing, called metacognitive control, basic processes – such as object recognition, speech analysis, and semantic memory access – are defined as 'object-level' processes, which are controlled by 'meta-level' processes. Meta-level processes monitor object-level processes, and – as a result of this monitoring – initiate control." (Shimamura, 2009). "Metacognitive control strategies involve the execution of responses to control the activities of one's cognitive system (Spada, 2013)."

- **Visual Thinking**– Awareness of mental imagery to engage in a process of conceptual learning and thinking.

- **Visual Processing**– Finding/seeking visual patterns in the environment to layer and create ideas or make sense of ideas.

- **Visual Leaning**– Using visual patterns, mental images and language to learn new ideas. Language needs to be discussed in some sense for visual learning to take place. **Strategies**– I'll break down the strategies into three sub-themes:

- **Preference-based Strategies**– These are strategies that were not covered in the class that may or may not be related to learning as laid out in the theoretical framework in this study. For instance, listening to music to focus would be a preference-based strategy. **Strategies for Memorization**– These are strategies that were covered in the class that may help with conceptual learning a tie into someone's learning system but are primarily used for memorization.

- **Strategies for Conceptual Learning**– These are strategies that are clearly for concrete to formal level (the 3rdand 4thlevels of the NsLLT) of learning and thinking based on one's learning system.

- **Meta-learning** - Statements that show knowledge (declarative or procedural) about one's learning and thinking processes, or strategies that support one's learning and thinking processes.

Codebook Part II – Provisional Coding Criteria

Process of Coding Metacognitive Processes, “MP” and Cognitive Processes, “CP”

Note on Process: Before the researcher assigns codes such as metacognitive knowledge, cognitive knowledge or metacognitive regulation the researcher assigns codes to two categories, either “MP” or “CP”. The researcher assigns an “MP” provisional code based on whether the participant uses language to discuss/explain a cognitive state (e.g., understanding, connection, recognition, mental pictures). If the participant does not discuss a cognitive statement, then the researcher assigns the code “CP”. Other provisional codes are assigned as following:

Process: Code responses as Metacognitive Processes (MP), if responses specifically relate to cognitive process and/or strategies for learning that support or relate to cognitive processes. In other words, code the response as MP if it relates to knowledge in relation to, or in support of learning or thinking (e.g., understanding, focus, differentiating, associating, making sense, etc.). Some codes, such as those related to drawing, have a lot of pertinent information that is both cognitive and metacognitive. Additionally, some quotes are primarily cognitive, and some quotes are primarily metacognitive. If there are metacognitive processes that are pertinent to the theme in general, the researcher will code the theme as a ‘metacognitive processes’, taking care to also code the theme as "cognitive processes" (CP) if there is information that is relevant to the creation of the theme, OR not code the theme as CP if the information is not relevant, periphery, or merely supports the primary relevance of the metacognitive statement.

Criteria for coding Metacognitive Knowledge (MK)

1. The response must directly or indirectly answer the prompt and contain clear rationale for the specified behavior as it pertains to thinking or learning.
2. If the participants' response refers to information (knowledge) that the participant holds about their own cognition (e.g., learning) or about strategies which impact their cognition (explicitly stated), code it as MK.
3. If the participants' response mentions a mental or physical behavior in relation to thinking or learning - *declarative or process-oriented in nature*.
   For example, "I started a new strategy where I used my own words in my note-taking rather than copying notes." Now, if the quote stopped there, there's no mental behavior to associate the behavior of taking notes; thus, this response would qualify as being a cognitive process. However, if the student added, "I do that so that I can engage with the ideas the teacher is presenting which helps me listen and understand what the teacher is saying," - that would be classified as metacognitive knowledge.
4. Additionally, Knowledge is considered to be metacognitive (rather than cognitive) in relation to learning, if it is actively used in a strategic manner to ensure a goal is met (Flavell, 1979; Jackson, 2004).
5. If the behavior is classified as MK, try to code the response as something to do with declarative knowledge “Understanding of…” or “Awareness of…”, "Realized that...", this will help keep the language of the coding consistent and help it to be more recognizable at first glance.

Criteria for coding Metacognitive Regulation (MR)

1. The response must directly or indirectly answer the prompt and contain clear rationale for the specified behavior as it pertains to thinking or learning.
2. If the participants' response mentions the processes of a physical or cognitive behavior (e.g., strategy) that supports another cognitive behavior associated with learning (e.g., understanding, thinking, associating, differentiating, visualizing, etc.). For example, "I *put notes into my own words* in class because it helps me better *connect the ideas* she's discussing. The above, example shows the deliberate use of a strategy because it supports another cognitive behavior, 'connecting the ideas'.
3. If the behavior is classified as MR, try to code the response as something to do with process-oriented knowledge, with a relevant verb signifying the process, such as "Thinking about...", "Using...", "Seeing...", "Creating...", "Asking...", "Integrating...", this will help keep the language of the coding consistent and help it to be more recognizable at first glance.

Criteria for Visual Thinking and Learning

Criteria for visual thinking and learning is based on the four levels of learning concepts as language, in the Neurosemantic Language Learning Theory (Arwood, 2011). There are three levels of Visual Thinking and Learning that I'm looking for.

1. Visual processing - 2nd level of NsLLT - Participant shows an ability to recognize that they process input visually and may need multiple visual patterns to be able to 'see' or understand concepts better.
2. Metacognition for visual thinking - Participant shows a recognition or awareness of their visual thoughts, e.g., visual mental images, mental movies.
3. Regulation for visual thinking - Participant shows an ability to metacognitively control their visual thoughts, e.g., engaging in a mental or physical strategy to a) better see their visual thinking, b) to learn, and/or c) to think with visual ideas.
4. Using language with visual thoughts - Participant utilizes language in connection with visual thinking to extend or displace thinking, which indicates higher-levels of thought, and layering of learning. For instance, a participant explains imagining what they are learning and then writing down their visual mental ideas in a drawing and/or in their own language.

Criteria for Meta-Learning

1. Statements that show knowledge (e.g., declarative or procedural) about one's learning and thinking processes, or strategies that support learning and thinking processes that were learned over the course of the last semester (in the context of the ASC).
2. NOT statements about the outcomes of meta-learning unless specific about knowledge gained or applied to support thinking and learning.
3. MUST be directly or indirectly related to something the student indicates they learned and/or became aware of over the course of the semester

4. MUST be metacognitive in nature

Criteria for Cognitive Processes

1. Statements that do not show knowledge for an aspect of cognition will be coded as “CP,” followed by sub-themes.
   a. These are often statements that represent beliefs, perceptions, or experiences (i.e., memories).

Important Note: Often there’s metacognitive knowledge associated with the act (e.g., cognitive behavior). In other words, the participant mentions their reasons why they engage in a specific behavior (e.g., strategy for learning). Thus, I often code the knowledge component as well as the behavioral component, so we understand that there’s an association between MK and MR or the act and the reason why the student engages in the act. Oftentimes this leads to parallel or integrative coding. The times I wouldn't code both MK and MR is if there isn't enough information or logic to support both codes (as listed in the criteria above). This may occur in situations when the process-oriented knowledge of the act is dominant in relation to the reasoning for the act. For example, "I engage in drawing as a strategy for learning, which I do by pulling meaning from the words on the board, then I connect the concepts I draw with arrows. After I'm finished connecting ideas, I usually look it over once or twice to make sure it makes sense." This is a process-oriented (mock) statement, with little reasoning to support why the individual engages in the drawing strategy. I could likely pull an MK code out of this statement, but it wouldn't be prudent, as the process-oriented features of the response are much more dominant that the declarative features.

Further considerations for Language-usage in Coding.

The overarching goal of the language in the coding process and structure is to utilize the participants explicit language-use when possible. However, if the theme would not be generalizable to other participants or to first-year, first-generation students in general then alternate language should be used *that still captures the intent of the participant. Additionally, in situations where participants' responses are closely-related to themes in the literature (peer-reviewed research) then the researcher should take care to strike a balance between 1) the language in the literature, 2) the participants explicit language, and 3) the generalizability of the language with other participants - with priority given in order with the criteria listed above.

Codebook Part III – Criteria for Structural Coding

Attention to Components of Learning and Thinking - Knowledge-based statements that shares "why" people do or do not engage in strategies, or "what" people do or do not do to support their own thinking, understanding, and/or learning. Examples include non-declaratory statements about learning and thinking, knowledge of learning and thinking strategies, attention to thinking while learning, awareness of viewpoints, awareness of logic, learnings, etc.

Awareness of Cognition - Participants' awareness of their thought processes, particularly their (mental) construction of meaning within a learning task or situation. In other words, specifics about what a person is thinking in a learning situation.

Developing Active Dispositions - Dispositions (e.g., attitudes) related to learning that have been actively formed and mentioned by the participant. These "dispositions" can be associated with intellectualism, critical thinking, self-efficacy, emotional intelligence, or other positive abilities/attributes associated with students' development and learning. For example, Open-mindedness (Dewey, 1916), Life-long Learning, Tolerance, Empathy.

Dispositions Towards Learning - Place codes in this category if the response relates to sociocognitive aspects of self-regulation, such as affect, motivation, volition, self-efficacy, and self-concept (Bandura, 1986, 2001; Efklides; 2011). Consists of awareness of cognitive processes.

Interview Experience - Place codes in this category if the response relates to what the experience of being a part of the interview (for the study was like) OR what the participant learned during the interview.

Knowledge of Self as Learner - Place codes in this category if the response relates to declarative statements the participant has about themselves as a learner or thinker.

Preferences Toward Learning - Place codes in this category if the response denotes what somebody likes to do, not what they have explained they need to do to learn.

Previous Challenges - Place codes in this category if the response relates to statements about challenges or difficulties the student had with academics before college.

Previous Experiences with Learning (*PEwL*) - Place codes in this category if the response relates to the participants previous experiences with learning (before college).

Previous Experiences with Meta-learning (*PEwML*) - Place codes in this category if the response relates to the participants previous experiences with learning about their own learning and/or thinking.

Previous Strategies - Strategies used before ASC and are likely not being used currently.

Ongoing Strategies - Strategies used prior to interview and are ongoing.

New Strategies - Strategies that are new to college. Either learned in the ASC or initiated on one's own during their first semester in college.

Metacognitive Confidence - A subjective belief and/or judgement (rating) regarding the validity of any primary cognition (e.g., understanding of learning). These primary cognitions can be focused on oneself, other people, the environment, or at any object (Moreno et al., 2022, p.140). Therefore, metacognitive confidence responses are reflections that pertain to the validity of cognition (e.g., understanding) in various contexts. So, rather than a belief in one's learning (i.e., primary cognitions), these are statements of validity of one's beliefs in their learning (secondary cognitions).

Metacognitive Experiences - Place codes in this category if the response relates to conscious feelings or judgements that arise “any time before, after, or during a cognitive enterprise” potentially in learning situations that require “highly conscious thinking (Flavell, 1979, p.908)." Can be prospective (e.g., judgment of learning or confidence that one will do well on the task), concurrent (e.g., feeling of difficulty), or postdictive (e.g., confidence about the response produced; Efklides; 2006,2008).

Metacognitive Regulation - Place codes in this category if the response corresponds to knowledge about the way students plan, implement strategies, monitor, correct comprehension errors, and evaluate their learning (Saricoban, 2015). In other words, the actions participants take in order to learn (Sandi-Urenaet al., 2011; direct quote form Stanton et al., 2015).

Outcomes - Place codes in this category if the response is an outcome-based statements about what the student has gained or learned or not gained or learned in the context of their last semester in college. Can relate to outcomes based on the ASC or not.

Potential Strategies - Statements that participants have made about strategies they might or may engage in. In other words, the statement leads the research to believe that the strategy is not actively being used but is something the student might do in a specific situation.

Recent Challenges - Place codes in this category if the response relates to challenges that the participant has recently encountered while in college - as it pertains to learning and thinking.

Visualizing Ideas with Mental Images - Place codes in this category if the response shows purposeful use of visualization or the active use of visual thinking to engage in thinking, learning, and/or understanding.

Metacognition for Visual Thinking - Place codes in this category if the response denotes metacognition of one's mental images - e.g., a description of images or movies in one's mind.

Appendix M – Pre-assessment Template

Template for Pre-Assessment, 05-27-2022

Key: The symbol "|" indicates that participants' responses were split into different provisional categories based on whether the response fit the criteria for metacognitive knowledge (MK), metacognitive regulation (MR), meta-learning (ML), metacognitive experiences (ME), metacognitive confidence (MC), visual thinking (VT), theory of mind (ToM), cognitive knowledge (CK), and learning.

Notes:

1. Themes are listed hierarchically to show their relationships.
2. Endnotes are included to give more information about specific themes.

Pre-assessment Template

1. Knowledge-Based Themes as a Learner

   1.1. Attention to Components of Learning and Thinking
   - 1.1.1. Access to More Input Supports Understanding [MK]
   - 1.1.2. Visual Shapes Support Understanding [MK]
   - 1.1.3. Feeling of Knowing (for Making Sense of Ideas) [ME]
   - 1.1.4. Hand-written Ideas Support My Understanding [MK]
   - 1.1.5. Most Peers are Visual Learners [ToM]
   - 1.1.6. Need to Find Subject Interesting to Learn Well [MK]
   - 1.1.7. Other Students Learn Best with One-on-One Attention [CK | ToM]
   - 1.1.8. Re-reads Text to Make Sense of Words [MK]
   - 1.1.9. Sometimes Unaware I'm thinking Visually [MK, VT]
   - 1.1.10. Understanding that Knowledge Impacts Mental Imagery [MK, VT]
   - 1.1.11. Using My Own Words Supports Thinking [MK]

   1.2. Awareness of Cognition
   - 1.2.1. Awareness of Challenges in the Learning Process [MK]
   - 1.2.2. Seeing (Understanding) with Mental Images [MK, VT]
   - 1.2.3. Motivational to See Mental Images [MK, ME, VT]

   1.3. Interview Experience
   - 1.3.1. Challenging to Answer Specific Questions [CK | MK]
   - 1.3.2. Comfortable Environment [CK]
   - 1.3.3. Enjoyable Interview Experience [CK, Dispositions]
   - 1.3.4. Discussed My Learning Processes [CK, Learning]
     - 1.3.4.1. Discussed Study Strategies for Learning [CK, Learning]
   - 1.3.5. Learned About Myself as a Learner [MK, ML]
     - 1.3.5.1. Reflected on My Learning during Interview [MK]
   - 1.3.6. Questions are Based on Personal Experiences [CK, Learning]

   1.4. Knowledge of Self as a Learner
   - 1.4.1. I am a Visual Learner [MK, VP]

1.4.2. Still Figuring Out What Works Best for My Learning [CK | MK]
1.4.2.1. Sometimes Unsure of Best Way to Learn Ideas [MK]
1.4.3. Try to Figure Out Material On My Own [CK]
1.5. Preferences Toward Learning
1.5.1. Prefer Visual Input [CK]
1.6. Previous Experiences with Learning
1.6.1. Communication in Groups Helps with Challenging Ideas [CK]
1.6.2. Relied on Memorization-based Strategies [MK]
1.6.3. Taught to Use Cornell Notes [CK]
1.6.4. Teachers Supporting Students Learning [CK]
1.6.5. Previous Challenges
1.6.5.1.Struggles in Math [CK]
1.6.5.1.1. Difficulty with Online Learning [MK]
1.6.6. Previous Experiences with Meta-learning
1.6.6.1. Experiences Learning About Learning/Thinking Lacking [CK]
1.6.6.2. Few to No Experiences that an Adult Helped Me with Learning [CK]

2. Judgments of Understanding One's Learning

2.1 Mid-Range Understanding of Learning (Rating) [MC]
2.2 No Change in Understanding of Learning (Rating) during Interview [MC]
2.3 Progressed in Understanding of Learning (Rating) during Interview [MC]

3. Physical Strategies for Learning

3.1 New and Ongoing Strategies
3.1.1 Writing Ideas in My Own Words to Understand [MR (Control), MetStrat, ML]
3.2 Previous and Ongoing Strategies
3.2.1 Asking for Clarification[i] [MR (Control) | CK, BfL]
3.2.2 Creating (Meaningful) Visual Formats for Learning [MK | MR (Control), VP]
3.2.2.1 Breaking Down Ideas on Paper to Understand [MR (Control), MetStrat, MetSkills, VP]
3.2.2.2 Color-coding Notes to Organize Ideas [MK | MR (Control)]
3.2.3 Keeping a List of Assignments [Behaviors]
3.2.4 Repetition-based Strategies for Learning [BfL]
3.2.4.1 Re-reading if I don't Understand [MK | CK \ BfL]
3.2.4.2 Re-watching Educational Videos to Understand Material [MK | CK \ BfL]
3.2.5 Searching in Google for Help with Class Material [Behaviors]
3.2.6 Using Cornell Notes [BfL]
3.2.7 Watching Educational Videos to Learn Better [MK]
3.2.7.1 Using Practice Problems in Educ. Videos Helps Understanding [MK, BfL]

4. Mental Strategies for Learning

4.1 Asking Self Questions about Class Material [ii] [MR (Monitoring, Control), MetStrat | MetSkills]
4.2 Focusing on Visual Movements of Speaker to Understand Their Words [MR (Control), VP]

4.2.1 Focusing on Lip Movements [MR (Control)]
4.2.2 Transitioned from Reading Lips to Body Language [MR (Control)]
4.3 Monitoring Learning [MR (Monitoring, Control), MetStrat | MetSkills]
4.4 Relating Prior Knowledge/Experiences to What I'm Learning[iii] [MR (Control), MetStrat | MK]
4.5 Using Dialogue to Support Thinking/Learning [iv] [MK | MR (Control, MetStrat, MetSkills]
4.6 Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills]
4.6.1.1 Creating Context through Visual Thinking [MR (Control), VT, MetStrat, MetSkills]
4.6.1.1.1 Visualizing with Different Perspectives [MR (Control), VT, MetStrat, MetSkills]
4.7 Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat, MetSkills]

Appendix N – Class Activities Template

Learning Strategies Assignment (LSA) Template

5. Knowledge-Based Themes as a Learner

1.7. Applied Strategies from ASC
- 1.7.1. Drawing as a Strategy for Learning [v] (13/21) [CK | MK | MR (Control, MetSkills | ML]
  - 1.7.1.1. Drawing and Seeing Thoughts [vi] (5/21) [MK, ML, VT]
- 1.7.2. Using Visualization for Academics [vii] (5/21) [MR (Control), ML, VT]
- 1.7.3. Taking Notes in My Own Words [viii] (9/21) [CK | MK| MR | ML]
  - 1.7.3.1. Metacognitively Translating Ideas for Notes [ix](4/21) [MK, ML | MR, ML]

1.8. Attention to Components of Learning and Thinking
- 1.8.1. Challenges to Applied Strategies
  - 1.8.1.1. Difficult to Think About What to Write or Draw (4/21) [MK, ML]
  - 1.8.1.2. Drawing is Time Consuming (6/21) [CK, Learning]
    - 1.8.1.2.1. Overcoming Time Commitment (3/21) [CK, Learning]
  - 1.8.1.3. No Current Challenges to Taking Notes in Own Voice (3/21) [CK]
  - 1.8.1.4. Perceived Drawbacks to Drawing for Learning (3/21) [CK]
- 1.8.2. What I Learned
  - 1.8.2.1. Drawing Supports Aspects of My Learning (6/21) [MK, ML]
    - 1.8.2.1.1. Drawing was Helpful for Classes (4/21) [CK | Learning]
  - 1.8.2.2. Language Supports Thinking (4/21) [MK, ML]
  - 1.8.2.3. Notes in Own Words Supports Aspects of Learning (4/21) [MK, ML]
  - 1.8.2.4. Various Learnings from Applying Drawing (6/21) [MK, ML]

1.9. Dispositions Toward Learning
- 1.9.1. Enjoyed Drawing [CK]

1.10. Recent Challenges
- 1.10.1. Applied Strategies Because of Difficulties with Learning or Academic Performance (4/21) [CK | MK]
- 1.10.2. Difficult to Focus on Material (3/21) [MK]

Journal Entry #6 Template

1 Knowledge-Based Themes as a Learner

1.11. Attention to Components of Learning and Thinking
- 1.11.1. Have Not Implemented any Strategies from ASC (3/21) [CK]
- 1.11.2. What I Learned [x]
  - 1.11.2.1. About Previous Strategies (4/21) [MK, ML]
  - 1.11.2.2. Connection between Drawing and Mental Images (3/21) [MK, ML, VT]
  - 1.11.2.3. Drawing Helps to Better Understand Material (4/21) [MK, ML]
  - 1.11.2.4. Discussion with Peers Supports Understanding [xi] (5/21) [MK, ML]

1.11.2.5. Integrated Strategies are Helpful for Academics [xii] (6/21) [MK, ML]
1.11.2.6. Mental Imagery Supports My Thinking/Learning (5/21) [MK, ML, VT]
1.11.2.7. Various Learnings from Drawing (6/21) [MK, ML]
1.11.2.8. Writing in My Own Words Supports Learning (6/21) [MK, ML]

1.12. Dispositions Toward Learning
1.12.1. Feel In Control of My Learning (9/21) [MK, MC, ML]
1.12.2. Learning about My Learning Makes Me Feel Empowered (16/21) [CK]
1.12.3. What I've Learned Helps Me Feel Confident in My Learning (4/21) [MK, MC]

1.13. Integrated Strategies from ASC
1.13.1. Drawing to Represent Ideas [xiii] (11/21) [CK | MK, ML]
1.13.2. Taking Notes in My Own Words [xiv] (9/21) [CK | MK, ML]
1.13.2.1. Metacognitively Reflecting on Ideas (3/21) [MK, MR [Control], ML]
1.13.3. Using Visualization as a Strategy to Support Learning [xv] (5/21) [CK | MK, ML, VT]

1.14. Knowledge of Self as a Learner
1.14.1. I am a Visual Learner [xvi] (5/21) [CK, Learning | MK, ML]
1.14.2. Learn Best through Application (4/21) [MK]
1.14.3. Learn Best When Engaged in Topic (3/21) [MK]

1.15. Outcomes from ASC
1.15.1. Ability to Improve Learning (5/21) [MK, ML]

1.16. Previous Experiences with Learning
1.16.1. Challenges with Retention (3/21) [MK]
1.16.2. Did Not Know How to Study (7/21) [MK]
1.16.3. Did Not Study Regularly in High School (4/21) [MK]
1.16.4. Previous Education not Challenging (4/21) [CK]

1.17. Recent Challenges (in College)
1.17.1. Challenging to Find Motivation to Work (3/21) [CK]
1.17.2. Challenging to Understand Material (3/21) [MK]
1.17.3. Difficulty Paying Attention (3/21) [MK]
1.17.4. Grades Less Than Satisfactory (3/21) [CK]

Cumulative Themes from LSA and JE6 (Class Activities) to Assess Change

1 Primary Meta-learning Themes

5.1 Drawing Supports My Learning (10/23) (MK, ML)
5.2 Language Supports Thinking/Understanding (7/23) (MK, ML)
5.3 Learned about Visual Thinking (11/23) (MK, ML, VT)
5.4 Notes in My Own Words Supports Learning (8/23) (MK, ML)
5.5 Diverse Learnings from Drawing (9/23) (MK, ML)

2 Applied and/or Integrated Strategies

2.2 Drawing as an Adapted Strategy for Learning (16/23)

2.3 Taking Notes in My Own Words (12/23)
 2.3.1 Metacognitively Reflecting on New Ideas (4/23)
2.4 Using Visualization to Support Self in Academics (7/23)

Appendix O – Post-assessment Template

Template for Post-Assessment, 05-27-2022

Key: The symbol "|" indicates that participants' responses were split into different provisional categories based on whether the response fit the criteria for metacognitive knowledge (MK), metacognitive regulation (MR), meta-learning (ML), metacognitive experiences (ME), metacognitive confidence (MC), visual thinking (VT), theory of mind (ToM), cognitive knowledge (CK), and learning.

Notes:

3. Themes are listed hierarchically to show their relationships.
4. Endnotes are included to give more information about specific themes.

Post-assessment Template

6. Knowledge-Based Themes as a Learner

- 1.18. Attention to Components of Learning and Thinking
  - 1.18.1. Draw to Process Ideas Better [MK, ML]
  - 1.18.2. Feeling of Knowing [ME]
  - 1.18.3. Learned about Flowcharting [CK, Learning]
  - 1.18.4. Learned about Metacognition, Visualization, Mental Imagery in ASC [MK, ML, VT]
    - 1.18.4.1. Learned About Using Mental Imagery [MK, ML, VT | CK, Learning][xvii]
  - 1.18.5. Physically Written Notes Help Learning [MK, ME]
  - 1.18.6. Structures Notes as a Visual (Semantic based) System to Understand Ideas [MK, ML][xviii]
  - 1.18.7. Using My Own Words (Language) Helps Thought Processes [MK, ML]
  - 1.18.8. Visual Elements in Notes are Helpful to Learning [CK, Preferences]
- 1.19. Awareness of Cognition
  - 1.19.1. Explaining Visual-Mental Thoughts in Learning Scenarios [MK, VT]
    - 1.19.1.1. Seeing (Understanding) with Mental Images [MK, VT][xix]
- 1.20. College Course Experiences
  - 1.20.1. Lecture-based Classes [CK]
- 1.21. Knowledge of Self as a Learner
  - 1.21.1. Could Still Improve Learning [MK]
- 1.22. Outcomes
  - 1.22.1. More Attention to Thinking when Learning [MK (Monitoring), ML]
    - 1.22.1.1. Improved Monitoring when Learning [MK (Monitoring), ML]
    - 1.22.1.2. Asks More Questions about Understanding [MK, ML]
  - 1.22.2. Understand More About the Ways I Learn Best [MK, MC, ML]
    - 1.22.2.1. Built Foundational Elements for Learning [MK]
      - 1.22.2.1.1. Improved Academic Performance [CK]
      - 1.22.2.1.2. Understand Ways to Develop Learning Strategies [CK]

1.22.3. Open-mindedness to New Ways of Learning [MK, ML, DTL]
1.22.4. Incorporating More Strategies for Learning [MK]
1.23. Recent Challenges
1.23.1. Being Motivated as a Challenge to Learning [CK]
1.23.2. Still Struggling to Understand Some Challenging Ideas [MK]

7. Judgments of Understanding One's Learning

7.1 High Understanding of Learning (Rating) [MC]
7.2 No Change in Understanding of Learning (Rating) During Interview [MC]
7.3 Confidence in Current Learning Abilities [MC]

8. Physical Strategies for Learning

8.1 New and Ongoing Strategies [Note: New strategy for some, ongoing for others]
8.1.1 Asking Clarifying Questions to Support Thinking [MR (Control) | MetStrat, MetSkills]
8.1.2 Developing (Meaningful) System for Notes to Support Thinking [MR (Control)]
8.1.2.1 Color-coding Notes to Separate Ideas [MR (Control) | CK, BfL]
8.1.2.2 Drawing Icons and Diagrams in Notes [MR (Control), MetStrat][xx]
8.1.2.3 Taking Notes Before/After Class to Pay More Attention in Class [MR (Control), MetStrat]
8.1.2.4 Writing Down Key Ideas to Learn Later [MR (Control), MetStrat]
8.1.3 Discussing New Ideas with Peers [MR (Control), MetStrat, ML][xxi]
8.1.4 Drawing to Represent Ideas Visually [MR (Control), MetStrat | CK, BFL | ML][xxii]
8.1.5 Reviewing Visual Materials Outside of Class [CK, BfL]
8.1.6 Writing Formula Logic on Paper to Support Thinking [MR (Control)]
8.1.7 Writing Own Meaning (Words) in Notes [MR (Control), MetStrat | ML][xxiii]
8.2 Ongoing Strategies
8.2.1 Cultivating a Learning Environment for Focus [MR (Control)][xxiv]
8.2.1.1 Using Music to Improve Focus [MK, BfL]
8.2.2 Re-reading Text when Challenged [MK | CK \ BfL]
8.2.3 Scanning [MK | CK \ BfL]

9. Mental Strategies for Learning

9.1 Creating Visual Images to Support Understanding (as Learned in ASC) [MR (Control), VT, MetStrat, ML]
9.2 Monitoring Understanding while Learning [MR (Monitoring & Control), MetStrat, MetSkills, ML]
9.2.1 Monitoring Attention in Class [MR (Monitoring & Control), MetStrat, ML]
9.2.1.1 Focusing Attention to Teacher / Material [MR (Control), MetStrat, ML]
9.2.2 Asking Self Questions About Understanding in Learning Scenarios [MR (Monitoring & Control), MetStrat, MetSkills, ML]
9.3 Reflective Thinking for Learning [MR (Monitoring, Control), MetStrat, ML]
9.3.1 Using Internal Dialogue to Support Thinking / Learning [MR (Control), MetStrat | ML][xxv]
9.3.2 Creating Context Through Visual Thinking [MR (Control), VT, MetStrat][xxvi]

9.4 Visualizing Ideas in Visual Environments [MR (Control), VT, MetStrat | MetSkills]
9.4.1 Creating Context Through Visual Thinking [MR (Control), VT, MetStrat]
9.4.2 Actively Relating / Connecting Visual Ideas [MR (Control), VT, MetStrat, MetSkills][xxvii]
9.5 Visualizing Ideas to Understand Speakers' Words [MR (Control), VT, MetStrat, MetSkills][xxviii]
9.5.1 Creating Context Through Visual Thinking [MR (Control), VT, MetStrat]
Actively Relating / Connecting Visual Ideas [MR (Control), VT, MetStrat, MetSkills][xxix]

[i] "Asking for Clarification" – Three students (Ashley, Dalisay and Daniel) show MR (control) and one student (Lilly) shows CK.
[ii] "Asking Self Questions About Class Material" – Lilly shows metacognitively skilled use of this strategy.
[iii] "Relating Prior Knowledge/Experiences to What I'm Learning" – MK for one participant (Ashley), and MR for another participant (Abby).
[iv] "Using Dialogue to Support Thinking/Learning" - MK for one participant (Dalisay), MR for two participants (Lilly and Daniel).
[v] "Drawing as a Strategy for Learning" for LSA - 11/13 students discussed drawing in a metacognitive context, in that they discussed how they engaged in the strategy mentally or how it supported them mentally when learning. Of those 11 students 7 were coded as MK and 4 were coded as MR. Those coded as MR showed specific procedural or declarative knowledge for the strategy they engaged in, which indicated metacognitive control of their strategy. The same four participants showed metacognitive skills - in that 1) they responded with procedural knowledge, 2) the strategy was deliberate, 3) they mentioned how the strategy supported thinking/learning, and 4) their artifact itself adhered to concepts that were discussed in the ASC. Seven students showed meta-learning. One student showed learning. Two students were coded as CK.
[vi] "Drawing and Seeing Thoughts" - all responses are coded as MK and meta-learning. There are elements of MR in this theme however, since this is parallel-coded with the "drawing as a strategy for learning" theme I will only capture the knowledge-based aspects of this strategy.
[vii] "Using Visualization for Academics" for LSA - This is MR for 4 participants, and MK for one participant.
[viii] "Taking Notes in My Own Words" for LSA - four responses were metacognitive with two clearly showing regulation while the other two showed elements of regulatory control, but the response primarily included knowledge about the strategy instead of a description of how the participant engaged in the strategy. These two responses (from different participants) were coded as MK. Three responses were coded as CK, as participants just mentioned they tried the strategy. Four responses (from different participants) were coded as ML.
[ix] "Metacognitively Translating Ideas" – MK for one participant, MR for three participants, ML for all participants.
[x] "What I Learned" - category contains the meta-learnings (and learnings) from the strategies that were integrated into students' studies and/or learning.
[xi] "Discussion with Peers…" - MK and ML for 4/5 participants.
[xii] "Integrated Strategies are Helpful for Academics" - metacognitive for 5/6 participants, meta-learning (ML) for 4/6 participants, learning for one participant, and cognitive knowledge (CK) for the other.
[xiii] "Drawing to Represent Ideas" for JE6 – metacognitive knowledge (MK) for 5/11 participants, CK for 6/11 participants, ML for 5/11 participants. This theme captures the most participants from the ASC. One participant, Daniel explicitly states he did not implement drawing as a strategy but rather used it once. He does mention he will use it again, in specific instances.
[xiv] "Taking Notes in Own Words" for JE6 - CK for 6/10 participants, MP (metacognitive) for 4/10 participants, MR for 2/10 participants, ML for 4/10 participants and learning for one other.
[xv] "Using Visualization as a Strategy…" - CK for 3/5 participants, MK for 1/5 participants, MR for 1/5 participants, and ML for 2/5 participants.
[xvi] "I am a Visual Learner" - 3/5 participants indicate they learned they are visual learners in the context of the ASC. 3/5 participants mention an attribute of their cognition that indicates how they visually learn, making this a metacognitive and meta-learning theme for some.
[xvii] "Learned about Using Mental Imagery" – meta-learning and MK for 2 participants, learning and CK for the other.
[xviii] "Structures Notes as a Visual…" – meta-learning for 3 of 4 participants
[xix] "Seeing (Understanding) with Mental Images" – meta-learning for 2 of 4 participants.
[xx] "Drawing Icons and Diagrams…" is parallel coded with Drawing to Represent Ideas Visually.
[xxi] "Discussing New Ideas with Peers" - shows meta-learning and metacognitive strategy-use for 3 of 4 participants.
[xxii] Drawing to Represent…" – shows meta-learning and regulation for 3 of 5 participants.
[xxiii] "Writing Own Meaning…" – meta-learning theme for 2 of 5 participants.
[xxiv] "Cultivating a Learning Environment…" – regulation for 3 of 4 participants.
[xxv] "Using Internal Dialogue…" – this is a metacognitive skill for Lilly; this is meta-learning for 2 of 3 participants.
[xxvi] "Creating Context Through Visual Thinking falls under three themes. The reason it's located under "Reflective Thinking for Learning" is primarily because of Lilly's responses who often talks about creating context for visual thinking in moments of reflection. Abby also mentions this theme in a moment of reflection. Shows up as a metacognitive skill for Lilly only.

[xxvii] "Actively Relating / Connecting Visual Ideas" shows up for one student, Ashley, under the theme "Visualizing Ideas in Visual Environments. The same theme is more prominent under the theme "Visualizing Ideas to Understand Speakers' Words," – showing up for four students.
[xxviii] "Visualizing Ideas to Understand Speakers' Words" is a metacognitive skill for all four students involved in this theme.
[xxix] "Actively Relating / Connection Visual Ideas" is not a metacognitive skill for one participant.