Spring 4-20-2022

Conceptualization of STEAM Education in the Elementary Classroom

Virginia Olmert McCullough

Conceptualization of STEAM Education in the Elementary Classroom

by
Virginia Olmert McCullough

A Dissertation
Submitted in Partial Fulfillment of the Requirements for
The Degree of Doctor of Education
In Curriculum and Leadership
(Curriculum)

Keywords: STEAM Education, Elementary Education, Intersubjective Knowledge

Columbus State University
Columbus, GA

Michael Dentzau, PhD, Chair, College of Education and Health Professions
Patricia Patrick, PhD, Methodologist, College of Education and Health Professions
Deniz Peker, PhD, Member, College of Education and Health Professions

Dedication

There are moments in our lives, there are moments in a day, when we seem to see beyond the usual. Such are the moments of our greatest happiness. Such are the moments of our greatest wisdom. If one could but recall his vision by some sort of sign. It was in this hope that the arts were invented. Sign-posts on the way to what may be. Sign-posts toward greater knowledge.

—Robert Henri

This moment, as I see beyond the usual, is dedicated to my mother and father, who shaped the enchanted places of my childhood: Santee and Bishopville. These places held the ones who showed me how to truly realize and passionately pursue my sign-posts. Also, to my sisters and amigotas who sustain me and inspire me in such pursuits.

Acknowledgements

Endless Gratitude

Dr. Dentzau,

Thank you for the sign-posts toward greater knowledge, sustained support, clever semantics, and your friendship.

Dr. Patrick,

Thank you for the sign-posts on the way to what may be by posing novel perspectives.

Dr. Peker

Thank you for the sign-posts that display the collaborative spirit of Columbus State University through your willingness to serve on my committee.

Toby,

Thank you for the sign-posts to our love and for being central in the moments of my greatest happiness.

Abstract

Science, Technology, Engineering, Art, and Mathematics (STEAM) education is an instructional approach to education in which students demonstrate creative approaches in experiential, inquiry-based learning within the STEM disciplines. Despite the national focus on STEAM education, there exists considerable uncertainty as to what constitutes STEAM education and how classroom educators make sense of their conceptualization of STEAM in their classroom within the state of Georgia. The method of conceptualization is the internal processing of thoughts that produce new ideas or knowledge. This descriptive case study offers thoughtful new insights on how educators in a STEAM-certified elementary school in a school district located in Georgia conceptualize STEAM education. The study employed three instruments to gain authentic insight into participants' conceptualizations of STEAM education in their elementary classroom settings. The data from this descriptive case study suggest STEAM education is a distinctively different approach to instruction beneficial for student success in the 21st-century landscape. The data indicated STEAM education is socially constructed and most effectively implemented in a transdisciplinary manner. This descriptive case study findings offers intersubjective knowledge for enhanced collective knowledge of STEAM in the elementary classroom setting and advances the understanding that one, singular conceptualization of STEAM implementation in the classroom setting may not be an appropriate goal or target. Instead, the basic tenets of culture, change, and context need to be considered on an individual basis if STEAM education continues to progress as a widely used curricular approach for student success in the 21st century landscape.

Table of Contents

List of Tables

List of Figures

CHAPTER I: INTRODUCTION

Reform in education to produce literate and innovative workers, predominantly in science education, has been a recurrent topic of discussion and interest for more than a quarter of a century (Toplovcan & Dubovicki, 2019). Many scholars identify the launch of Sputnik, which placed the United States behind the Soviet Union in scientific advancement, as the major catalyst for intensified educational reform of science in the United States (Daugherty, 2013). Moreover, investments in education were relied upon greatly for global vitality during the Cold War, and the need to strengthen science and math education continued to gain traction after the height of the Cold War into the 1980s (Breiner et al., 2012).

Educators from all disciplines have experienced, and presently experience, significant systematic change in educational strategies and practices to meet the challenge of remaining viable and capable in the world's competitive market (Sabol, 2013). Several solutions have been linked to student literacy in the field of Science, Technology, Engineering, and Mathematics (STEM; Margot & Keller, 2019). Even with the push and focus for student recruitment in the STEM disciplines, however, the ability to recruit, train, and retain students for literacy in the fields was and currently is problematic (Liao, 2016).

Nevertheless, in response to the need for students in the United States to be literate in the STEM fields, STEM education has gained significant momentum in school settings nationwide, especially within the last two decades (Holmlund et al., 2018; LaForce et al., 2016). To advance STEM learning, educational reform movements stressed moving the subjects of mathematics and science to the forefront in all K–12 education which doubled the federal investment of research in mathematics, science, and engineering, and promoted the deliberate recruitment of students to pursue careers within the STEM fields (Barakos et al., 2012).

Though STEM education is presently an educational and political priority to reinforce national security though STEM literacy, considerable uncertainty exists around what constitutes STEM education and how STEM education is conceptualized by educators who implement the practices (Breiner et al., 2012; Holmlund et al., 2018; LaForce et al., 2014). Although the STEM acronym can be easily understood, Holmlund et al. (2018) suggested STEM education is not conceptualized in the same way by all stakeholders. Bybee (2010) explained the education community adopted the STEM acronym without having a consistent definition as to what STEM was, nor was there clarity of what was needed to effectively implement STEM education.

In addition to STEM educational goals, the realization that producing a competitive workforce depended on students developing a skillset in innovation became widely recognized as vital to global success (Godin, 2008; Hunter-Doniger & Sydow, 2016). In response, a convergence of governmental, educational, and industry findings led to policy discussion and debate centered on improving STEM education through innovative and creative means (Allina, 2018). Inserting the arts into STEM education, expanding STEM into STEAM, has been suggested as a strategy to elevate United States to a better global advantage due to the nature of the art's creativity factor and its association with innovation (Hunter-Doniger & Sydow, 2016; Liao, 2016). Furthermore, proponents of STEAM education presented the arts as the gateway to successful STEM learning due to the arts ability to increase student engagement and motivation, especially for those who did not have a prior interest in STEM (Bequette & Bequette, 2012; Hunter-Doniger & Sydow, 2016).

According to Herro et al. (2017), the implementation of STEAM within the educational framework is expected to be adopted by many states nationwide in the K–12 school setting within the decade. The transition from STEM to STEAM is considered a dynamic process that continuously evolves and gains momentum in classroom settings (Hunter-Doniger & Sydow, 2016); however, although STEAM education is an area of active reform consideration, existing research indicates a lack of consensus concerning how STEAM education is conceptualized through application (Holmlund et al., 2018)

For example, a comprehensive explanation of what STEAM implementation looks like in the classroom or how teachers should engage in the instructional practices has not been realized (Jamil et al., 2018). There is a lack of a distinct conceptualization of what STEAM actually is beyond the addition of the arts into the STEM acronym (Quigley et al., 2017). If STEAM education is considered a necessary means for students to be successful within the 21st-century global society, then better understanding how elementary educators in a STEAM certified school conceptualize STEAM education is significant.

Statement of the Problem

National and global attention to STEAM education continues to increase, and STEAM education is predicted to be a significant and sustained educational trend in the K–12 setting in years to come (Herro et al., 2017). Considering this momentum to integrate the arts into STEM education, particularly in the elementary classroom, it is meaningful to understand how classroom educators conceptualize and make sense of STEAM education (Dell'Erba, 2019). As STEAM education implementation has gained traction, schools in the states of California, Virginia, North Carolina, South Carolina, Ohio, Texas, Massachusetts, and Georgia have adopted varied STEAM curriculums (Quigley & Herro, 2016); however, Georgia and Ohio are currently the only states that have extended their educational structures for STEM certification to include the arts by offering a STEAM certification (Dell'Erba, 2019).

To facilitate STEAM certification in Georgia, STEAM leadership positions were established in Georgia by former Governor Nathan Deal through the *Arts Learning Task Force* (2021). The task force, formed by the Georgia Council for the Arts in 2014, made recommendations to Governor Nathan Deal which included directives such as establishing STEAM program specialists for the state. Georgia's STEAM program specialists develop and dispense the STEAM continuum for elementary schools interested in pursuing STEAM certification (GaDOE, 2020).

The GaDOE STEAM continuum for elementary schools requires schools to consider the following criteria: STEAM Vision and Culture, Non-Traditional Career Exposure, Characteristics of the Curriculum, Student Rigor, Relevance, and Instructional Quality, Professional Learning: Content Knowledge, Professional Learning: Instructional Practices, Teacher Collaboration, Business, Community, and Post-Secondary Partnerships, STEAM Competitions, Exhibits, and/or Clubs, Project/Problem Based Learning, Interdisciplinary Instructions, Technology Integration, Investigative Research, STEAM Journals, and Accountability/Sustainability (GaDOE, 2020).

Purpose of the Study

According to the Georgia Department of Education (GaDOE, 2020), in 2020 there were 1,363 elementary schools in the state. Presently, seven elementary schools have received STEAM certification by the GaDOE. The purpose of this qualitative descriptive case study was to gain insight on how elementary educators within a single STEAM certified elementary school in a school district in Georgia conceptualize STEAM education in their classroom setting.

Research Question

This study considered the following research question: What are the collective conceptualizations of elementary educators concerning STEAM education in their classroom settings in a STEAM certified school in Georgia?

With respect to this question the delineation between the perceptual and conceptual processing of information is important to address. According to Bueno (2013) there is a substantial difference between perception and conception. Perception, derived from the verb perceive, is a means to gain awareness of something through the senses and/or experiences; and conception, derived from the word conceive, is the ability to form something in the mind to develop an understanding (Bueno, 2013; Sequeria, 2014).

Morita et al. (2008, p 370) provide a succinct explanation of how ones' perceptual processes and conceptual processes are different: "[h]uman cognitive systems consist chiefly of two components: one for perceptual processing, which extracts information from the external world, and the other for conceptual processing, which retrieves and uses knowledge in the memory." Fundamentally, the method of conceptualization is the internal processing of thoughts that produce new ideas or knowledge (Bueno, 2013; Morita et al., 2008: Sequeria, 2014;). While empirical research exploring teachers' perceptions of STEAM education is developing (Herro & Quigley, 2016), this study seeks to examine elementary educators' conceptualizations, formation of new ideas and/or knowledge, concerning the lived experience of STEAM education in their classroom setting.

Conceptual Framework

The conceptual framework of this study incorporates the theoretical lenses of constructivism, social constructivism, and sensemaking to investigate how elementary educators in a STEAM certified school conceptualize STEAM education in their classroom setting (see Table 1).

Table 1

Lens of Researcher

Process	Lens
Paradigm	Constructivism: Conceptualizations are realities formed by mental constructions (Bueno, 2013; Lincoln & Guba, 2013; Sequeria, 2014; Tobin & Tippins, 1993).
Type of understanding	Social Constructivism: The cultural and social circumstances affect conceptualizations (Glasersfeld, 1995; Lincoln & Guba, 2013; Vygotsky, 1978).
Knowledge assembly	Sensemaking is a process to organize one's conceptualizations (Dervin,1992; Vygotsky, 1978).

Constructivism

The overarching framework of this study derives from the educational philosophies of John Dewey (1938) and Lev Vygotsky (1978) who believed that knowledge is not acquired but constructed through active processes. This theory of knowledge, known as constructivism, serves as an account of how a person comes to know (Dewey, 1938; Vygotsky, 1978). Tobin and Tippins (1993) define constructivism as:

> A form of realism in the sense that the existing of a reality is acknowledged from the outset. What constructivism has to say about that reality, however, is that we can only know about it in a personal and subjective way (p.3).

This study aimed to investigate how educators in the STEAM certified elementary school constructed knowledge concerning STEAM education through a progressive development of thought as they made sense of the dynamic and complex phenomenon of STEAM education experiences in their classroom setting (Dewey, 1938; Vygotsky, 1978).

Social constructivism posits all knowledge develops as a result of social interactions and is a shared, rather than an individual process (Vygotsky, 1978). As the introducers, conceivers, and producers of STEAM in their classrooms, the teachers actively construct knowledge concerning STEAM education and such constructions are socially and experientially based. Glasersfeld (1995), explained how knowledge is modified through our social communications:

> The mutual compatibility in our use of words and language is, of course, the result of social interaction. The process that leads to such compatibility, however, is not one of giving, taking, or sharing meanings as an existing commodity, but rather one of gradual accommodation that achieves a relative fit (p.3).

The study aimed to gain insight concerning the social and cultural realities of STEAM and how they impact participants' understanding of what STEAM education is.

Knowledge Assembly: Sensemaking

According to Odden and Russ (2017), once a phenomenon had been identified as something that needs explanation, the next step in the sensemaking process is to map out the associated ideas and beliefs and their connections. Sensemaking, a knowledge assembly tool, was used in this study to aid in the construction of a mental map of STEAM conceptualizations and ultimately intersubjective knowledge.

Sensemaking stems from work by Dervin (1992) and was initially used as a means to understand the gaps between institutions and the publics they served.The construct has primarily been used within the fields of library science, information science, and knowledge management, but has expanded to provide an approach for information use in myriad contexts, including education (Savolainen, 2006). Sensemaking is a process that considers the individual's situational factors in flux through time as they move to bridge a gap toward an outcome.

According to Dervin (1992), there is a fundamental connection on how one looks at a situation and what sense they can make of the situation. When sensemaking, one uses their existing and established bank of knowledge and experiences they have constructed in their social and cultural settings to make sense of a situation (Odden & Russ, 2017). This represents an individual's conception of a particular topic, event, or situation.

Sensemaking is a dynamic reasoning process where individuals use their own identities, experiences, and cultural belonging to make sense of their situation (Dervin, 1992). Lincoln and Guba (2013) identified 130 assumptions of constructivism in the research setting in their book, *The Constructivist Credo*. Many of these assumptions identify sensemaking as a human effort to construct organization of one's conceptualizations of realities, which are formed from intangible mental constructions that are socially and experientially based. Sensemaking, especially within the context of the sociocultural framework, is aligned with the view that individual thought processes, conceptualizations, and knowledge building are culturally embedded within social, linguistic, and human foundations (Vygotsky, 1978).

Intersubjective Knowledge

The research question was specifically designed to investigate the elementary educators' conceptualizations to create intersubjective knowledge concerning STEAM education. Intersubjectivity is considered the process whereby participants who begin a task with different understandings arrive at a shared understanding (Newson & Newson, 1975). The formation of intersubjective knowledge relies on individual conceptualizations and sensemaking formed within a social context such as a STEAM certified school. According to Wan (2012), "The widely shared representations that members of a culture hold are the intersubjective representations about the culture" (p. 109).

When using the constructivist lens, knowledge "consists of those constructions about which there is relative consensus (or at least some movement toward consensus) among those competent (and, in the case of more arcane material, trusted) to interpret the substance of the construction" (Guba & Lincoln, 1994, p. 113). Although each individual educator may arrive at varied conceptualizations of STEAM education in their classroom setting, this study sought to investigate the participants' descriptions of their conceptualizations to identify collective knowledge concerning STEAM education in the elementary classroom setting. Collective knowledge is considered intersubjective knowledge which is agreed upon among members of a certain culture or organization (Wan, 2012).

Qualitative Paradigm

The use of a qualitative approach to research is appropriate when the phenomenon of interest is poorly understood and therefore, the voices of the participants are essential to gaining insight for a deeper understanding (Creswell, 2008; Merriam, 2009). Due to the limited intersubjective knowledge concerning STEAM education in the elementary setting (Holmlund et al., 2018; LaForce et al., 2014), the selection of a descriptive case study design was selected to gain a better understanding of the phenomenon. In addition, a descriptive case study design is appropriate in the constructivist paradigm, which is dependent on mental constructions of individuals (Vygotsky, 1978).

Methodological Overview

Research Design

The design of this qualitative study was composed of a descriptive case study. Yin (2003) explained case study design is appropriate for answering the "what," "when," and "how" questions to make sense of a phenomenon within a real-life context. In the current study, the focus was on “what” and “how” and a descriptive case allowed for me to deconstruct and reconstruct the phenomenon for a more complete understanding of the phenomenon (Yin, 2003).

Sample

The descriptive case study took place at a STEAM-certified school in a school district in Georgia for a duration of approximately two months for data collection and three months, subsequently, for data analysis. I work within the same school district of the participants, but not at the same school, and I have never held any authoritative position over the participants nor do I have any current relationship with the participants.

Participants in the study are comprised of classroom teachers currently employed at the STEAM-certified school. Purposive sampling was used to recruit at least one classroom teacher from each grade level in this elementary school (K–4), rendering five to 10 participants out of the pool of 20 current teachers. In a conscious effort to maintain the privacy of the certified school, demographics for the contributing school and participants are intentionally omitted.

Instrumentation

The study was executed through three phases: Phase I and Phase II used two visual methods of data collection: (a) personal meaning maps (PMM), and (b) photo elicitation to gain visual depictions of the participants’ conceptualization of STEAM education in their elementary classrooms. Phase III employed semistructured interviews with each participant to gain insight of how the participants make sense of their contextual positions surrounding STEAM education in their elementary classrooms. Three instruments in this study were specifically chosen as sensemaking tools for knowledge assembly.

Personal meaning maps and photo elicitation are visual methods that can enhance sensemaking by allowing the participants to map out and express their construction of knowledge concerning STEAM in a nonverbal manner with no prescribed format (Falk, 2003; Harper, 2002). The semistructured interviews used the data gleaned from the visual methods and information from the literature review to elicit in-depth, verbal responses used to create structure of intersubjective knowledge of STEAM education in this particular elementary classroom setting (Merriam, 2009).

All data collected and shared in the three phases of data collection were stored in a secured Google Shared Drive. In each participant's shared drive both the participant and I had access to all necessary documents and files related to the study. The internet was utilized during the semistructured interviews through my Zoom account which is a secured and password protected.

Data Analysis

Thematic analysis was chosen to organize, categorize, and ultimately construct meaning from the data. Step 1 involved familiarizing myself with the data through repeated scrutiny. Step 2 involved open coding. Open-ended coding is also referred to as initial coding (Saldaña, 2015) and is often used by novice researchers due to the straightforwardness of this method. Initial coding assigns pieces of data into categories that emerge from and are grounded in data, using a constant comparative method (Glaser & Strauss, 1967; Lincoln & Guba, 1985). These codes were not predetermined, and the researcher in this process remained open to any new concepts that may emerge in other phases of data collection (Charmez, 2006). All data—including PMMs, photographs from the photo elicitation, and semistructured interviews—were initially analyzed using initial coding.

The next step of thematic analysis was axial coding to refining and cross-reference the data. This step was followed by selective coding to organize the axial codes into themes that formed the narrative of the case (Williams & Moser, 2019). Braun and Clark (2006) stated thematic analysis is appropriate in a constructivist theoretical framework and seeks to focus on the sociocultural contexts that form the individual accounts of the participants gleaned from the data collection instruments. Furthermore, thematic analysis is a flexible approach that can be effective in producing thick and rich description of the data set as well as identifying similarities and differences across the data set (Braun & Clark, 2006).

Research Diary

According to Nadin and Cassell (2006), research itself is a social experience that requires critical self-reflection and awareness of the researcher's own epistemological position. A research diary was used as a tool for reflexive analysis. Ongoing running dialogue of decisions and issues surrounding this epistemological position as it related to the methodology and research process was recorded in the research diary to flesh out any biased interpretations and explore any impact on the data. Spurgin (2009) stated:

All researchers come to their work through the lenses of their own experiences, biases, theories, understandings, and hunches. The Sense-Making Approach requires the researcher to acknowledge this and reflect upon how it may affect her research. It also requires that the researcher ensure any study using the approach is framed in such a way that participant has the opportunity to share his own experiences, biases, theories, understandings, and hunches, and that these will be considered and represented in the analyses and reporting. (p. 103)

In addition to reflexivity, the research diary will serve as a source of memo taking and a place to record any affective notes during the Zoom semistructured interview process. Memos can effectively be used as an analytic tool to allow concepts to emerge and identify the core categories (Charmaz, 2006).

Definitions of Terms

- *Arts Integration:* As Zhou and Brown (2018) stated, “Arts integration is an approach to teaching in which students construct and demonstrate understanding through an art form. Students engage in a creative process, which connects an art form and another subject area and meets evolving objectives in both” (p. 7).
- *Claim, Evidence, Reasoning (CER):* Allen and Rodgers (2015) defined CER as a “framework which supports students’ learning and writing through forming statements (claims) based on their observations (evidence) and then discussing these results with respect to the underlying scientific principles (reasoning) to build a deeper understanding of the content” (p. 33).
- *Concept:* A concept is the idea or image that one forms around related observations or ideas (Bueno, 2013; Sequeria, 2014).
- *Conceptualization:* Conceptualization is the internal processing of thoughts that form new ideas or knowledge (Bueno, 2013; Sequeria, 2014).
- *Engineering:* According to National Academies (2014), engineering “is both a body of knowledge about the design and creation of human made products—and a process for solving problems” (p. 14).
- *Engineering Design Process (EDP):* EDP is an iterative process of problem solving where students conduct background research, develop multiple ideas for solutions, develop and create a prototype, and then test, evaluate, and redesign (Margot & Kettler, 2019).

- *Intersubjective:* Intersubjectivity is knowledge collective and agreed upon (Wan, 2012).
- *Mathematics:* According to National Academies (2014), mathematics "is the study of patterns and relationships among quantities, numbers, and space" (p. 14).
- *Project Based Learning (PBL):* A PBL approach emphasizes long-term learning through interdisciplinary and student-centered experiential that have real-life application (Hawari & Noor, 2020).
- *Science:* National Academies (2014) defined science as "the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines" (p. 14).
- *Science, Technology, Engineering, and Math (STEM)*: STEM is the application of technology and engineering to solve scientific and mathematical problems (Daugherty, 2013).
- *Science, Technology, Engineering, Art, and Mathematics (STEAM)*: According to Katz-Buonincontro (2018), "STEAM can be broadly defined as the integration of the arts disciplines into curriculum and instruction in the areas of science, technology, engineering, and mathematics" (p. 73).
- *Sensemaking:* Sensemaking is a communication-based tool designed to conceptualize knowledge and information to bridge gaps between institutions and the public they serve (Dervin, 1998).
- *Technology:* As defined by National Academies (2014), technology "comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves" (p. 14).

- *Transdisciplinary Learning:* According to Helmane & Briska (2027), "Transdisciplinary learning is the "exploration of a relevant issue or problem that integrates the perspectives of multiple disciplines in order to connect new knowledge and deeper understanding to real life experiences" (p.11).

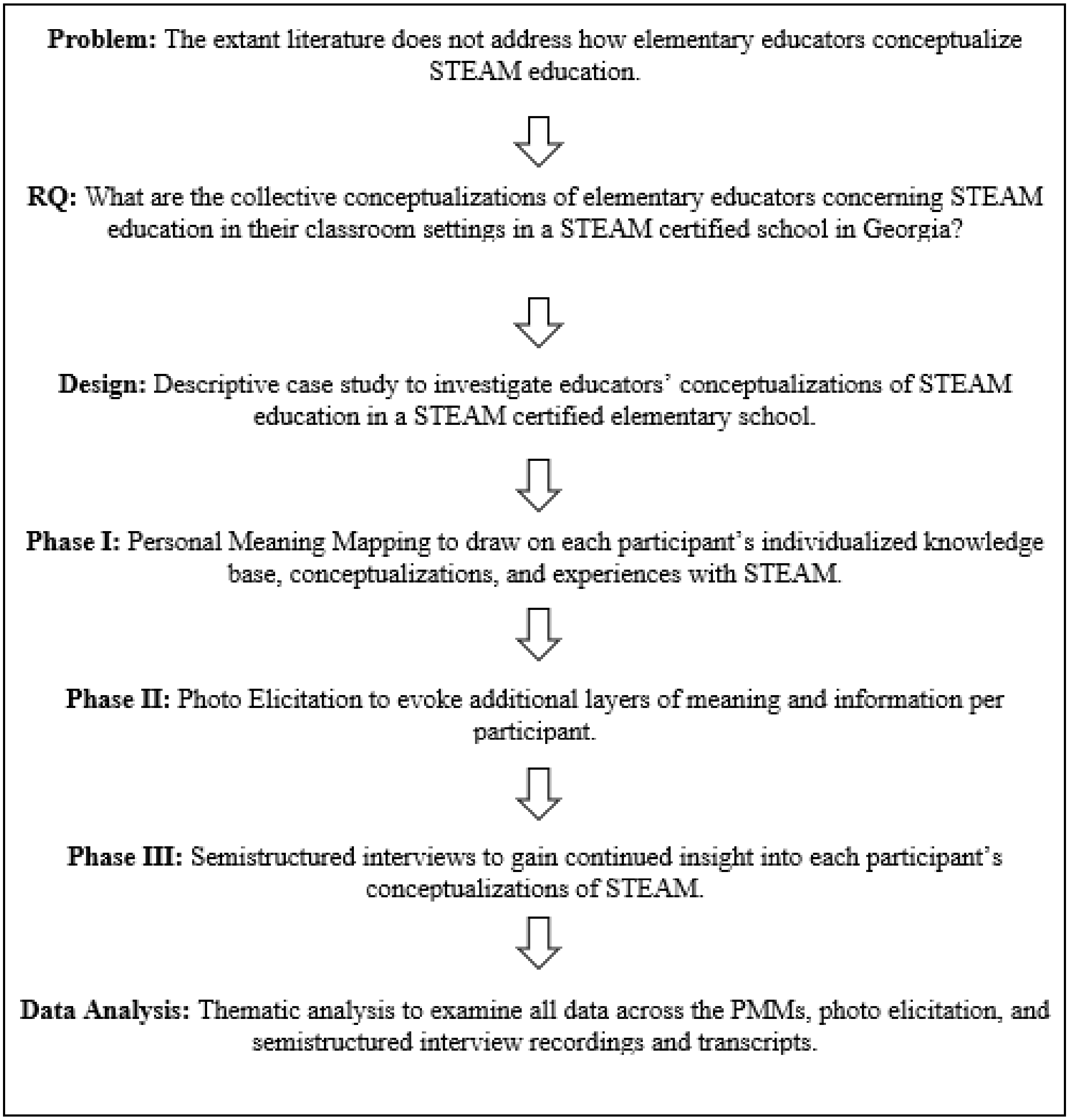
Summary and Alignment

An abundant interest in the promotion of STEAM education within the K–12 school setting exists nationwide, but a well-defined conceptual model of STEAM education has not been realized (Quigley & Jamil, 2017). The state of Georgia has extended their instructional structures for STEM education certification by including the arts, thereby offering STEAM education certification; however, there exists considerable ambiguity as to how classroom educators make sense of their conceptualization of STEAM in their classrooms (Quigley et al., 2017). Before an elementary educator can implement STEAM education in their classroom, they must first form a concepts and/or knowledge as to what STEAM education is in their classroom setting (Herro et al., 2017; Katz-Buonincontro, 2018; Quigley et al., 2017). This problem impacts all stakeholders invested in STEAM education in the elementary school setting (Herro et al., 2017).

According to Katz-Buonincontro (2018), considerably more research is needed to help define and develop a distinct foundation for STEAM education due to the broad definitions and ill-defined conceptualizations of STEAM education. This study contributes to the body of knowledge needed to address how elementary educators conceptualize STEAM education in their classroom setting and what aspects of STEAM education are collective conceptualizations and what aspects are not and their impact. Conceptualizations of STEAM education could inform the practice of STEAM education within elementary schools by the creating structure of the unknown for intersubjective knowledge of STEAM education. For a better understanding of the study, Figure 1 provides alignment chart to summarize the study.

Figure 1

Summary Alignment Chart



CHAPTER II: REVIEW OF LITERATURE

The 21st century's rapidly developing global economy necessitates an innovative workforce literate within the STEM fields (Godin, 2008; Hunter-Doniger & Sydow, 2016, Liao, 2016; Margot & Keller, 2019). In response, various approaches to STEM education have evolved in the United States to better prepare students in the K–12 setting to be successful in the global economy. However, the numerous STEM education reform efforts have failed to recruit, prepare, and maintain the needed STEM workforce (Herro et al., 2017). One rising trend designed to recruit, prepare, and maintain students is the addition of the arts to the STEM fields expanding STEM education to STEAM education (Herro et al., 2017). STEAM education is considered a means to enhance and improve STEM education by integrating the arts to advance student outcomes and proficiencies within the STEM disciplines (Herro et al., 2017; Hunter-Doniger & Sydow, 2016). K–12 schools nationwide have been increasingly called upon to implement STEAM education to aid in the production of students capable of creative contributions in the STEM fields (Margot & Keller, 2019).

Although there is a growing literature base that offers suggestions for guiding principles within STEAM education, there have been few reports substantiating the comprehension of what STEAM education is in the K–12 classroom setting (Quigley & Herro, 2016; Yakman, 2012). A contributing factor to the lack of understanding concerning STEAM education is because a well-defined conceptual model of STEAM education has not been realized (Breiner et al., 2012; Quigley & Jamil, 2017). For STEAM education efforts to render expected outcomes, a clear conceptualization of what STEAM education is needs to be established (Katz-Buonincontro, 2018; Margot & Keller, 2019). The existing literature lacks specificity and insight of what elementary educators actually think STEAM education should look like in practice in their classroom (Breiner et al., 2012; Quigley & Jamil, 2017). Therefore, the aim of this study is to gain insight concerning how elementary educators conceptualize STEAM education in their classroom setting.

One should first understand how STEM education, and subsequently STEAM education, became a major educational reform movement in the K–12 school setting. In addition, one should be familiar with how the impetus for STEM and STEAM education evolved and how it is being sustained within the United States (Herro et al., 2017; Holmuld et al., 2018; Hunter-Doniger & Sydow, 2016).

Historical and Legislative Background of STEM Education

STEM is widely accepted as a key educational approach for the development of skills necessary for student success in the 21st century (National Research Council, 2014). This belief that educators in the K–12 setting must promote student proficiency in STEAM to prepare their students for successful global citizenry is virtually a worldwide priority (Holmund et al., 2018). STEM education has become a national edification priority for many nations such the United Kingdom, Germany, South Korea, and the United States to meet the challenges of the 21st-century global economy and workplace (Kang, 2019).

Some argue the realization for the need of student proficiency in the STEM fields in the Unites States began with the launch of Sputnik in 1957 (Daughtery, 2008; Stevenson, 2014). The ensuing "Sputnik shock" thrust the United States into the realization that they had lost their competitive edge specifically in the space race (Daughtery, 2008). This awareness led to educational reform movements to regain global footing; however, even with such efforts, the United States continued to lose their competitive edge, in part, by failing to produce students who were competent within the STEM fields (Hunter-Doniger & Sydow, 2016).

The U.S. Department of Education endorsed many educational policy goals to ensure STEM education within K–12 schools nationwide was continuously promoted (US DOE, 2015). In addition, as seen below in Figure 2, STEM education garnered significant attention in educational reform efforts from both political and legislative entities in the past and continues to do so presently (Holmuld, et al., 2018).

Figure 2

Outline Background of STEM Education

- 1958 National Defense Act provides funds for improving education in all levels of American schools.
- 1958 NASA was established by President Eisenhower to stay globally competitive.
- 1983 *A Nation at Risk* is published under President Reagan highlighting our national failure and calling for the reinvigoration of the subjects of science, technology, engineering, and mathematics.
- 2001 Ramaley, director of NSF coins the acronym STEM
- 2002 No Child Left Behind Act passed holding schools accountable through new assessment instruments for math and science scores.
- 2007 *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* is published recommending that mathematics and science should be at the forefront of K–12 education.
- 2010 President Obama's *Change the Equation* calls for improvement in STEM education nationwide.
- 2013 President Obama's *Educate to Innovate is* supported by more than $1 billion in private funding.
- 2015 Every Student Succeeds Act (ESSA) Under ESSA, states can spend federal education dollars and measure school performance and accountability to support STEM education.
- 2018 Charting a Course for Success: America's Strategy for STEM Education Federal Government aids in STEM education by allocating funds for STEM educational resources.

STEM Education

Though STEM education has continued to gain momentum and global attention, not all researchers and practitioners have reached a consensus on what STEM education means and how STEM education practices should be applied in the classroom (Gao et al., 2020). Bell (2016) suggests that STEM education has not been fully conceptualized and translated completely into practice. Breiner et al., (2012) pointed to the lack of intersubjective knowledge, or a collective agreement amongst educators and proponents of STEM education, as a contributing factor for this disconnect.

STEM education has been defined in numerous ways within the literature (Ugras, 2018). Bybee (2010) defined STEM education as a means to teach science and mathematics integrated with technology and engineering within the K–12 setting. Sanders (2009) defined STEM education as an interdisciplinary approach utilizing one or more of the STEM disciplines while teaching one or more other school subject areas. According to Ugras (2018), more modern definitions of STEM education included the application of the STEM disciplines to find solutions for real-world problems. Zollman (2012) suggested STEM education was a dynamic process in flux and evolving over time, suggesting that a consistent definition was problematic. Consequently, STEM education, while prominent in the literature, mission statements, and educational goals of institutions, continues to have a variety of uncertain parameters and undefined definitions nationwide and globally (Brown, 2012).

Educators who implement STEM through the integrated approach in the elementary classroom are often in disagreement and unclear concerning effective ways to integrate the disciplines (Holmlund et al., 2018). Furthermore, though the disciplines of math and science are well defined within elementary education nationwide, the disciplines of engineering and technology have customarily been reserved for secondary and vocational instruction (Holmlund et al., 2018). Prioritization of content also varied as some educators promote the engineering design process as integral to STEM literacy and others promote real world applications, community partnerships, robotics, and/or maker spaces (Holmuld et al., 2018).

Holmlund et al., (2018) investigated the commonalities and variations in educators' conceptualizations of STEM education in three different contexts using sensemaking. Both individual and collective sensemaking resulted in varied conceptualizations. The findings indicated the educators' conceptualizations and sensemaking of STEM education were influenced by the contexts in which they implemented STEM education and their professional roles within the school setting. The researchers suggest educators and stakeholders within the same school district should "explore the common elements that are being attributed to STEM education and co-construct a vision that provides opportunities for all their students to attain STEM-related goals" (p. 17).

Similarly, Brown (2012) argued STEM education was not a set construct. Therefore, the focus should not be for an agreement on what STEM education is but, on a consensus, that STEM education is a dynamic process that evolves over time specific to the location. Other existing research showed that individual experiences with STEM conceptualization varied significantly even within the same school setting (Paull et al., 2013). While the goal in education is often to ensure consistency in student learning experiences and opportunities, conceptualization of STEM education, as single definition, may not be feasible (Holmlund et al., 2018). However, research to construct intersubjective knowledge, knowledge that is agreed upon, concerning STEM education is needed; "to understand more specifically what ideas educators notice, select, and retain about STEM education and how to support educators' construction of plausible stories that promote a consistent vision of STEM education across a system" (Holmlund et al., 2018, p. 17).

Guiding Principles of STEM Education

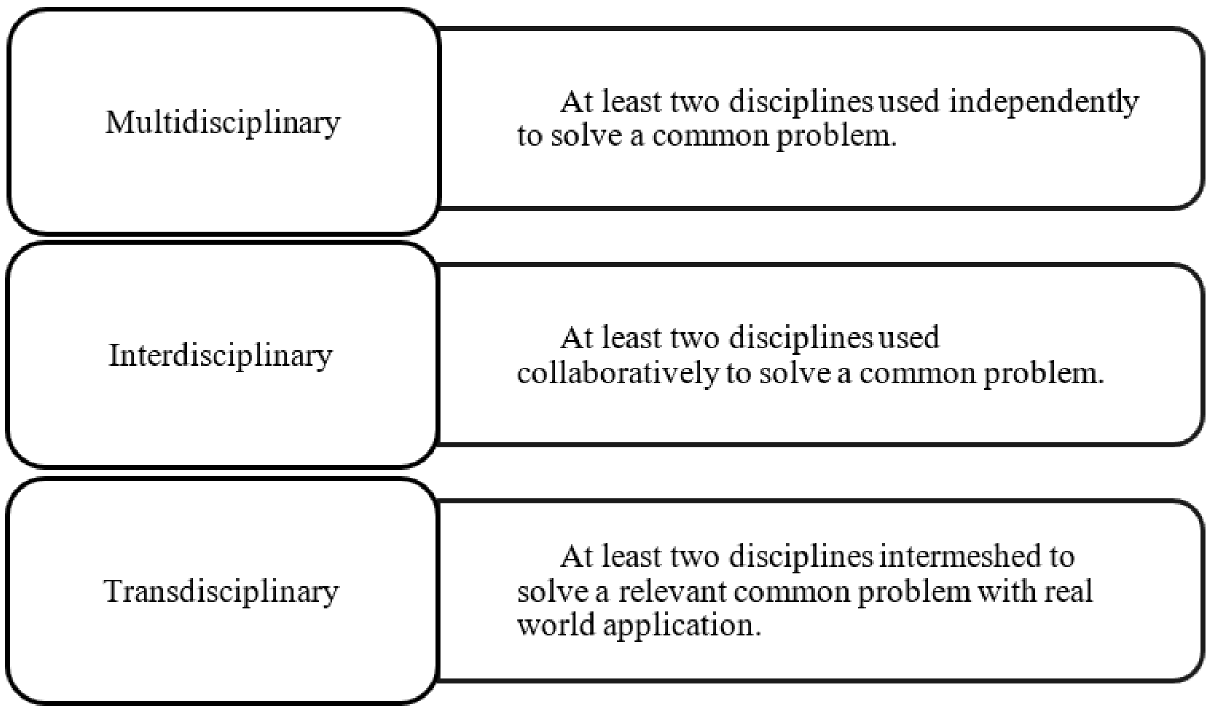
According to Brown (2012), practitioners journals have offered insight for guiding principles of STEM education in the classroom setting and also calls for research to "determine the effectiveness of STEM education initiatives in classroom settings, including performance data for students and teacher reflections of STEM teaching and learning" (p. 7). Even though there are varied interpretations of STEM education there are attributes, recognized as guiding principles that have emerged (Holmlund et al., 2018; Margot & Kettler, 2019). These guiding principles include content integration, inquiry-based learning methods (including project-based learning), the incorporation of the engineering design process, the need for collaborative efforts, and the concepts of failing forward.

Integration

At the core of STEM education is the idea of the integration, or connection, of the STEM disciplines to explore a common theme or solve a common problem (Breiner et al., 2010). Integration in education can be defined as an approach that connects students' knowledge and skill sets through two or more disciplines (Helmane & Briska, 2017). In STEM education, integration involves the disciplines of science, technology, engineering, and mathematics being taught in some interconnected or integrated manner (Breiner et al., 2010). Educators use a variety of terms to define their approach to integrated STEM including, multidisciplinary, interdisciplinary, and transdisciplinary (Gao et al., 2020). These are common terms that are frequently used interchangeably in STEM education even though their definitions can be considered different in context and hold different implications in practice as seen below in Figure 3 (Wall & Shankar, 2008).

Figure 3

Terms of Integration



An approach to STEM education is considered multidisciplinary when there is a common theme used to connect the various STEM disciplines (Vasquez et al., 2013). For example, a group of students use science and math standards separately to explore and learn about a certain ecosystem. The thematic alignment gives coherence to the lesson and allows students to investigate a certain ecosystem through two or more STEM disciplines (Vasquez et al., 2013).

The interdisciplinary approach is when the students use the STEM disciplines in conjunction to solve a common problem (Vasquez et al., 2013). For example, students must use their math skills to understand and make sense of science content, such as using the concept of central tendency to understand population dynamics.

The transdisciplinary approach to STEM is when students use their synthesized knowledge of the STEM disciplines to make connections to real world problems that are meaningful and relevant to students. (Scorse, 2014). For example, students who have an established garden, in which they honed their science and mathematical skill sets, have a problem with rabbits eating their produce. The students are therefore challenged with solving the problem of the rabbit using their STEM based knowledge in a way that they have a personal investment in.

In practice, integration in STEM education is more typically realized through a multidisciplinary approach or an interdisciplinary approach (Gao et al., 2020). However, many STEM educators are advocating for a transdisciplinary approach to STEM education which "refers to the unity of knowledge and skills beyond disciplinary framing' (Nicolescu, 2002, p. 2, as cited in Gao et al., 2020). The fusing together of the disciplines in transdisciplinary integration allows students to make real-world connections and develop a 21st-century skill set necessary for STEM careers which is a primary goal of an integrated curriculum (Margot & Kettler, 2019).

Regardless of which integrated approach to STEM education is employed, the implementation and practices of STEM has been fraught with challenges due to the lack of consensus among educators on how the STEM disciplines are to be linked effectively (Gao et al., 2020). Any integrated approach to STEM education is complex and multifaceted especially when one considers the various aspects of multidisciplinary processes and practices (Margot and Kettler, 2019).

Scorse (2014) believes that making connections to real world problems that were meaningful and relevant to students was a primary goal of an integrated curriculum. STEM education has been shown to elicit a more authentic experience for students within the STEM disciplines through a more student-centered and student-driven approach (Shernoff et al., 2017). At the core of student-centered pedagogy is the belief that students are capable of guiding and driving their own learning while teachers facilitate the process (Margot & Kettler, 2019).

Problem Based Learning

According to Margot and Kettler (2019), integrated STEM lessons require educators to facilitate student-centered learning with authentic connections oftentimes through problem-based learning (PBL). PBL lessons in STEM education are based upon real-word problems where students apply knowledge, skills, and application from the STEM fields to solve problems and challenges (Kang, 2019). The real-world application of PBL learning has been known to foster student interest and engagement in STEM (Liao, 2016). In addition, many educators believe that the open ended, student led problem solving approach of PBL is critical for building 21st century competencies and for fostering collaborative skills (Margot and Kettler, 2019).

The complexities of implementing PBL STEM learning effectively has also been a challenge for educators (Kang, 2019). For example, for educators to provide an in-depth genuine PBL STEM lesson they must possess confidence in their own content area of expertise and be capable of applying other content areas to foster an integrative PBL environment (Margot & Kettler, 2019).

Engineering Design Process

Often a typical PBL challenge requires solutions through application of knowledge in the STEM fields but does not necessarily require creativity in a design aspect (Berland, 2013). However, one approach to PBL in STEM education does integrate a design aspect using the engineering design process (EDP). EDP requires students to define problems, conduct background research, develop multiple ideas for solutions, develop and create a prototype, and then test, evaluate, and redesign them (Margot & Kettler, 2019). These inquiry-based processes revolve around questioning and understanding concepts versus finding the answer to a given problem. There are multiple right answers. Both PBL and EDP can be a difficult challenge for both educators and students as failure and perseverance are part of the process.

Failing Forward

One significant aspect of STEM implementation in classroom settings is that educators must become comfortable in allowing their students to take control of their own learning which can lead to failure at times (Margot & Kettler, 2019). Acceptance of student failure in STEM education is an important aspect of the student-centered approach to PBL and EDP (Stein & Muzzin, 2018). When failure occurs, students ask questions, consider new ideas and solutions, and can develop a critical thought process that considers new approaches to the problem (Stein & Muzzin, 2018). These experiences in failure, often termed as failing forward, can substantially affect student attitudes in a positive means towards the STEM disciplines (Ugras, 2019).

Research has shown that early experiences in STEM education that are positive and encouraging, even in failure, can directly affect student retaining their interest in the STEM disciplines (DeJarnett 2018), and positive experiences within STEM education could lead to growth in STEM career interests throughout students' educational careers (Ugras, 2019). Research has shown that experiences in failing forward are especially important because students' attitudes towards science can deteriorate as they advance in age (Osborne, 2003). Therefore, if students have a foundation of constructive experiences in STEM when they are younger, this can promote the retention of these students as the rigor of science-based learning increases (DeJarnett, 2018).

Collaboration

Collaboration in STEM is considered another guiding principle as it is considered an essential 21st-century skill that prepares students to adapt and succeed in the rapidly developing information and technology age (Ugras, 2018) Collaboration in STEM education is significant to ensure students are making use of appropriate and most effective technologies in their problem solving, research, and communications (Holmlund et al., 2018). Because the role of educators is one of facilitators in the STEM student-centered processes, students are often forced to collaborate with one another and other stakeholders. Therefore, the students can establish a variety of relationships formed through their collaborative efforts (Margot & Kettler, 2019).

In addition, students are empowered in STEM activities in the classroom setting as they take coownership of the outcomes produced in the collaborative efforts (Radziwill et al., 2015). These connections built through STEM education collaborative efforts in the classroom setting offer opportunities for student development of a wide variety of 21st century skills. These include sharing a common goal or problem, commitment to earn, work, and problem solve together, and the development of responsibility for successes within their school district and beyond (Holmlund et al., 2018).

Collaborations outside of the school setting, such as with STEM industry partners and other stakeholders, are also essential in forming relationships between students and their community and workforce partners (Holmlund et al., 2018). Moreover, collaboration, as a skill set, can be developed in STEM education for future negotiating endeavors, not only in the classroom, but in students' future careers (Herro, et al., 2017).

In addition to the value of collaboration in STEM education for the students, educators benefit from the culture of collaboration in STEM education implementation (Herro & Quigley, 2017). Collaborations with other educators and with community partners equips educators to feel more proficient in approaching STEM lessons (Margot & Kettler, 2019). Educators who felt more proficient were also willing to take more risks and incorporate STEM concepts outside of their areas of expertise (Margot & Kettler, 2019).

STEM to STEAM

STEM educations' effort to effectively recruit, prepare, and maintain students for STEM education has continued to not achieve the desired goals (Herro et al., 2017).The expansion of STEM education into STEAM education, in part, is founded upon the belief that the integration of the arts could increase student motivation and engagement in the STEM disciplines and address th s (Quigley et al., 2017) Therefore, considering the challenging factors of STEM education coupled with the need to prepare students to be competent in fulfilling the STEM field demands, a new vision for an arts integrated STEM curriculum has been offered as a solution (Shernoff et al., 2017).

STEAM education is generally identified as the integration of the arts into the STEM disciplines (Katz-Buonincontro, 2018). Some art advocates claim the beginning of STEAM education in the United States could be traced back to the economic crisis of 2008, when some in the field began to consider arts integration in STEM education a way to foster economic innovation and sustain global competitiveness (Allina, 2018).

Art advocates believe that to regain our reputation in the United States as a powerful contender in world economics, a comprehensive plan to yield problem solvers and creative leaders is crucial which can be achieved by the promotion of the arts to aid in the attainment of those goals (Guyotte et al., 2014). More specifically, they believe that STEAM education could employ students' aesthetic skills and talents to design, plan, and implement the innovative and novel technologies necessary to regain economic prowess (Katz-Buonincontro, 2018).

The inclusion of the arts into the acronym STEM was spearheaded by the Rhode Island School of Design (RISD) whose leaders were determined to call nationwide attention to the possibilities the arts offered in improving U.S. economic competitiveness (Allina, 2018). RISD's leadership in the promotion of STEAM on a state and national level gained a vast community of outspoken supporters such as policy makers, business leaders, art education activists, and teachers (Allina, 2018).

One way that RISD gained support was to launch an internship program in 2012 that placed RISD trained art and design students in internship positions within government institutions and other top industries (McGarry, 2018). These internships offered firsthand opportunities for RISD students to showcase their innovative and creative capabilities within the STEM fields (Allina, 2018; McGarry, 2018). The successful internship endeavor, in part, led to the 2013 RISD bi-partisan STEAM Caucus which supported and promoted growth in the STEAM movement. The Caucasus called for research of the arts in STEM, more integration of art and design in K–12 education, and the use of artists and designers as problem solvers in industry (Allina, 2018).

One hurdle in the realization of STEAM was the overall de-emphasis of the arts in recent decades as a result of the implementation of *No Child Left Behind* (NCLB) legislation. This legislation's focus on language arts, mathematics, and science, and reliance on standardized testing to account for progress, led to marginalization of the arts in the K–12 setting (McClure et al., 2017). Art advocates capitalized on RISD's efforts to tie creativity to STEM and reintroduced the value of art education which had been diminished significantly in the wake of NCLB (Katz-Buonincontro, 2018).

Aiding in the effort to reestablish the need for art integration within the STEM educational landscape was a study titled Beyond *Productivity; Information, Technology, Innovation, and Creativity* (National Academies, 2005). This study was not generated by an art advocating entity; therefore, the findings added increased validity to the idea that creativity through the arts could successfully connect with 21st century technology and enhance the legitimacy for the need of art integration in STEM education. The study reported creativity and innovation was critical to cultivating economic development and should be paired with information technology to establish a new educational field within the 21st century called information technology and creative practices (ITCP). Recommendations from the study included using art and design to increase the rigor for students involved in science and technology programs.

Another report that supported arts integration in STEM education had been produced by the Conference Board and Americans for the Arts in collaboration with the American Association of School Administrators (Lichtenburg et al., 2008). Survey results of 155 U.S. business executives and 89 educational leaders specified certain skillsets and abilities they believed were needed to establish an innovative workforce. The results of the survey, published in the report *Ready to Innovate,* reinforced the growing need for creativity to produce an innovative and capable workforce (Lichtenburg et al., 2008). In fact, both the business executives and the educational leaders surveyed agreed that they all must work together to establish the necessary efforts and investments needed to promote creativity for the future workforce.

Furthering the support for integrating the arts was the 2010 joint committee findings of the National Art Education Association and the National Science Foundation (Allina, 2018). This report indicated innovation and creativity were necessary in STEM education and substantial investments for arts integration in STEM education were needed and warranted (Allina, 2018). According to Katz-Buonincontro (2018), around that same time, the report *State of Create Study: Global Benchmark Study on Attitudes and Beliefs About Creativity at Work, School, and Home* (Brady & Edelman, 2012) reiterated with certainty that creativity was critical to economic growth.

In December 2015, the U.S. Congress passed Every Student Succeeds Act (ESSA). ESSA afforded state and district leaders increased flexibility to best meet the needs of all students by looking beyond the traditional methods of approaching student achievement and finding innovative means for ensuring that all students could experience a well-rounded education with a whole child approach (Arts Education Partnership, Education Commission of the States, 2018).

Prior to ESSA being passed, only the core academic subjects, not the arts or humanities, were considered important, but now a well-rounded education was defined as core academic subjects in conjunction with a wide variety of other disciplines including the arts and humanities (Arts Education Partnership, 2018). Furthermore, art measures, such as arts integration within core academic disciplines, were now options for indicators of student success in states' accountability plans opening up the possibility of federal funding for STEAM education (Arts Education Partnership, 2018).

In 2019 *The Education Commission for the United States* released the report: *Policy Considerations for STEAM Education* (Dell'Erba, 2019). Within the report STEAM education was defined as an instructional approach in which students demonstrated creative approaches in experiential and inquiry-based learning within the STEM disciplines (Dell'Erba, 2019). The report identified the current policy components in place to support STEAM education which included: access to state school certification processes, financing through federal funds designated under (ESSA), and statewide leadership for the promotion of STEAM education.

STEAM Education

Similar to STEM, instead of a well-defined conceptual model of STEAM education existing, several less defined models have been offered (Quigley et al., 2017). Though there is abundant interest and promotion surrounding STEAM education within the K–12 school setting, a well-defined conceptual model outlining the essential components of STEAM education is missing (Quigley et al., 2017). More specifically, although there are data available to support the adoption of STEAM education in the K–12 setting, little research has revealed how STEAM education is conceptualized and realized in practice (Katz-Buonincontro, 2018).

Amid the early stages of the promotion and implementation of STEAM education models, preliminary findings indicated the addition of the arts in STEM education increased student motivation, cross curriculum learning, and student interest in the STEM fields (Kang, 2019). However, Quigley et al. (2017) cautioned that reliable and valid data showing the efficacy of STEAM education in the K–12 setting was needed before K–12 schools continued their widespread adoption of STEAM education. According to Quigley et al. (2017), a well-defined conceptual model that clearly articulates both the instructional content and learning context of STEAM education was necessary as a precursor to accumulate evidence demonstrating efficacy of STEAM education.

Several models of STEAM, like STEM, have been partially conceptualized. One conceptualization of STEAM education involves utilization of the arts for increased transdisciplinary integrative approaches where the arts act as a vehicle for meaningful and personal connections compared to the multidisciplinary or interdisciplinary approach often used in STEM education (Herro et al., 2017). Another conceptualization of STEAM is one of integrating multiple art-based disciplines such as the performing arts, design, creative problem solving, and graphic design (Herro et al., 2017). These conceptualizations consider the arts as an equal and integral component in STEAM education which capitalizes on design thinking, innovation, and creativity (Hunter-Doniger et al., 2018). These partial conceptions provide minimal guidance to practicing educators being asked to implement STEAM (Quigley et al., 2017).

Jamil et al. (2018) used qualitative study design to identify early childhood educators' beliefs about STEAM which identified some insight concerning conceptualizations of STEAM education. Notably important was the consensus among the educators that STEAM held great potential for gaining student engagement and motivation in the STEM disciplines, but the study also identified a significant relationship between teachers' experience levels and positive views in STEAM. The more seasoned educators felt more efficacious implementing STEAM education. This may be a product of the more seasoned educators' experience and expertise informing their ability to conceptualize STEAM implementation in their classrooms (Jamil et al., 2018). Jamil et al. (2018) explained:

> Especially in the case of emerging teaching approaches, such as STEAM, which may challenge teachers' conceptualization not only of what is being taught but also of how it is being taught, a more nuanced exploration of teacher belief is essential to understand and support positive influences that the STEAM approach may garner in early childhood classrooms (p. 410)

Even STEAM initiates outside of the United States have suffered from inadequate conceptualizations of the model. South Korea passed a nationwide policy agenda promoting STEAM education in 2011 which acknowledged a lack of a collective conceptualization of STEAM education (Kang, 2019). One significant aspect of the STEAM initiative in South Korea is that the "A" does not solely stand for the arts but encompasses the fine arts, language arts, liberal arts, and physical arts. However, a lack of contextual variables in STEAM education in South Korea exists much like in the United States. Kang (2019) explained, "STEAM should be carefully conceptualized" (p. 19) through research for improved theory and practice in implementation.

One reason for the lack of a collective understanding could be the sociocultural aspect of STEAM education in a classroom setting. Ghanbari, (2015) views STEAM education as a socially constructed process that considers stakeholder's emotions, feelings, and perceptions typical of the sociocultural worldview. Without a collective or common agreement concerning what exactly STEAM is, it is plausible that elementary educators who are left to conceptualize STEAM in their sociocultural settings are bound to arrive at different constructs.

Guiding Principles of STEAM Education

Despite the vagueness of STEAM education conceptualizations in the K–12 classroom setting and the efficacy of achieving the desired educational results, STEAM continues to emerge as a well-respected pedagogical approach to prepare students for the 21st century (Khine & Areepattamannil, 2019; Hunter-Doinger & Sydow, 2016). As STEAM education evolves, innovation, creativity, and design thinking are considered central components to foster learning across the disciplines towards meaningful and relevant solutions (Rolling, 2016).

Additionally, STEAM education proponents claim STEAM implementation requires a wider variety of abilities which could be a game changer for student achievement in the STEM landscape (Gettings, 2016). Hunter-Doniger and Sydow (2016) identified certain abilities STEAM promotes including ingenuity, higher order thinking skills, communication, learning autonomy, and problem-solving proficiencies as integral components to student success. Marshall (2014) explained that such skills were critical to advance educational reform to a more dynamic and meaningful pedagogical model in the United States. The guiding principles of STEAM: innovation and creativity, design thinking, increased student motivation and interest, and the advancement of transdisciplinary learning, are considered additional principals that bolster the guiding principles of STEM education (Khine & Areepattamannil, 2019).

Innovation and Creativity

The economy and culture of the 21st century is dependent on methods of teaching that include creativity to produce a competitive workforce with an innovative skillset (Conradty & Bogner, 2018; Godin, 2008). Whereas STEM education aims to prepare students as potential members of the 21st-century society where the use of a STEM skillset is essential, STEAM education aims to develop students' innate innovative capabilities to capitalize on that skillset (Gettings, 2016; Land, 2013). As students enter the workforce, they will encounter problems that require more than aptitude in STEM disciplines, but also necessitate innovative and creative approaches and processes (Land, 2013; Shernoff et al., 2017). In fact, the ability to think creatively has been identified as an indispensable skill for student success in the 21^{st} century (Conradty & Bogner 2018; Guyotte et al., 2015; Liao, 2016).

The connection of disciplines through innovative and creative processes for greater outcomes is not a new concept. Throughout history, art-based methods have been used by forward-thinkers to achieve effective results (Rolling, 2016). For example, Leonardo da Vinci's achievements were defined by his creative thought processes that led to his unrivaled success in a multitude of disciplines (Rolling, 2017).

Integration of innovative practices is not only considered imperative for economic growth but for a better quality of life for students entering the STEM fields (Shernoff et al., 2017). According to Hartle et al. (2014), the arts foster embodied cognition, meaning that the arts engage the brain and the body in a unified system of learning. Art based strategies afforded learners ways to express, communicate, understanding, and connect through innovative and creative means, which is critical to prosper in a global community (Hartle et al., 2014).

In addition, innovation and creativity are significant aspects to apply in STEAM education when considering personalizing learning for a greater impact (Shernoff et al., 2017). The arts play a critical role in the development of the mind due to their fundamental capacity in utilizing emotion to connect the body and mind, fostering empathetic connections, and offering deep emotional and interpersonal experiences (Blanken-Webb, 2014). Such personal experiences in STEAM education can highlight students' unique abilities in expression aiding in student buy-in for STEAM education (Blanken-Webb, 2014).

Design Thinking

Eisner (2008) cautioned any schools' curriculum can become "intellectually debilitating" (p. 115) if the pedagogical goals are centered on standardization. According to Land (2013), before NCLB legislation passed, learning in the classroom was process-based where students constructed knowledge. After NCLB legislation passed, students were often measured on memorization of facts instead of comprehension of knowledge through standardized assessments. Most importantly, the focus on standardized assessments trained students to look for only one correct answer instead of seeking numerous solutions to complex problems (Land, 2013).

Design thinking in STEAM education is a means to move away from standardization of learning toward a student-centered learning in which students are engaged and focused on knowledge production as they approach design challenges (Gross & Gross, 2016; Pahl & Beitz, 2013, as cited in Gess, 2017) noted, “The purpose of design projects is to develop the students' ability and confidence to work through the complete design process, ending up with a feasible design solution” (p. xxvii).

Numerous integrated STEAM programs include problems that require learning and thinking that incorporate a multitude of design disciplines such as architecture, industrial design, and graphic design (Kang, 2019). Design thinking engages learners through an iterative cycle of design, redesign, and creation of prototypes to promote deeper understanding as they approach a problem (Gess, 2017; Gross & Gross, 2016). The way STEAM students work through a problem contemplating questions, issues and a multitude of solutions possible is a significant consideration Gross & Gross, 2017). Eisner believed, “the arts teach children that in complex forms of problem-solving purposes are seldom fixed, but change with circumstance and opportunity” (Eisner, 2002, item 4). Design thinking prepares students to be flexible and creative within the challenging and uncertain parameters of a global society (Graham, 2016).

In addition, design thinking in STEAM education can allow for a creative approach to real-world problems that are meaningful to the students (Graham, 2016). Design thinking can effectively promote student success in a global society where individuals must be able to frame imaginative and creative solutions to problems they face and in which they are personally invested (Gross & Gross, 2016). Design thinking is a student-centered approach to STEAM that requires collaboration and communication which can foster collective understandings and empathy in complex, problem-oriented, and authentic learning environments (Gess, 2017).

Student Motivation and Interest

One impetus for adding the arts to the STEM education is the belief that the arts improve student confidence and interest in the STEM disciplines (Gettings 2016; Land, 2013; Liao, 2016). Guyotte et al. (2014) noted STEAM education promotes connections between disciplines by emphasizing the role of creative thinking which enhances student interest and motivation in the STEM disciplines. Conradty and Bogner, (2018, p. 238), explained “STEAM may offer an educational roadmap for different teaching approaches and successfully prove that creativity promotes motivation through self-efficacy.” This aspect is significant because even with the increased educational focus on STEM education, educational reform has failed to foster students’ interest and aptitude within the STEM disciplines (Conradty & Bogner, 2018; Liao, 2016).

According to Daugherty (2013), the United States has historically ranked first in the world for innovation but currently ranks between the third and the eighth in the world. To combat this issue, educators are capitalizing on the connection between students’ attitudes about learning in meaningful ways and the integration of the arts into their curriculum to recruit, prepare, and maintain students within the STEM fields (Conradty & Bogner, 2018; Medina-Jarez et al., 2012;). STEAM education can be the answer to motivate students to link learning to gratifying and meaningful experiences through the inclusion of the arts (Wynn & Harris, 2012). Therefore, STEAM education is considered a pathway where art-based experiences are intentionally utilized so that students are more likely to persevere and stay motivated in the STEM fields (Gess, 2017).

Advancement of the Transdisciplinary Approach

Many STEAM advocates claim the arts advance the transdisciplinary approach through a more holistic process that presents an overarching idea or problem that holds bearing to student's lived experiences versus a multidisciplinary approach of STEM which was often presented thematically (Herro et al., 2017). Although a call has been made for STEM education to employ transdisciplinary implementation, STEAM advocates believe that the arts allow for an easier means to involve issues of relevance and personal connection to the student central to transdisciplinary learning (Herro et al., 2017).

The transdisciplinary approach of STEAM can promote opportunities for community outreach and advocacy (Segarra et al., 2018). For example, established practices, such as student recruitment for scientific educational opportunities, can be improved with the inclusion of the arts and personal connections via STEAM challenges that gain a wider diversity of student participants (Segarra et al., 2018). Students who may have concerns about their scientific aptitude yet identify with the arts could be reached through STEAM initiatives engaging them in scientific concepts, questions, and narratives through their love of the arts (Segarra et al., 2018).

Diversity

Despite purposeful recruitment of a diverse population of students for STEM education, STEM careers remain largely occupied by a homogenous population with minorities and women being only marginally represented (Quigley et al., 2017); however, various studies have shown STEAM recruiting a more diverse population of students pursuing careers, not just in STEM fields, but in careers in fields that support STEM (Segarra et al., 2018). Elementary students have served as a targeted audience for STEAM education recruitment to foster more diversity in

STEM careers, because younger students are often more open to alternate perspectives for learning in the STEM disciplines (Quigley et al., 2017).

The necessary workforce for global competitiveness will need to reflect multiple perspectives and diverse ways of thinking.; thus, approaches to STEM education need to be altered to recruit and retain a more diverse population of students (Quigley et al., 2017). The addition of the arts to STEM education has been promoted as a tool to encourage and engage students, especially young students, within the science and math disciplines (Jamil et al., 2018).

Eisner (2004) argued, "In a word, the forms of thinking the arts stimulate and develop are far more appropriate for the real world we live in than the tidy right-angled boxes we employ in our schools in the name of school improvement" (p. 9). Some argue the arts can positively influence STEM students' propensity for open minded thinking within our diverse global community (Hunter-Doniger & Sydow, 2016). Artistic learning strategies are believed to hold the capacity to foster a more open-minded environment along with enhanced self-awareness making the recruitment of a diverse population more fruitful (Herro et al., 2017).

Summary

Sabol (2010) noted, "People living in the 21st century face a confluence of unique changes, opportunities, and possibilities that have never existed in the recorded history of human beings" (p. 3). The last 2 decades has been inundated with reform efforts intensifying the importance of STEM and STEAM education in the K–12 educational setting across the United States (Herro et al., 2017). These efforts were fundamentally based upon the need to regain competitive economic and scientific advancement ground with other first world nations (Hunter-Doniger, & Sydow, 2016).

Classroom educators are the implementers of STEAM education; therefore, their conceptualizations of STEAM education are at the core of the success and/or failure of STEAM education in their setting (Jamil et al., 2018). Effective STEAM education implementation depends on educators being able to make sense of STEAM through their own established belief system, experience within the field, and their ability to navigate through the rewards and challenges of STEAM (Land, 2013). Land (2013) explained that supporters of the STEAM initiative may theorize how the STEAM curriculum may look in the classroom or what STEAM education is, but ultimately conceptualization was left up to classroom teachers to make sense of and navigate through.

A significant challenge exists for educators and other stakeholders involved in the promotion of STEAM education particularly at the elementary level (Shernoff et al., 2017). According to Cook and Bush (2018), “The community of elementary educators are critical in this discussion of integrated learning spaces as STEAM initiatives continue to be implemented in schools around the world” (p. 712). Liao (2016) suggests a “STEAM map” as a means to assist educators in visualizing the content associated STEAM education to form a sense of a common agreement concerning STEAM education.

This study offers thoughtful new insights and perspectives on how classroom educators in a STEAM certified elementary school make sense of their conceptualization of STEAM education in their classroom settings. The aim of this study was to create a structure of intersubjective knowledge which may reveal unique characteristics and contributions for STEAM education. This study also aimed to compare the conceptualizations in this specific setting with the established literature on the guiding principles of STEAM education.

CHAPTER III: METHODOLOGY

Qualitative research is widely accepted as an effective means to produce rich, contextual data by the researcher engaging in conversations with the research participants within a natural setting (Creswell, 2007). This qualitative study employed the use of a descriptive case study. Yin (2003) explained the descriptive case study design is appropriate for answering the “what,” “how,” and “when” questions to make sense of a phenomenon within the real-life context. In the current study, the focus was on “what” and “how” and a descriptive case allowed for me to deconstruct and reconstruct the phenomenon for a more complete understanding of the phenomenon (Yin, 2003). The case study method is appropriate for the intention of advancing a field’s body of knowledge (Merriam, 2009); therefore, to gain insight into the conceptualizations of STEAM education within the elementary setting, a qualitative descriptive case study design was selected.

Research Design

I chose the qualitative descriptive case study method for my research to gain a better understanding of the phenomenon of STEAM education in the elementary classroom setting (Holmlund et al., 2018). The descriptive case study design was an appropriate strategy while taking into consideration how the phenomenon of STEAM education is affected by the contextual surrounding in which it is situated (Baxter & Jack, 2008). The goal of this descriptive case study design was to gather data concerning the conceptualizations of elementary educators in a STEAM certified school to construct intersubjective knowledge. Intersubjective knowledge is knowledge that is collective and agreed upon among members of a certain culture or organization (Wan, 2012).

The descriptive case study design gathered data concerning the conceptualizations of STEAM education according to elementary educators in their classroom settings to better understand what they believed STEAM education to be. This case study sought to offer thoughtful new insights on how elementary educators in a STEAM certified school conceptualize STEAM education which I believe revealed unique characteristics and contributions for STEAM education.

Binding the Study

In case study research, emphasis is placed upon providing boundaries for the phenomenon under study to avoid having a research study that is too wide-ranging and unclear (Baxter & Jack, 2008). The descriptive case study was bound within the context of a single STEAM certified elementary school in Georgia serving grades K-4 to explicitly examine the phenomenon of STEAM education within that specific setting. The study investigated the phenomenon solely through the lens of seven elementary classroom educators that are actively implementing STEAM education within their classroom setting. This case study was bound temporally, and data collection was conducted within the span of 4 weeks.

Role of Researcher

In qualitative research, the membership position of a researcher is significant in the areas of observation, field research, and ethnography (Dwyer & Buckle, 2009). I have been an educator involved in the adoption of STEAM education for the past 5 years in the same school district but within another school. This involvement in STEAM education adoption led to the realization of the problem driving this study: the extant literature does not address how elementary educators conceptualize STEAM education.

I do not work with or advise any of the participants nor have any authority or connection with the participants; yet the fact that I have experiential knowledge in a similar setting as it applies to STEAM education can lead to implicit bias. When researchers conduct research with populations in which they are also members, they are considered an insider researcher because they share an identity, culture, and experiential base with the study's participants (Asselin, 2003). Creswell (2007) referred to this type of research as "backyard research" because the study takes place in the backyard, or in this case, in the school district of the researcher's employment. Acknowledgement of the potential impact of my insider epistemology is important to address.

One advantage of being an insider researcher is the ability to facilitate a study's effectiveness based upon an established rapport, such as being in the same district, that may yield a greater depth to the data gathered (Dwyer & Buckle, 2009). Other advantages of insider research include having knowledge concerning the culture of the setting, possessing the ability to easily engage in social interactions necessary to conduct a study effectively, and having an established identity within the setting, often allowing for more accessibility to the field of study (Greene, 2014).

There are difficulties, however, associated with being an insider researcher (Dwyer & Buckle, 2009); for example, the established rapport and familiarity a researcher has within the culture could lead to loss of objectivity and promote subjectivity (Greene, 2014). Van Huegten (2004) offered a way to combat bias and subjectivity by creating distance between the researcher and participants by establishing a social and emotional disconnect. The necessary disconnect was addressed and facilitated by sole use of professional and virtual platforms to conduct the study:

Google Shared Drive and Zoom instead of more social engagement such as face-to-face interviews or classroom observation of practice. The ongoing COVID-19 global pandemic affected the ability to meet in person, collaborate among schools, and halted any districtwide initiatives. The ability to combat bias and subjectivity due to cultural connectedness has increased due to the pandemic. In other words, the established culture that once promoted rapport and familiarity within the culture, leading to loss of objectivity and subjectivity, has been somewhat deconstructed by the pandemic.

Additionally, I employed the use of a research diary throughout the entire process to explore any predisposition typical of an insider researcher. Cypress (2017) suggested insider researchers combat bias through reflexive strategies, such as a research diary. According to Greene (2014), reflexivity in insider research forces researchers to examine their own personal preconceived notions and conceptualizations to help ensure the participants' voices and conceptualizations gained through the data are authentically represented. To address my own subjectivity, I employed an adaptation of Peshkin's (1988) *Subjective I's.* Peshkin's (1988) work is a means to meet researchers' obligations to be 'meaningfully attentive' (p. 17) to their own subjectivity as they gather and analyze data. An audit of my own subjectivity is recorded in Table 2.

Table 2

Subjectivity Investigation

Personal I's	Description
My *STEAM Educator I*	My background as an educator within a STEAM certified school shapes my perspective through my own lived experiences and my willingness to adopt STEAM pedagogy myself My belief is that effective educators are the ones that are enthusiastic about serving their students in innovative means even if they are uncomfortable themselves. *I personally value "getting out of the box" type mindsets in educators.*
My *Art Educator I*	My sense of self is driven by aspiring to be an outstanding teacher with expansive experience, expertise, and discernment to serve students' aesthetic intelligence. My goal is to grow aesthetic intelligence while simultaneously expanding and stimulating students' minds to reach outside of their comfort zones. Acknowledging *my bias concerning aesthetics is paramount*.
My *District Member I*	My sense of community is informed by the district's unprecedented support for the arts. While larger and wealthier counties slashed art education, our community supported and promoted it and I have reaped the benefits personally and professionally. This gives me *a sense of rose-colored glasses concerning all district personnel and endeavors*.
My *Doctoral Student I*	My value system concerning my academic career holds me accountable to my *prominent core aspiration to achieve* my goal of a doctoral degree. This degree holds significant value as I am the last one of my father's three daughters to achieve a terminal degree as he did in his short life.
My *Personal Human I*	My sense of self as an emotive and personable individual who tends to *soften my judgment and distance between other individuals and myself.* My interpersonal skill set can affect my interactions and communication with participants.

Data Collection

For data collection I used three instruments to gain insight into the participant's conceptualizations of STEAM education within their elementary classroom settings. Phase I used a personal meaning mapping and Phase II used photo elicitation. Both instruments worked in conjunction to inform the Phase III semistructured interview process. According to Yin (2003), the chief source of data in case studies are the interviews. In this study, personal meaning mapping and photo elicitation as instruments were specifically chosen to promote richer data collection in the interview process. Table 3 provides an overview of the three phases.

Table 3

Phases of Data Collection

Phases	I Week 1	II Week 2	III Week 3–4
Data collection method	Personal meaning mapping (PMM)	Photo elicitation	Semistructured interviews
Process	Shared Google drive	Shared Google drive	Interviews via Zoom

To ensure credibility and validity of the results, I used the practice of triangulation to produce rich insight and information concerning the participant's conceptualizations of STEAM education within their elementary classroom settings. This practice of triangulation was achieved by using three data collection methods designed to bring different insights and understandings to the study (Denzin, 1978). According to Creswell (2014), triangulation involves using various sources of data collection to gain insight and ultimately develop themes. Triangulation allowed the investigation of the phenomenon from multiple points of view from each participant (Baxter & Jack, 2008), and improved rigor by capitalizing on the combined strengths of the three instruments (Guba, 1981). Insight gained from reviewing the PMMs and the photographs were further explored during the semistructured interview process. This allowed for a convergence among the different sources to form initial codes, axial codes, and themes in the data analysis (Creswell 2007).

Case Details

Setting

To date, there are seven STEAM certified elementary schools in the state of Georgia. A single school serving K–4 grades in a rural setting was selected for the study. This non-Title 1, K–4 school was founded in 1989. The school is in a rural setting and serves approximately 600 students. According to the State of Georgia's Governor's Office of Student Achievement (2020), students' overall performance at this particular school is higher than 60% of schools in the state and the 2019 College and Career Ready Performance Index (CCRPI) score was 77.8. In a conscious effort to maintain the privacy of the STEAM certified school where the participants serve as educators, further demographics for the contributing school and participants are intentionally omitted.

STEAM Certification Process

This STEAM certified elementary school began the certification process in 2016 by implementing STEAM curricular practices to meet the criteria set forth in the Georgia Department of Education (GaDOE) STEAM Continuum. This process typically takes 2 years and allows schools to determine their readiness for certification.

During these 2 years, the schools' rural location in a farming community shaped the way STEAM education was approached. As a framework for STEAM implementation, the school utilized an agricultural lens that embedded the eight practices of science and engineering identified in the *Science and Engineering Practices in the NGSS* (2013). These eight practices are:

- Asking questions (for science) and defining problems (for engineering);
- developing and using models;
- planning and carrying out investigations;
- analyzing and interpreting data;
- using mathematics and computational thinking;
- constructing explanations (for science) and designing solutions (for engineering);
- engaging in argument from evidence; and
- obtaining, evaluating, and communicating information.

The school's grounds are divided into various garden and agricultural spaces managed and maintained by the entire learning community on campus. Annually, each grade level develops and implements a year-long investigative research question centered on a phenomenon of study in the agricultural spaces. During the time of the study, kindergarten's research was centered on the life cycle of the chicken, first grade's research was centered on growing vegetables such as loofahs, second grade's research was centered on the effects of pollinators in gardening, third grade's research was centered on designing and developing a cooling station on campus, and fourth grade's research was centered on using aquaponics as a watering system to grow plants and herbs.

The eight practices of science and engineering identified in the *Science and Engineering Practices in the NGSS* (2013) were executed using three instructional approaches: Problem Based Learning (PBL), Claim Evidence Reasoning (CER) and Engineering Design Process (EDP) (Table 4).

Table 4

Approaches used to implement NGSS Science and Engineering Practices

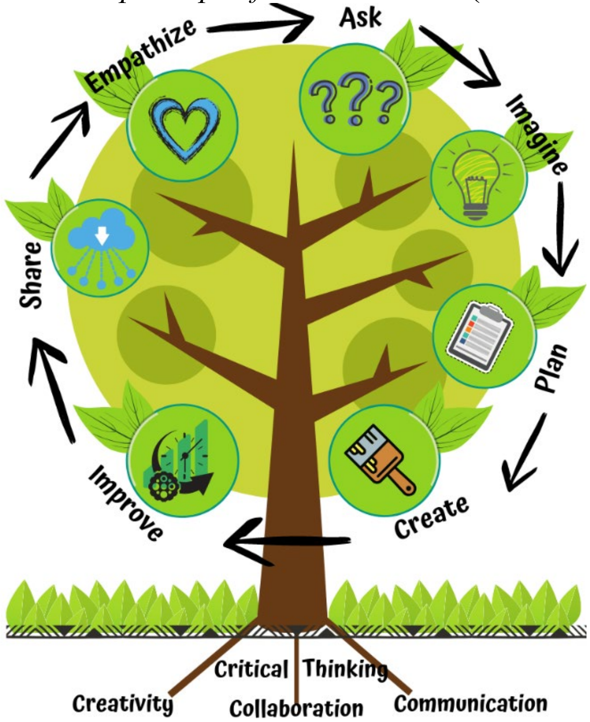
Approach	Description
PBL	PBL emphasizes long-term learning through interdisciplinary and student-centered experiential that have real-life application (Hawari & Noor, 2020).
CER	According to Allen and Rodgers (2015), CER "supports students' learning and writing through forming statements (claims) based on their observations (evidence) and then discussing these results with respect to the underlying scientific principles (reasoning) to build a deeper understanding of the content" (p. 33).
EDP	EDP is an iterative process of problem solving where students conduct background research, develop multiple ideas for solutions, develop and create a prototype, and then test, evaluate, and redesign (Margot & Kettler, 2019).

In support of this approach, the school collaboratively designed and adopted an EDP schoolwide graphic (see Figure 4). This customized graphic was created by educators on campus implementing STEAM and used throughout the process of meeting the criteria set forth in the

Georgia Department of Education (GaDOE) STEAM Continuum and the STEAM certification application process.

Figure 4

EDP Graphic Specific to the School (S. Banks, personal communication, 2018)



In 2018, the school officially applied for STEAM certification by following the steps below to become STEAM certified in 2019:

Step 1: After the school met the criteria indicated in the STEAM Certification Continuum, the school-initiated contact with the GaDOE STEAM Program Specialist to arrange for a pre-application visit.

Step 2: The recommended adjustments by the STEAM Program Specialist after the pre-application visit were implemented.

Step 3: The school completed the STEAM Certification application.

Step 4: Three separate site visits were conducted by a GaDOE appointed team consisting of representatives from the disciplines of math, science, engineering, technology, arts, and other industry stakeholders.

Step 5: After the last site visit, the GaDOE appointed team reconvened to compare the school's completed application to the evidence observed during the site visits.

Step 6: The team officially recommended the school for STEAM certification.

Step 7: The GaDOE state superintendent of education and the GaDOE appointed team visited the school to award the STEAM certification to the school.

Participants

The seven participants for the study were classroom teachers currently employed at the described STEAM-certified school in Georgia. Purposive sampling was used to recruit at least one classroom teacher from each grade level (K–4). Yin (2009, p. 162) highly recommended that novice researchers begin "with a simple and straightforward case study" so a minimum of five and a maximum of 10 participants was determined to be appropriate. Prior to initiation of the study, I completed the necessary steps to obtain the approval of the Institutional Review Board (IRB) at Columbus State University. Once IRB approval was granted, I made a phone call to the principal of the STEAM certified elementary school describing the purpose of the study and seeking permission to recruit teacher participants. This was followed up with an official Principal Approval letter (see Appendix A). Along with this letter, I included the Letter of Interest, and Informed Consent (see Appendix B & C) that would be provided to the individual participants. After principal review and approval, the Letter of Interest and Informed Consent was sent by the researcher to all 20 classroom (K–4) teachers at the school via email. Of the 20 K–4 classroom teachers at the school, seven volunteered to participate in the study, and all seven were included.

Though the participants work within the same school, they each have different roles, backgrounds, years of service, etc. Furthermore, each participant has a professional role that is situated within institutional structures of the school such as grade level, specific standards they cover, individual responsibilities, cultural and social experience, STEAM colleagues they collaborate with, and years served in that role. The dynamics of this STEAM-certified elementary school is shaped by the rural location, agricultural approach to STEAM education, and professional roles of the participants. Table 5 presents additional descriptive characteristics concerning each participant including an assigned pseudonym.

Table 5

Participant Descriptive Characteristics

Participant	Current grade level	Years in elementary education	Years in STEAM elementary education	Highest education degree
1 (Anne)	Second	17	3	MEd
2 (Bette)	Third	9	9	MEd
3 (Claire)	Kindergarten	15	2	EdS
4 (Dorothy)	Fourth	25	18	EdS
5 (Elizabeth)	First	9	7	MEd
6 (Frances)	Third	16	5	MEd
7 (Ginny)	Kindergarten	6	6	MEd

Instrumentation

In this case study, I specifically employed methods of visual data collection to address the research question by investigating the educators' conceptualizations of STEAM education in a STEAM certified elementary school. The study was executed through three phases. Phase I and Phase II used visual methods of data collection: personal meanings maps (PMM) and photo elicitation. Personal meaning maps and photo elicitation are visual methods that can enhance sensemaking by allowing the participants to map out and express their construction of knowledge concerning STEAM in a nonverbal manner with no prescribed format (Falk, 2003; Harper, 2002).

Visual data is becoming increasingly utilized in qualitative studies as a means for researchers to develop an enhanced understanding of the characteristics that are essentials of human reality (Barbour, 2014; Prosser, 2008). Visual data can include photographs, drawings, maps, animations, and a variety of other media which can provide the researcher "very particular information about our existence" (Prosser, 1998, p.1). Visual data can offer deeper understanding and additional layers of meaning through investigations of human experiences by engaging participants more fully in the research process (Glaw et al., 2017). Prosser and Schwartz (1998) explain that:

> Visual data can show characteristic attributes of people, objects, and even events that often elude even the most skilled wordsmiths and can provide a degree of tangible detail, a sense of being there, and a way of knowing that may not readily translate into other symbolic modes of communication (p. 116).

This study employed the use of two forms of visual data to advance my investigation of the human experience of conceptualization by engaging the participants more fully in the research process (Glaw et al., 2017). The first form of visual data collection was through personal meaning mapping (PMM).

Phase I: Personal Meaning Mapping (PMM). PMM is a form of mind mapping that allow participants to graphically represent their sensemaking processes (Adams, 2003). PMM is an instrument which can capitalize upon the strengths of mind mapping through the constructive process of organizing and creating structure of one's conceptualizations (van Winkle & Falk, 2015). Falk (2003) developed PMM to better understand how learning occurs in informal learning settings, such as museums. PMM is a variation of concept mapping that could be used by participants with no prior experience in formal concept mapping and still yield valid insight into their construction of knowledge.

Prior to PMM, concept mapping was originally developed by Novak (1990) as a way for learners to organize and represent their knowledge. In the classic concept format, concept maps have concepts listed in a hierarchical fashion which are connected to other concepts through terms that link the concepts together (Novak & Cañas, 2008). The process of PMM is a less rigid method which allows for greater freedom on part of the creator (Falk, 2003). Falk et al. (1998) considered PMM as applicable to a variety of learning experiences as an effective approach to measure knowledge, associated ideas and beliefs, and their connections. The PMM process considers each participant's situational factors in flux through time as they move to an outcome of learning (Falk et al., 1998).

In the current study, the purpose of PMM was to better understand how the participants conceptualize STEAM education in their classroom setting by allowing them to freely associate any words, concepts, phrases, thoughts, images, experiences, or ideas with a standardized prompt (van Winkle & Falk, 2015). The PMMs offered each participant an opportunity to make sense of their unique experiences and situational factors surrounding their conceptualizations and understanding of STEAM in their classroom. In other words, the PMMs offered them a means to show how they make sense of their implementation of STEAM in their classrooms. Sensemaking is a reasoning process where individuals utilize their own identity, experiences, and cultural belonging to make sense of their situation, and includes the interconnectedness and complexity of one's conceptualization of a situation within the social and cultural context (Dervin, 1998).

The prompt I provided was: Write “STEAM” on the center of a piece of paper in pencil or ink. Now write or draw anything that comes to mind in relation to STEAM education in your classroom setting (see Appendix D). After the PMM prompt was uploaded to each participant’s Google Shared Drive, the participants were asked to complete their map and upload their completed map back to the Shared Drive within one week.

Phase II: Photo Elicitation. Photo elicitation is a methodological tool gaining traction within educational research as an effective tool for the interpersonal communication between the researcher and the participants (Nelson, 2019). Harper (2002) defined photo elicitation as an image-based method aimed at eliciting reflections from participants. Hatten et al. (2013) explained participants feel more invested in a study when they are permitted to choose or produce their own photograph separate of the researcher’s choice, voice, or bias. Nelson (2019) believed this method also allows for empowerment of the participants in the research process potentially rendering a more meaningful interview process.

According to Nelson (2019), discussion of an artifact submitted through photo elicitation allows for the participant to be self-reflexive. The process of asking participants to explain and reflect on their choice of the photograph builds a space and time for reflexivity. Therefore, this instrument of data collection allowed both me and the participant to gain a better understanding of the participant’s sensemaking and conceptualization (Ponelis, 2015).

Photographs used in a photo-elicitation method can be provided by the researcher, produced by the participant, or selected by the participant (Prosser & Loxley, 2008). Due to the ongoing COVID-19 global pandemic, which limited in-person learning, participants were limited in producing or taking a photograph in their classroom setting. Therefore, the photograph was selected by the participant from photographs they had taken prior to the pandemic. Because the

STEAM certification process in place within the state requires educators to collect and archive images of STEAM implantation, activities, and experiences, this was a reasonable approach to adopt.

In this study, each participant submitted a single photograph or selected a single photograph from their personal archives of what they believed best represents their conceptualization of STEAM education in their classroom setting. One visual image, such as a photograph chosen by the participant, can produce richer data because images induce emotions which, in turn, evoke additional layers of meaning and information (Harper, 2002). More specifically, areas of the brain that process visual images evoke a more profound level of meaning than areas that process verbal information (Glaw et al., 2017; Harper, 2002). In other words, verbal information (i.e., words alone), employs less of the brain's capacity to conceptualize, whereas visual images evoke richer parts of human conceptualizations (Harper, 2002).

Instructions and a prompt for photo elicitation was uploaded to each Google Shared Drive (see Appendix E). The instructions asked each participant to choose a single photograph after reading the prompt. Any photographs in their archives which included children had already been cleared for publication during the STEAM certification process. The prompt for the photo elicitation was: Please choose from your archives one photograph of what you believe best represents what STEAM education looks like in your classroom setting. Participants had one week to complete the photo elicitation phase, which was uploaded to their individual Shared Drive. The photographs served as a visual account that represented their conceptualization of STEAM education. Each participant was asked to explain their photograph during the semistructured interview process.

Phase III: Semistructured Interviews. An interview is defined as a conversation process amid the researcher and the participant to provide a more complete understanding of the phenomenon of study (Merriam, 2009). According to Starks and Trinidad (2007), semistructured interviews offer researchers an opportunity to elicit a participant's narrative in a distinct and personal manner. The semistructured interview served as an instrument specifically to gain continued insight concerning the participants' conceptualizations of STEAM education through a verbal format that supplemented and extended the understanding of the visual data.

According to Creswell (1998), semistructured interviews allow researchers to better understand the participants' point of view and sensemaking concerning the phenomenon in question. The flexible nature of a semistructured interview allows for a researcher to use a base set of interview questions and provide follow-up questions depending upon the responses provided to allow the exploration of concepts that may arise during the interview process (Ponelis, 2015).

After all the PMMs and photographs were collected, I emailed each participant to schedule an interview via Zoom. A link for a Zoom interview process was sent to the participant the day before their scheduled interview. A video recording through the Zoom platform of each semistructured interview was made and stored in the Zoom cloud until transcribed. All recordings were transcribed via Microsoft Word within a months' time and then deleted permanently from the Zoom cloud storage.

On the scheduled date, I initiated Zoom and allowed time for appropriate introductions. Then, prior to starting the interview, due to the potential questions the participant may have about the research process, I dedicated five minutes to share the purpose for conducting the research, for review of informed consent including confidentiality, anonymity, and voluntary participation, and to remind the participant they had the option to withdraw at any point.

The interview questions (see Appendix F) were crafted from information gained from the review of literature and from the examination of each participant's PMM and photograph. The semistructured interview process afforded me an opportunity to have a detailed dialogue concerning each participant's conceptualization of STEAM education. The semistructured interview also allowed me to ask follow-up and clarifying questions to probe each participant's sensemaking of the phenomenon.

The interview process began with the examination of the participant's PMM. Discussion and inquiries were made concerning each concept listed on the participant's PMM along with follow up and clarifying questions based upon their answers. Then, the same process was employed for the examination of each participant's chosen photograph. Additional follow-up questions were asked aimed at further clarification, identification of relationships, importance of certain items, added reflections, and other explanations.

The participants were allowed ample time to explain their sensemaking concerning STEAM education in the classroom setting. At the conclusion of the interview process, the participant was thanked for their time and their contribution to this study. The average time of the seven interviews was 32 minutes. A thank you letter (see Appendix G) was emailed to each participant at the conclusion of their interview.

Trustworthiness of Data

According to Cypress (2017), reliability and validity should drive the design of any qualitative study, because "reliability and validity are 2 factors that any qualitative researcher should be concerned with while designing a study, analyzing results, and judging its quality" (p.

257). The study employed several validity procedures to safeguard the credibility of the findings. Validity procedures generally begin with identifying the researcher's lens and the researcher's paradigm assumption in which they chose to validate the study (Creswell and Miller, 2000). As an educator within a STEAM-certified elementary school, I believe conceptualization of STEAM education is socially constructed in a pluralistic manner dependent upon the place and situation. In other words, "the qualitative paradigm assumes that reality is socially constructed, and it is what the participants perceive it to be" (Creswell & Miller, 2000, p. 125).

Additionally, to help ensure the integrity of each participant's conceptualizations of STEAM education in their specific elementary classroom, triangulation was used as a systematic way to sort through the data looking for concepts and overlapping concepts to develop categories and themes (Creswell & Miller, 2000). Triangulation of the data established the credibility of the data gained from the instruments as each participant was allowed to express their individual conceptualizations according to their own knowledge base through three distinct methods. Additionally, triangulation of the data collection methods produced rich and thick descriptions via the two visual methods (PMMs and photographs) which informed the semi structured interview process.

The dependability of the study can be based upon the procedures and processes the researcher used to collect, analyze, and interpret the data (Lodico, 2010). The strategies in place to ensure dependability are the separate phases of data collection designed to produce rich and thick descriptions, transcriptions of the semistructured interviews and the Google Shared Drive that houses an audit trail and evidence to support the research conclusions. The reflexive practice of the research diary also helped in establishing reliability by maintaining a fair and balanced view of all perspectives including my own and of each participant's. The trustworthiness of this study was also supplemented by peer debriefing. My anticipation of using peer debriefing with a coresearcher within the STEAM educational field reinforced self-credibility of my own analysis before their scrutiny and offered me an additional opportunity for reflexive analysis after their scrutiny (Stahl & King, 2020).

Data Analysis

Creswell (2007) explained qualitative researchers analyze data to make sense of the phenomenon in terms of the contextualization the participants hold of the phenomenon. Data analysis for this study was thematic analysis. According to Ponelis (2015), studies that incorporate visual data, such as PMM and photographs, which inform an interview process should be analyzed thematically across all data to present themes that relate to the data. Therefore, I engaged in a thematic analysis whereby concepts and categories were searched for across the PMMs and the photographs. The concepts along with additional participant reflections, were further explored in the interviews. With this corpus of data, thematic analysis allowed me to find and identify repeated patterns of conceptualizations and meanings of STEAM education in the elementary classroom and to compare these to the literature that guides STEAM education implementation.

Braun and Clark (2006) stated thematic analysis is appropriate in a constructivist theoretical framework and seeks to focus on the sociocultural contexts that form the individual accounts of the participants gleaned from the data collection instruments. Furthermore, thematic analysis is a flexible approach that can be effective in producing thick and rich descriptions of the data set as well as identifying similarities and differences across the data set (Braun & Clark, 2006). The process is iterative where I analyzed the data in an ongoing manner returning to early steps as needed throughout the review.

Initial Coding

Flick (2019) noted, “The first step (open coding) aims at expressing data and phenomena in the forms of concepts” (p. 307). Open-ended coding is also referred to as initial coding (Saldaña, 2015) and is often used by novice researchers due to the straightforwardness of this method. Initial coding was used to establish codes from the three instrument phases.

PMM

The initial coding process began with the careful familiarization of all PMMs collected in Phase I (Appendix H). participants I scrutinized each PMM several times to examine the words, concepts, beliefs, outcomes of thoughts, phases, and/or ideas the participants included in their PMM. Each entry on the PMM served as an initial code which I recorded verbatim (see Table 6).

Table 6

Concepts Provided in Personal Meaning Maps

Anne Work, Music, Art, Student Centered and Driven, Movement, Unique, Cooperation/Collaboration, Safe, Integration, Research, Personal, Recycled Goods, Future, Progressive, Nontraditional, Legos, Innovative, Independence, Content Areas, Creativity, Facilitator, Planning,
Bette Student Curiosity Led, Teacher is the Moderator, Arts Integration that is Simple, Meaningful Instruction and Learning, Easy to Add to Daily, Research, Student Centered and Driven, Nontraditional
Claire Learning, Chickens, Technology, PBL, Engineering, Math, Science, Hands-on, Process, Empathy, Share, Investigative Research, Art, Collaboration, Why, Plan, Purpose, Spring, Data Collection, Fun, Winter, Ask, CER, Improve, Fall, Create
Dorothy Same Concepts and Standards, Thinking Outside of the Box, Out of Comfort Zone, Real World Problems Solving, Revamp Solutions, Took a While to get Used to, Different Way of Solving Problems, Challenging Problem Solving, Agriculture, Challenging Myself, Application of Concepts, Student Centered and Driven
Elizabeth Integrate, Math, Arts, Hands-on, Science, Technology, Engineering, Student Focused, Student Led, No Worksheets, Thinking Outside the box, Student Centered and Driven
Frances Engineering, Art, Engineering Design Process (ask, imagine, plan, create, improve), Science, Critical Thinking, Math, Technology, CER (claim, evidence, reasoning), Fun, Variable, Constant, Cooperation, Teamwork, Challenge, Career Exposure, PBL Problem based learning), Cross-curricular, Helping Community, Unit integration Student Centered/Driven
Ginny Meaningful Learning Activities/ Authentic Learning/ Learning Activities, Chickens, Creativity, Journals, Investigative Research, Design Process, Collaboration, Science, Support, Math, Arts, Empathy, Real Life Problems/Real world connections, Engaging, Planning, Training, Certification, CER, Evidence, Rigor, Reasoning, Community, Data Collection, Integration, Engineering, Careers, Innovate, Exploration, Critical Thinking, Interdisciplinary, Inquiry, Partnerships, Technology, Student Centered/Driven

This process allowed me to recognize the specific concepts each participant attributed to STEAM education. This data concerning their individual conceptualizations was used to generate verbal discussion during the semistructured interview process.

Photo Elicitation

Continuing to explore each participant's individual conceptualization of STEAM education, familiarization of each photograph took place by repeated scrutiny. Making sense of photographs is dependent on what sort of social or experiential situation is being depicted (Prosser & Swartz, 1998). Because this study aimed to gain insight concerning the social and cultural realities of STEAM, I examined each participant's photograph (see Appendix I) to identify which relevant and meaningful concepts emerged concerning participants' understanding and knowledge of STEAM education. These emerging concepts were recorded as initial codes. The codes that arose and a verbal description of those codes are provided on Table 7. These codes and descriptions were used to generate verbal discussion during the semistructured interview process (Jenkings et al., 2008).

Table 7

Initial Codes that Emerged from the Review of Photographs

Participant	Initial Codes	Verbal Description
Anne	Student Centered/Driven Nontraditional	Students recording data in journals in a nontraditional educational garden environment.
Bette	Student Centered/Driven Nontraditional Technology	Students gathering research data in journals and using technology in a nontraditional outdoor learning environment.
Claire	Student Centered/Driven Nontraditional Chickens	Students with chicken eggs in a nontraditional outdoor learning environment.
Dorothy	Student Centered/Driven Arts	Students appear to be applying knowledge of an art process.
Elizabeth	Arts Nontraditional	The photograph is of a student generated illustration which depicts students in a nontraditional outdoor learning environment with descriptive text concerning a loofah garden.
Frances	Student Centered/Driven Technology	Students use technology in a nontraditional outdoor learning environment.
Ginny	Student Centered/Driven Arts Integration	Students appear to be using art forms illustrating science standards in a performance for their peers.

Semistructured Interviews

The semistructured interview questions (see Appendix F) were used to elicit descriptions and explanations of each participant's PMM and photograph. Follow-up and clarifying questions helped me broaden the interview process and gain more understanding concerning each participant's conceptualizations of STEAM education.

All transcripts were printed out and scrutinized several times. I also reviewed the original recordings on Zoom while I read and reread the Microsoft Word transcripts of the semistructured interviews to ensure that the transcripts were accurate. After each transcript was deemed accurate, each participant's PMM and photograph were inserted at the end of their transcript and printed out for further inspection. I assigned colors to the initial codes to assist with my review and recorded each color with the assigned code in the researcher's diary. Review continued in an iterative manner as initial codes were organized, modified, split, combined, or discarded using a constant comparison method (Glaser & Strauss, 1967; Lincoln & Guba, 1985). This process continued until no further codes emerged and the code categories remained static.

Peer Debriefing

Initial coding was then supplemented by peer debriefing. According to Stahl and King (2020), "Peer debriefing or peer scrutiny are solid communication habits that create trust" (p. 27). The peer chosen for scrutiny had extensive contextual knowledge of curriculum development and familiarity with STEAM curriculum and held CITI certification and IRB approval to examine and analyze data from this study. Because both the PMM process and the photo elicitation worked in conjunction to inform the Phase III semistructured interview process, the peer was sent a transcript (Appendix J) from the semistructured interview process along with the participant's PMM and photograph. The randomly selected transcript was de-identified to protect the rights of the participant and sent via an email attachment. The peer was asked to color code the words and phrases within the transcript.

After the peer returned the color-coded transcript (see Appendix J), I compared and cross-referenced the peer results to my results. Then a discussion of findings with the peer via Zoom took place. We discussed all the evidence the peer used to code and how the codes were identified and sorted. We debated the meaning of the codes and cross-referenced our codes. And developed a mutually agreed upon understanding of the codes that were grounded in the data. All transcripts, PMMs, and photographs were again reviewed to ensure no changes or modifications to the initial coding of the data sources were needed. Through this iterative review of all data sources, the negotiated understanding from the peer review, and the reflections contained in the researcher's diary, I found 21 stable initial codes (see Table 8).

Table 8

Initial Codes

1) Meaningful/Authentic Learning
2) Student Centered/Student Driven
3) Real World Connections
4) Inquiry Based Learning/ PBL/CER
5) Collaboration/Teamwork
6) Challenging/Difficult
7) Different Means of Instruction/Shifting Practices
8) Nontraditional
9) Integration of the STEAM Disciplines
10) Sense of Community
11) Thinking Outside of the Box/ Problem Solving/Divergent Thinking
12) Arts Integration
13) Student Buy-In/Success
14) 21st Century Preparation/Real World Application
15) Same Standards/New Application
16) Creativity/Innovation
17) Took Time to Get Used to
18) Planning/Lesson Planning/Team Planning
19) Professional Development/STEAM Team/Training
20) Agriculturally Based/Chickens/Gardens
21) Certification Process

Axial Coding

These initial codes, identified through color coding, served as meaningful concepts related to the participants' conceptualizations of STEAM education. The next step of the process was axial coding to identify relationships between the codes and to find patterns of meaning in the data (Williams & Mose, 2019). To complete this process, I cut out the colored codes from the data and arranged them into categories on a table to establish axial codes. In this manner, axial coding served as a comparison method where the data was organized and refined which sometimes involved them being further divided, pooled, or discarded. The research diary was also used to practice reflexivity. This step allowed me to see patterns and meaning from the data emerge.

Through this process of axial coding, I found five logical and comprehensive axial codes: Student Centered/Teacher Facilitated, Nontraditional/Unique, Inquiry Based Learning, Strategic Integration, and Collaborative Efforts. Each axial code reflects a content categorization of the meaningful concepts of the participants' conceptualizations of STEAM education.

Selective Coding

Following initial coding, axial coding was applied which examined and compared the codes for categorization and comparison. The next step was selective coding. According to Flick (2009), "Selective coding continues the axial coding at a higher level of abstraction through actions that lead to an elaboration or formulation of the story of the case" (p. 310). This step in the process of thematic analysis was used to assimilate the axial codes to develop four emerging themes that show the collective conceptualizations from the narrative of the data to answer the research question:

What are the collective conceptualizations of elementary educators concerning STEAM education in their classroom settings in a STEAM certified school in Georgia?

Through selective coding, I found all axial codes influenced each theme in varying degrees (Table 9). The themes are: Shift in Instructional Practices, Beneficial for Student Advancement, Socially Constructed, and Transdisciplinary Learning is Crucial.

Table 9

Initial Codes, Axial Codes, & Themes

Initial codes	Axial Codes	Themes
Student Centered/Student Driven Meaningful/Authentic Learning Real-World Connections Thinking Outside of the Box/ Problem Solving/Divergent Thinking Different Means of Instruction/Shifting Practices	Student Centered/Teacher Facilitated	Shift in Instructional Practices Beneficial for Student Advancement Socially Constructed Transdisciplinary Learning is Crucial
Student Centered/Student Driven Meaningful/Authentic Learning Real-World Connections Nontraditional Different Means of Instruction/Shifting Practices Thinking Outside of the Box/ Problem Solving/Divergent Thinking	Inquiry Based Learning	Shift in Instructional Practices Beneficial for Student Advancement Socially Constructed Transdisciplinary Learning is Crucial
Took Time to Get Used to Thinking Outside the Box/Problem Solving/Divergent Thinking Sense of Community Agriculturally Based/Chickens/Gardens	Nontraditional/Unique	Shift in Instructional Practices Beneficial for Student Advancement Socially Constructed Transdisciplinary Learning is Crucial
Meaningful/Authentic Learning Real-World Connections Same Standards/New Application Art Integration Integration of STEAM Disciplines Student Buy-In/Success Creativity/Innovation	Strategic Integration	Shift in Instructional Practices Beneficial for Student Advancement Socially Constructed Transdisciplinary Learning is Crucial
Collaboration/Teamwork Planning/Lesson Planning/Team Planning Professional Development/STEAM Team/Training Certification Process	Collaborative Efforts	Shift in Instructional Practices Beneficial for Student Advancement Socially Constructed Transdisciplinary Learning is Crucial

Summary

I chose a descriptive case study to investigate the phenomenon of STEAM education in the real-life context of the elementary classroom setting (Yin, 2003). According to Baxter and Jack (2008), case study research provides an excellent opportunity to gain meaningful insight into a specific case. Both the triangulation of the data and the process of thematic analysis provided rich insight and information.

CHAPTER IV: FINDINGS

In this chapter, I employed a descriptive analysis method to report the findings in a meaningful manner. I structured the findings to address the problem statement, the purpose of the study, and how the data addressed the research question driving this study.

Through thematic analysis, I found five axial codes and four themes. The axial codes are: Student Centered/Teacher Facilitated, Nontraditional/Unique, Inquiry Based Learning, Strategic Integration, and Collaborative Efforts. The themes are: Shift in Instructional Practices, Beneficial for Student Advancement, Socially Constructed, and Transdisciplinary Learning is Crucial. I found that all axial codes influenced each of the four themes in varying degrees.

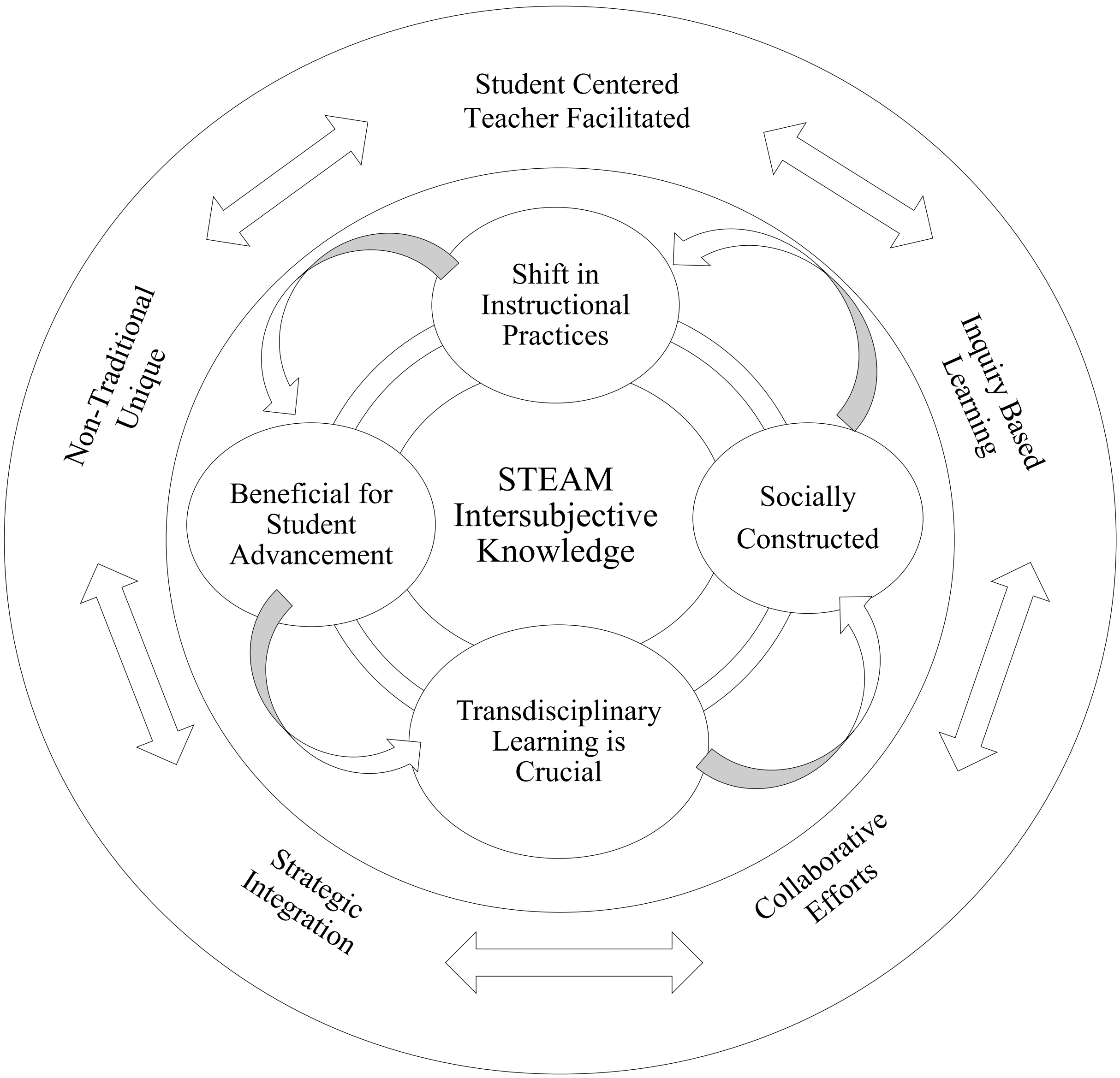
A characteristic of thematic analysis is the drawing of a thematic map (Vaismoradi et al., 2013). Therefore, for coherence I crafted Figure 5 to serve as a map of the participants' collective "plausible story" of STEAM education in their specific setting. The participants' "plausible story" is told through the formulation of intersubjective knowledge the findings revealed. This intersubjective knowledge answered the research question:

What are the collective conceptualizations of elementary educators concerning STEAM education in their classroom settings in a STEAM certified school in Georgia?

According to Wan (2012), "The widely shared representations that members of a culture hold are the intersubjective representations about the culture" (p. 109). The research question was specifically designed to investigate the elementary educators' conceptualizations to create structure for intersubjective knowledge concerning STEAM education. The themes, influenced by the axial codes, are discussed below.

Figure 5

Formulation of Intersubjective Knowledge



Shift in Instructional Practices

The theme representing that STEAM requires participants to be prepared for a shift in instructional practices speaks directly to the essential problem driving this study: the extant literature on STEAM education in the elementary classroom setting does not fully address how, or in what ways, elementary educators should begin to conceptualize STEAM education in their setting. STEAM requires a shift away from: "the teacher as a source of knowledge and place the students at the intersection of learning, critical thinking, exploration, and deepening of understanding" (Khine & Areepattamannil, 2019, p.165).

The axial code of student centered/teacher facilitated was identified by six of the seven participants during the interview process. Participants explained that STEAM education shifted their traditional role of being the teacher as "the expert" standing and delivering content to becoming a facilitator who allows students to formulate their own ideas and problem solve on their own. *Frances* explained: "(It was) a real shift in my mindset. As teachers we stand up and give the information. Now what we do assist in communicating an idea and provide support. That way you're not formulating student ideas on your end." This idea of the student-centered learning was also represented in the visual data sources. Review of the photographs submitted by the participants reflecting STEAM in their classroom showed the students engaged in exploration, data collection or the presentation of findings in authentic ways. In addition, three of the seven PMMs specifically identified this concept of facilitation on behalf of the teacher.

Ginny was the only one who did not have to significantly shift her instructional practices because her first year of teaching was in the STEAM school. "I was kind of a lucky one within my learning of STEAM education because when I started my first-year teaching, we were implementing STEAM." Therefore, she did not have to face the challenges other educators have in shifting her pedagogical approach. *Ginny* explained, “So I didn't have a lot of crazy transitions and changes because I was learning as we were all going through that process together.”

Bette attributed the shift of her implementation and pedagogical practices to her students’ inquiries and interests through STEAM education engagement. *Bette* considered her classroom a lab where her instructional approach is in constant flux dependent on her students’ interests. She explained she has to let go of her traditional teaching style to tailor-made instruction to her students’ interests: “instead of me planning a lesson and presenting, I allow student curiosity in a certain phenomenon or problem to drive instruction. Then I go back and plan around that idea fitting in the standards and STEAM disciplines.”

The axial code of nontraditional/unique provides additional context on the shift that was required in instructional practices throughout the data sources. The participants explained STEAM is implemented in a unique manner that is crafted around their specific classroom, school, and district STEAM approach to realize their identified STEAM learning goals. *Anne* explained, “I think STEAM is unique. It’s not something you see every day. It’s not something you hear about.” She extended this concept by assigning the term nontraditional to STEAM in her PMM “because you can’t be dependent on a curriculum being handed to you because you develop it for your learning goals.” *Anne* described STEAM’s distinctiveness; “It definitely was unique to me and there is a shift in teaching, so this is different for children and school districts too. I mean, it’s unique to all.” *Anne* explained, “Because there aren’t really a lot of model schools or model classrooms where you can go and where it is given to you.” Because STEAM implementation requires a personalized and unique approach, model classrooms that are utilizing similar investigative research and/or phenomenon of study are not typically available.

In the current case, the overarching STEAM learning goal was is a schoolwide agricultural investigative research approach. *Claire's* photograph showed students involved in raising chickens to study life cycles in a chicken coop while *Bette's* and *Frances'* photographs showed students developing prototypes for playground and garden cooling stations to better support living things by using technology to gather data in the field (see Appendix I). Such activities were considered unique and non-traditional by the participants.

Since the teachers must customize their method to reach the school's overarching STEAM learning, each grade level chooses a specific phenomenon to investigate and study. *Elizabeth*'s grade level focused on planning and growing different vegetable gardens on campus. Yields from these gardens are used in a variety of STEAM activities and lessons. *Elizabeth's* students selected to grow loofahs in their garden. The class documented the process of the loofah growing seasons through drawing observational pictures as shown in *Elizabeth's* photograph (see Appendix I).

Though the participants were implementing STEAM in a unique and nontraditional manner, two participants clarified that the standards taught through STEAM implementation are the same standards they were previously teaching but via a nontraditional approach unique to their STEAM learning goals.

The shifting instructional practices identified by the teachers also necessitated having to strategically to integrate standards the participants were not familiar with such as art standards. The participants shared how difficult it was to be intentional and strategic concerning how they integrated the different disciplines of STEAM. *Anne* shared this was significantly more laborious due to her lack of experience teaching the arts, "Music with math or science has been difficult for me because I don't teach art and I don't teach music."

While examining her PMM (see Appendix H), the term *art* was most noteworthy with the addition of the stars she included to emphasize the word. *Anne*: “I put little star bars around art because for me, personally, I have found art has been the most difficult but the most fun for me in STEAM. I enjoy integrating that art piece.” Anne explained integration of the arts helps engage her students and herself just out of pure enjoyment of the arts processes: “me and the students like being creative and getting messy.”

Several participants commented that the adoption of the overarching STEAM learning goal for the school shifted instructional practices to inquiry-based learning pedagogy. Similar to the codes of non-traditional and student-centered, the specific need to actively incorporate inquiry-based learning into their classrooms represented a shift in their more traditional instructional practice. These approaches included project-based learning (PBL), the engineering design process (EDP) and the use of claim, evidence, and response (CER). Three ER participants *(Claire, Frances, and Ginny)* referenced the terms in their PMM’s and four participants (*Anne, Bette, Claire, and Elizabeth*) explained during their interviews that their chosen photograph depicted inquiry-based learning.

This shift in instructional approaches required increased collaboration on behalf of the teachers. *Elizabeth* claimed that collaboration was needed not only with her grade group, but with other grade levels and stakeholders as well. The annual PBL in her grade centered on gardening which required collaborative efforts for maintenance and data collection even when school was not in session. She and her students had to figure out how to recruit and work with others to take care of their garden through the year. *Elizabeth* explained their solution:

> We got families involved. We have a signup sheet for the families to come help over the holidays and over the summer we recruited families of rising first graders

> to come take care of the garden. That way students coming up to first grade already have ownership over the garden.

Beneficial for Student Advancement

The next theme emerging from the axial codes is the understanding by the participants that STEAM was beneficial for the advancement of their students. Each participant acknowledged during their interviews that STEAM education was an effective means to enhance student learning and motivation to prepare their students to be successful in the 21st century. *Bette* believed STEAM education was beneficial for her students because STEAM was a student driven phenomenon in which the students gain ownership of their learning and can set the pace of their learning. However, she admitted that allowing the students to take the lead can be difficult for teachers who are used to being the "sage on the stage" and controlling the pace of learning in their classrooms. She explained: "It's student-led. And I really believe that it is what is best for kids. That doesn't mean it's what's easiest for teachers, but that's not what our job is meant to be anyways." *Anne* also thought that students being at the helm of their own learning in STEAM benefitted their ability to manage their own pace of learning. She noted:

> I think because STEAM is, so student driven, and student centered, that the students that we have now are not the students that we were when we were in school. They want the technology, they want fast paced learning, they want to be thinking about problem solving the fastest way, and STEAM allows that for them.

Claire spoke more of the ownership the students gained through leading their own learning processes and claimed, "I think it's a great way of teaching and a great way of learning for the kids and for teachers as well."

Teachers expressed the opinion that the unique and non-traditional structure of the STEAM year-long investigation added to the beneficial nature for the students and their academic advancement. The customized approach, necessary for the implementation of STEAM in their classroom, facilitated the development of beneficial habits of mind in their students such as: ownership of learning, problem-solving skills, meaningful connections through experiential learning, real world application, and demonstration of knowledge in their PBL nontraditional learning environments.

Dorothy recalled one important moment where she recognized how advantageous STEAM implementation was during a STEAM meeting: "I remember we were in a grade level meeting or in a state meeting and a question was simply asked for us to think about: What is best for your students? And that was a major milestone for me." The uniqueness of not being the provider of information, but rather the facilitator of discovery, was also noted as being beneficial for the students. *Elizabeth* shared "I think STEAM is a good thing because kids have to learn how to figure it out rather than being told what to do. They need to know how to do it, how to be a solver." *Frances* discussed the sustainability of STEAM based upon the advantages for students, "I think this STEAM is here to stay based on our workforce constructed on what these kids need when they exit school. I hope STEAM is here to stay because these are the careers that these guys are going to have as they're exiting high school." *Ginny,* who teaches Kindergarteners, recognized the benefits of STEAM in her young students:

> They're able to really explore through their own way of learning instead of me being like, oh, here's what you must do or here is what you have to write. This exploration slows them to openly express themselves and that gives them a lot of ownership to their learning. It makes them proud of what they have learned.

Claire suggested the nontraditional approach of utilizing the outdoor spaces, gardens, and learning communities were central to why she believes STEAM benefits her students' academic growth because they take responsibility for the "living things" they are researching through their PBLs. *Claire* explained:

> Each grade level has different living things that they are in charge of and take care of. We raise chicken, fourth grade has fish in their aquaponics watering system, and second and third grade have vegetable gardens. So, the kids take care of both plants and animals which the kids know are their living things.

Claire offered that student responsibility grows with STEAM which could benefit them throughout their academic careers and beyond. "They have a job to do and their job is to take care of these chickens." She believed she was instilling a sense of pride by assigning STEAM "jobs" that grew their sense of responsibility in their own learning experiences. She explained, "They have to support these living things and that gives them the sense of responsibility and duty that they need to develop even at these young ages."

Student benefits were also attributed to the need for the students to be innovative and "out of the box" thinking. *Dorothy* offered that she witnessed such efforts lead to unexpected student gains: "one thing that I noticed was that STEAM allows for those students that have not been identified as strong academic students to advance by approaching the lesson in a creative or unusual way." According to *Dorothy*, STEAM afforded opportunities for all students, regardless of their academic ranking, to be involved in discovering, designing, and creating their own solutions and connections which created opportunities for success. She attributed this "leveling of the playing field" is due, in part, to the creative hand-on approach that STEAM lessons make more “real life” to all of her students versus solving mathematical problems on worksheets that the students did not have any real-life connection with. She gave an example:

> A real-life connection is the change I see; such as measuring, designing gardens, and figuring out the right spacing in our garden so the plants will grow is real to all the students. Not just the high achievers. They can use all kind of mathematical ways to figure that problem out so it is not limited to paper and pencil.

Bette agreed, explaining STEAM “opens up school to be a good place for atypical learnings because lots of times your atypical learners don’t fit into your regular curriculum.”

The learning that was facilitated in the PBL projects also required students to work collaboratively. For example, when *Claire* was asked what made the most sense to her about STEAM education, she was clear: “What makes the most sense for me? Ah, the teamwork and collaboration.” *Ginny* agreed that teamwork leads to meaningful learning activities and experiences: “student success to me is when the students are working together in an authentic learning and exploring together.”

Participants explained teamwork was not always easy and there were disagreements especially considering the young age of these students who are still developing their own personalities and social skills. However, as *Frances* acknowledged, learning to work together was important and beneficial for all students regardless of age: “STEAM promotes the idea that you're going to work with different people that may not think the same way that you think. But you still have to work together. I definitely think STEAM helps with that.”

Socially Constructed

The understanding that STEAM implementation was shaped socially within the collaboration among the teachers, students, and community partners to alter instructional practices was evident in the interviews and PMMs. This collaboration, however, was not always a seamless and easy process. *Bette* spoke of this during her interview: “STEAM can be hard. We had a lot of tears from teachers during our certification process.” Regardless of the struggles, the participants shared they depended on collaborations and teamwork to realize, support, and sustain STEAM education in their classroom settings.

For example, the participants depended on their grade group meetings and administrator input to find the right balance between “student choice and voice” while still ensuring that the grade specific content standards are addressed. *Claire* who began her teaching career in this STEAM school still wrestles with making sure her students are meeting their standard based learning goals: “they love our PBL and going out to the gardens and I see a lot of growth, but I still have to make sure that they can read proficiently and there are only so many books about gardens.” Other participants explained too that student “choice and voice” is great but sometimes you have to rely on other teacher-led initiatives to meet the standards. They discussed these and other complexities of STEAM education in their collaborative meetings to gain support and clarity. *Anne* explained, “The teamwork and the collaboration between me and my grade level helped a lot. I had to rely on them a lot and it was good to learn from each other.”

One way the participants maintained their schoolwide STEAM cohesiveness through their personalized and unique classroom STEAM goals is through the adoption of a schoolwide EDP graphic (see Figure 4). This customized graphic was collaboratively created by the STEAM educators on campus during the certification process and was subsequently adopted schoolwide. *Ginny* explained “We have our own engineering design process posted in our classrooms and all around our school to familiarize the design process. We created our own so that it was more meaningful for our students at our school." This collaboratively designed graphic illustrates the socially constructed process of EDP specific to this school setting.

The participants shared that successful STEAM implementation also required a collaborative review of how the disciplines could be authentically integrated. This was accomplished through scheduled STEAM grade level, school level, and district level meetings which were crucial during the certification and after certification. Additionally, professional development opportunities have been offered to the STEAM educators to promote collaborative efforts with other STEAM educators regionally and statewide.

Participants spoke of their growth from the professional development opportunities and STEAM meetings they participated in during the certification process. *Ginny* included "training and support" on her PMM. She explained:

> Well, we had to learn as well as the kids. I didn't know anything about chickens so I had a lot of questions. Questions not just about chickens but about, of course, STEAM. I wanted to know how to integrate the disciplines. To me, it all leads back to collaboration and having a strong STEAM committee that we could always reach out to.

Other participants spoke of county administrators coming to consult and collaborate on STEAM PBL efforts. This district "teamwork" helped *Frances*, who noted: "The County STEAM person coming and helping us come up with ideas and working with our team to make the right disciplinary connections was super important for our PBLs. I learn something new every time we meet with her." The participants believed that inquiry-based learning requires an adoption of a schoolwide, even districtwide, culture of collaboration to develop and sustain their PBL to meet the needs of the students' learning goals. Additionally, they expressed these meetings and collaborations concerning their PBLs should be on-going to maintain their STEAM learning goals and successes. *Bette* shared that collaboration within the school and within the district is key to helping teachers implement STEAM. She explained: STEAM comes naturally to kids. It just doesn't come naturally to teachers because we compartmentalize. It's harder on teachers."

Transdisciplinary Learning is Crucial

The final emerging theme centered on the importance of transdisciplinary learning in their setting. Specifically, with respect to STEAM education, Herro et al. (2017) considered transdisciplinary learning as requiring the incorporation of an overarching idea or problem that holds bearing to student's lived experiences embedded within the learning. Although not always referring to it by name, most participants expressed that the principles of transdisciplinary learning were important in STEAM education. According to the participants, STEAM experiences that connect students' knowledge and skill sets to real world problems or projects that are meaningful, relevant, and significant to the students is crucial to the success of STEAM.

All participants indicated STEAM education was most effective when the students' interests were central because the personal relevancy and meaningful connections in transdisciplinary learning sustains student engagement and motivation. The participants shared that in order to gain these relevant and personalized connections they relied upon students' "voice and choice' driving STEAM education experiences. For example, while looking at her PMM (see Appendix H) *Bette* elaborated on her term of "Student Curiosity Led." *Bette* explained that her STEAM instruction all goes back to "student voice and choice" She clarified, "every time I do a STEAM lesson or unit, or it is based on student curiosity." She gave the example that her class was currently looking at the phenomenon of climate change and how that affects whale populations. "I had one student that was really into whales and he shared his excitement with the class and now we have *Whale Wednesday* each week which I use for student buy-in for STEAM education."

Elizabeth explained the CER approach to STEAM assures transdisciplinary learning in her experience. "I love CER because the kids have to state what they believe, show evidence as to why they believe that, and then reason through the results. They really care about their claims and take it personally." Once they are personally involved in CER concerning a relevant phenomenon or problem she claimed, "that is when you see them becoming more of critical thinkers."

The data revealed a transdisciplinary approach was viewed by some as enriching student knowledge in unique and nontraditional means. For instance, the photograph (see Appendix I) *Dorothy* chose shows students developing their personal artistic proclivities through the art of Gyotaku. Gyotaku, a form of printmaking using fish, is an art integration strategy she chose that was unique and customized to their PBL. *Dorothy's* chosen image pictured students looking at and emulating the artistry of Gyotaku which allowed them "to use their own individual interpretation of Gyotaku art and design to paint their fish in their personal style." The students cared personally about the fish in their compositions because their annual PBL was centered in aquaponics. *Dorothy* identified that art processes offer students the ability to create representations of the knowledge they have gained through their annual STEAM PBL as "their personal and creative skills begin to develop."

Two participants, *Ginny* and *Elizabeth* also shared examples of how art was integrated into their PBLs which promoted meaningful connections. *Ginny* highlighted this in her chosen photograph (see Appendix I) showing the culminating activity in which the students used their knowledge gained from their annual PBL to perform a play. She described how the play was used: “to wrap up our investigative research by letting the kids retell everything that they learned.” She explained: “So this shows their personal and meaningful connections and expressions of their learning processes through this culminating activity.”

Because *Elizabeth*’s class documented the process of the loofah growing seasons through drawing observational pictures, as shown in *Elizabeth’s* photograph (see Appendix I), she explained that the students took great care to draw the garden realistically to show the details concerning what was happening. “We were not perfect at growing loofahs and some of them rotted like in this picture. But that did not keep the kids from being excited about their crop and adding details to their drawings.”

As *Elizabeth* experienced, inquiry-based learning such as EDP, CER and PBL experiences do not always lead to intended outcomes but to perceived “failures” which *Dorothy* claimed actually increased problem solving capacity and increased personal connection to the phenomenon of study. However, to make these gains educators must learn to become comfortable with allowing learning to progress down a pathway they believe may lead to failure. This is counterintuitive to many teachers.

Dorothy explained during her interview that her class had been “plagued” with significant STEAM failures concerning their annual PBL. Their aquaponics watering system struggled with a slime mold condition which they tried to rectify by introducing sucker fish to the tank. When this failed they collaborated with a community partner who had expertise in the field to come and help them diagnose and solve the problem. The initial diagnosis failed as well so they had to reconvene to continue to research and find the right solution. *Dorothy* shared though there was a great deal of frustration throughout the process, the students stayed committed to solving the problems and when finally, successful; “they were very, very happy to show every visitor and parent the tank and explain their struggle and successes." Ownership of their problem, which was personal and significant to the students, sustained their application of knowledge and skills and helped shape their learning experience significantly.

As *Dorothy's* example showed, this transdisciplinary approach to STEAM can productively involve community partners. The students' connection and collaboration with the aquaponics expert helped deepen their investment in their PBL. *Dorothy* shared, "working with the aquaponics expert helped the kids feel like their fish and aquaponics tank was important. Not just to themselves, to people outside of our school. That was cool to watch."

Teachers also benefit from collaborative efforts when implementing transdisciplinary STEAM learning practices (Khine & Areepattamannil, 2019). Participants discussed collaborative efforts that led to relationship building and enhanced communication within their school setting. For example, *Ginny*, who teaches Kindergarten works directly with the other teachers on campus to recruit her prior students back to her classroom during garden activities. These former students help instruct by sharing their experiences and knowledge with her current students which sustains and grows STEAM knowledge and personal connections to "their gardens" for all parties involved.

Summary

The collective conceptualization from the data in this case indicated that the participants believed that STEAM education is a uniquely different approach to instruction which is beneficial for student success in the 21st-century landscape. The data also showed STEAM education in this setting to be a socially constructed phenomenon that is most effectively implemented in a transdisciplinary manner using non-traditional, inquiry-based strategies, and placing students at the center of learning. The data resulted in construction of intersubjective knowledge which could impact STEAM education by helping to form a common conceptualization and a more comprehensive vision for STEAM education in this elementary school setting.

CHAPTER V: DISCUSSION

The problem driving this descriptive case study is that the extant literature does not fully address how elementary educators conceptualize STEAM education (Herro et al., 2017). While guiding principles of STEAM have been offered, the literature supports that a comprehensive explanation of what STEAM implementation looks like in the classroom or how teachers should engage in the instructional practices has not been realized (Jamil et al., 2017). If STEAM education is considered a necessary means for students to be successful within the 21st-century global society, then understanding what STEAM education looks like in the elementary classroom setting, according to the educators implementing STEAM education, is significant. The research question guiding this study is best answered by providing a detailed case summary.

Case Summary Details

In the construction of the case that is the subject of this study, I focused on uncovering the intersubjective knowledge concerning STEAM education in the elementary classroom setting. This aligns closely with the lens of social constructivist learning that framed the study. This framework assumes conceptualizations of realities are formed from intangible mental constructions that are socially and experientially based (Lincoln & Guba, 2013). As the implementers of STEAM education in their classrooms, the participants have conceptualized STEAM as an internal process of thoughts that produce new ideas or knowledge (Sequeria, 2014).

My purpose for researching elementary educators' conceptualizations of STEAM education was to investigate the participants' individual conceptualizations and sensemaking to form intersubjective knowledge that could be used to foster an improved understanding concerning STEAM education in this case. Intersubjectivity is considered the process whereby participants who begin a task with different understandings arrive at a shared understanding (Newson & Newson, 1975).

Overall, in this case, the participants arrived at a shared understanding that STEAM education was not an educational philosophy or even a dominant instructional strategy, but rather a purposeful approach to experiential learning centered around a relevant phenomenon of study or problem that were significant to the students. STEAM education, in this case, was ultimately shaped by the schools' framework for STEAM education adoption and implementation. Within the state, approaches to STEAM education are individualized to each school environment and therefore, lead to personalized implementations by respective administration, teachers, district leaders, and other stakeholders.

In the current case, the schools' rural location in an agricultural and farming community established the overarching context for STEAM education. Within this agricultural context, the teachers and school administrators collaboratively developed yearlong investigations that were appropriate for grades K-4 and could be used to incorporate the grade appropriate standards required by the state. Each phenomenon of study or problem was relatable to the students and their surroundings, appropriate for inquiry instructional strategies (PBL, CER, EDP), and utilized the nationally agreed upon practices of science and engineering. Driving these investigations were the interests of the students, thereby incorporating a transdisciplinary approach to learning. While the results of this study revealed intersubjective knowledge specific to these participants and their setting of a STEAM certified school in Georgia, the findings can be used to better understand the complex phenomenon of STEAM education in the elementary classroom setting for other concerned parties by examining the findings revealed in this case study.

Shift in Instructional Practices

The finding that almost all participants indicated they had to shift their instructional practices aligns with the literature. STEAM implementation in the classroom requires the teacher to "place the students at the intersection of learning, critical thinking, exploration, and deepening of understanding" (Khine & Areepattamannil, 2019, p.165). This finding makes sense because educators from all disciplines are experiencing significant systematic change in educational strategies and practices to meet the challenge of preparing their students to be viable in the world's competitive market (Sabol, 2013).

The teachers in this case acknowledged that STEAM implementation required a switch from their more traditional role of "sage on the stage," where they acted as the dispenser of knowledge to students that were blank slates. This shift to a more student-centered approach is a departure from strategies that are more mainstream in education and focus on direct instruction, guided learning, gradual release of responsibility, and the concept that learning should be pre-packaged for easy assimilation. STEAM as conceptualized in this study aligns with the concept of discovery learning offered by Jerome Bruner. Bruner believed that discovery "includes all forms of obtaining knowledge for oneself by the use of one's own mind (Bruner, 1961, p 21).

Moon (2020) explained this shift from teacher-directed to teacher-facilitated is not just a significant change for educators but also for the students. The author offered that STEAM educators do not have to change the standards or what the students need to know, but use STEAM to create learning environments and experiences where the students learn the standards through real word application. In this case, the participants explained that the uniqueness of their specific PBL, CER, and EDP approaches requires many customized shifts in instruction and learning for both teachers and students to meet their STEAM goals.

The understanding that STEAM implementation, as conceptualized herein, requires a different approach to instruction on the part of the teachers, administrators and students is relevant especially in the light of rigid accountability measures that pervade United States public education. On the tensions between addressing uniformed standards and incorporating student-centered teaching, Deboer (2002, p. 415) offers, "There is considerable evidence that, although well-intentioned, standards-based education has created impediments to student-centered teaching and learning while at the same time it has reduced the autonomy and creativity of classroom teachers." Acknowledging that systematic shifts throughout all layers of the system may be required in any given situation, may serve as a roadmap for other schools desiring to explore STEM or STEAM in their settings.

Beneficial for Student Advancement

While acknowledging struggles along the way, the participants uniformly agreed that placing the students at the core of the learning, allowing failure to drive innovation and motivation, and fostering collaboration among age groups that sometimes struggle with such collaborations was ultimately beneficial for the student learning. In this manner, STEAM education was beneficial to students because STEAM education provided opportunities and experiences that built content knowledge and developed 21st century skill sets necessary for the 21st century landscape.

The conceptualization by the teachers that STEAM is beneficial for student advancement aligns with previous conclusions in the literature. Hunter-Doniger & Sydow's (2016) research investigating the benefits of STEAM education in the secondary school setting found 93% of middle school teachers involved in their longitudinal study believed that the STEAM curriculum benefited students. As the data accumulate supporting the idea that STEAM is a beneficial pedagogical approach, this study might encourage other districts and educators to investigate the benefits of STEAM education in the elementary classroom.

Similar to the existing literature, the participants identified key components of STEAM that formed the basis of their shared conceptualization, including inquiry and meaningful problems. Yakman (2012) cited students' experiential learning experiences centered around their phenomenon of study as resulting in increased student ownership of their learning. Margot and Kettler (2019) considered the student benefits were a product of the open ended, student led problem solving approach of STEAM, which is critical for building 21st century competencies and for fostering collaborative skills necessary for the workforce. As students enter the workforce, they will encounter problems that will require more than aptitude in science, technology, engineering, and math disciplines but necessitate problem solving processes and application of understanding in experiential learning environments that STEAM education supports (Land, 2013; Shernoff et al., 2017).

One reason the participants believed STEAM was beneficial for student advancement was the real-world application of content knowledge during PBL, CER, and EDP processes. The participants made accounts of how students' experiential learning experiences centered around their phenomenon of study resulted in increased student ownership of their learning which is in alignment with the literature (Yakman, 2012). Such hands-on experiences also required collaboration and teamwork involved in discovering and creating their own solutions to problems.

Proponents of STEAM, such as the participants, believe that the open ended, student led problem solving approach of STEAM is critical for building 21st century competencies and for fostering collaborative skills necessary for the workforce (Margot & Kettler, 2019). As the participants discussed, as students enter the workforce, they will encounter problems that will require more than aptitude in science, technology, engineering, and math disciplines but necessitate problem solving processes and application of understanding in experiential learning environments that STEAM education supports (Land, 2013; Shernoff et al., 2017). Student benefits are also derived from the incorporation of creative thinking, including design thinking. Research suggests that such approaches serve to engage learners through an iterative cycle of design, and redesign that promotes student engagement and deeper understanding of the problem or project of focus (Gess, 2017; Gross & Gross, 2016).

Socially Constructed

The realization that STEAM is a socially constructed phenomenon, as in this case, could promote collaborative efforts, relationship building, and enhanced communication within a district, school, and/or classroom setting while adopting and/or implementing STEAM education (Ghanbari, 2015; Moon, 2020). Social constructivism teaches that all knowledge develops because of social interactions, and is a shared, rather than an individual experience (Lincoln & Guba, 2013). Considering a constructivists' lens, this finding make sense because the participants explained how STEAM education is a collective phenomenon that: "consists of those constructions about which there is relative consensus (or at least some movement toward consensus) among those competent (and, in the case of more arcane material, trusted) to interpret the substance of the construction" (Guba & Lincoln, 1994, p. 113).

Khine and Areepattamannil (2019) explained that STEAM is dependent on substantial and sustained collective efforts among all constituents to construct STEAM practices. STEAM can be considered a form of social practice among the teachers, students, administrators and other stakeholders (Guyotte et al., 2014). The participants conceptualized STEAM education as a socially constructed phenomenon where teachers act as facilitators and/or guides that must shift their instructional practices from teacher centered to student centered.

The findings also emphasized that the collective understanding of STEAM in this case was dependent on consistent and sustained collaborative efforts and teamwork. Emphasizing teamwork over individuality was defined by Kasza and Slater (2017) as a process by which individuals negotiated and shared meanings related to a problem-solving task. Teachers require time, patience, and collaborative support to feel safe enough in STEAM implementation to take the risks that allow their students to forge the learning path (Moon, 2020). This finding may push educators to set the stage where teamwork and collaboration was an intentional activity to sustain a collective conception of STEAM education. These collaborative opportunities build co-ownership of STEAM learning goals and outcomes within their school district and beyond (Holmlund et al., 2018; Radziwill et al., 2015).

Transdisciplinary Learning is Crucial

Finally, the awareness that STEAM education in practice should ideally focus on world problems or projects significant to the students via a transdisciplinary approach, could help districts, schools, classroom educators, and/or stakeholders identify relevant and significant emphasis for personalized STEAM application. Transdisciplinary learning is driven by the relevant connections that lead to authentic student driven questions, participation, collaboration, and involvement (Helmane & Briska, 2017). STEAM education was considered by the participants as a pathway to authentic and personalized learning environments and experiences that are intentionally utilized to achieve learning outcomes. As Scorse (2014) stated, the relevant connections to real world problems that were meaningful to the students was central to an effective integrated curriculum.

The data also revealed a transdisciplinary approach, which specifically incorporates the arts in personal ways, enriches student knowledge in unique and nontraditional means. Dewey (1934) claimed applying aesthetic and arts-based practices as an integral part of learning create enriched and meaningful experiences which are central to transdisciplinary integration. Several participants spoke of art processes and experiences that deepened the connection to the problem or project in focus. Integrating the arts in STEAM education purposefully allows for a sense of personal accomplishment for students as they gain the desired multicurricular connections (Scorse, 2014). Arts integration in STEAM during this case study also highlighted students' unique abilities in expression, which play a critical role in the development of the mind (Blanken-Webb, 2014).

Acceptance of student failure in STEAM education is also considered an important aspect of the student-centered transdisciplinary approach to PBL and EDP (Stein & Muzzin, 2018). The participants explained that such "failures" are opportunities to expand intellectual growth and help develop skill sets. When failure occurs, students ask questions, consider new ideas and solutions, and can develop a critical thought process that considers new approaches to the problem (Stein & Muzzin, 2018).

The transdisciplinary approach to STEAM also involves meaningful and relevant connections outside the classroom. The participants explained that their agricultural based STEAM approach involved members of the community and other stakeholders' involvements. Community outreach and advocacy not only fosters growth in content knowledge and application but also grows emotional and empathetic connections with off-campus stakeholders (Segarra et al., 2018).

Relation to Conceptual Framework

Sociocultural theory is grounded upon the premise that social experience shapes the way one thinks and interprets their world (Vygotsky, 1978). This study employed the sociocultural lens to gain understanding how the participants conceptualize STEAM education as they make sense of the dynamic and complex phenomenon within the setting of their classrooms and school. The process of teaching is a dynamic and fluid experience where individuals utilize their own identity, experiences, and cultural belonging to make sense of their situation (Vygotsky, 1978). The process of sensemaking starts when one perceives a change or disruption to the status quo. Sensemaking is an evolving effort to construct organization of one's conceptualizations to address the disruption. As stated by Spurgin (2009):

> Sense-Making assumes that each individual is the expert on his own world, or experience of it. Since each individual is involved in developing strategies for bridging his own gaps, each individual consciously or unconsciously theorizes why certain strategies are appropriate or useful for him. (p. 103)

In this study, the participants' sensemaking efforts began during the STEAM certification process and continued with the implementation of yearlong projects in their classroom setting. While sensemaking the participants designated certain aspects, ideas, and requirements of STEAM they deemed essential to make their account of STEAM plausible. The creation of a "plausible story" (Weick et al. 2005, p. 410) provides the implementer a way to reconcile the various requirements, aspects, and other ideas associated with a proposal for change within their current situation.

The "plausible story" formed from the findings of this descriptive case study is that STEAM education in the elementary classroom setting is a distinctively different approach to instruction which is beneficial for student success in the 21st century landscape. This approach, however, is not necessarily a replacement for other modes, such as expository instruction, but rather a supplement. Teachers still need to address specific standards and learning objectives that are not easily incorporated into the question driving the PBL. The participants' "story" conveyed that STEAM education is socially constructed and most effectively implemented in a transdisciplinary manner. The "story" of these participants provided meaningful insight concerning the aspects, ideas, and requirements of STEAM education implementation which could serve as a functioning guide for other educators interested in STEAM education implementation.

The "story" is reliant on the context in which STEAM was implemented in this setting. In this case, the schools' rural location in a farming community shaped STEAM education implementation. The STEAM focus by which the school made the required state standards meaningful was agriculture, which is something that is real and known to this population. As a framework for STEAM implementation, the school adopted a schoolwide agricultural investigative research approach by utilizing eight practices of science and engineering identified in the *Science and Engineering Practices in the NGSS* (2013). Understanding the specific topical framework that will engage the students, enhance participation, and apply the standards meaningfully is essential to a successful STEAM program. Not every school is going to adopt this specific application but must designate their personalized application after considering their collective characteristics.

Analysis of the Findings

The intersubjective knowledge as to what constitutes STEAM education according to these teachers led me to the realization: This is their story. Other elementary STEAM educators at other STEAM certified schools will have their own story. Although there have been researchers advocating for the development of a conceptual model of STEAM education (Katz-Buonincontro, 2018; Margot & Keller, 2019), the data herein suggest individualized conceptions may be more appropriate. Breiner et al. (2012) offer:

> We do not need a common conceptual model but a framework upon which to construct your own conceptual model. However, while it is probably necessary for stakeholders within a certain STEM initiative to have a common conceptualization, caution should be paid as the many initiatives across the nation are probably too varied to be placed into too narrow a framework. It is important for best practices to be shared, but a one-size-fits-all approach is not likely to work with each STEM initiative's strengths (p.10).

Though a universal model of STEAM may not be possible or even desirable, the analysis of the findings demonstrated that a STEAM education framework may be appropriate. This case study identifies three formative and foundational facets at the core of this framework: culture, change, and context.

Culture relates to the idea that effective STEAM education requires a collaborative infrastructure among all the constituents that needs to be sustained and not just associated with the initial initiative (Holmlund et al., 2018; Herro & Quigley, 2017). Such collaboration over the long term requires both nourishment and support from all parties. Rolling (2017) believed this collective culture is essential for developing shared understandings and establishing common STEAM goals. Holmuld et al. (2018) also suggested the culture of STEAM needed to be actively cultivated through the process of "sensemaking as a collaborative, reflective, and iterative process that can surface the differences and commonalities of people's understandings to better ensure consistency" (p.17). Regardless of the process STEAM schools may employ to establish a shared culture, the collective beliefs, knowledge, goals, and ideas should be established before any efficacious transformation can occur.

The second facet was the acceptance, and ultimate execution, of change. In most situations, STEAM requires educators to shift to a student-centered approach where they facilitate student learning. Such change is not always easy, and in fact remains difficult to incorporate into practice, particularly in urban, high-poverty settings (Corkin et al., 2018). Another factor working against change is the understanding that the adoption of new strategies and instructional practices requires training and support. The literature does suggest that teachers need support to develop the self-efficacy necessary to teach in a manner that is divergent from the mainstream (Gess, 2017; Margot & Kettler, 2019; Stein & Muzzin, 2018). In a case study by DeJarnet (2018), both the sociocultural perspective and the social learning theory were utilized to examine two elementary teachers implementing STEAM learning experiences. The purpose of the study was to gain understanding of the impact of support through varied resources on the teachers' self-efficacy specifically in their implementation of STEAM education. The results showed that teachers' self-efficacy in STEAM implementation improved when provided professional development and consistent support (DeJarnet, 2018).

Finally, the facet of context should be considered. STEAM education is a complex phenomenon that is socially constructed and evolves over time specific to the setting and situation (Brown, 2012; Holmlund et al., 2018). Schools must discover and curate their own specific context that is sensitive to both a sense of place and the resources that are available. What is the "place" that STEAM learning is embedded within? This will drive investigations and problems of interest to students and that connect to their prior experiences. Similarly, understanding what your context provides with respect to external resources and professionals, helps demonstrate the real-world connections of the school activities.

The existing literature does not address how elementary educators conceptualize STEAM education. Perhaps because STEAM education is a complex phenomenon and every conceptualization or "story" is reliant on: creating a collective culture, implementing change, and cultivating context. Then you have your own intersubjective knowledge base.

Delimitations and Limitations of the Study

The delimitations of this study were set through the binding of this descriptive case study. The binding provided boundaries for the phenomenon of study and helped avoid the problem of a research study that is too wide-ranging and unclear (Baxter & Jack, 2008). The descriptive case study was bound within the context of a STEAM certified elementary school in a school district in Georgia to explicitly examine the phenomenon of STEAM education within that specific setting. The study investigated the phenomenon solely through the lens of classroom educators that are actively implementing STEAM education within their classroom setting to gain a deeper understanding of this certain phenomenon.

Additionally, as Spurgin (2009) cautioned, every researcher views their study subjectively through the lenses of their own experiences, biases, philosophies, identifications, and instincts. My epistemological position as an art educator holds the potential for problems such as reactivity, selection biases, availability, and reliability. However, as Naddin and Cassell (2006) explained, a researcher can implement potential methodology avenues to combat bias within the stages of research such as a research diary and triangulation of the data which were both employed. Additionally, my reflexivity was bolstered through my adaptation of Peshkin's (1988) *Subjective I's* to combat both objectivity and subjectivity.

The findings of this study were subject to at least two limitations. The first limitation was the period of history in which the study was conducted. The COVID-19 global pandemic and all factors included may have influenced the descriptive case study's outcome. The conceptual framework of this study is centered on the participants' conceptualizations of realities which are formed socially and experientially. The pandemic has altered education in innumerable means therefore, it is plausible that the cultural and social circumstances of the pandemic could have affected the participants' conceptualizations of STEAM education in their classroom settings.

I chose a smaller sample size which is acceptable in qualitative research, but a larger sample size may have yielded more nuanced data (Yin, 2009). Additionally, the study drew participants from the same STEAM certified elementary school. This limitation was partially addressed by the purposive sampling of teachers from all grade levels in the case to maximize diversity. According to Cypress (2017), both purposive sampling and an inductive approach does improve the transferability of the results. The sample does necessarily represent other STEAM elementary educators, but transferability is not necessarily contingent on a true representative sample but "it is how well the study has made it possible for readers to decide whether similar processes will be at work in their own communities by understanding in depth how they occur at the research site" (Lodico et al., p. 173, 2010). However, to advance the transferability, recruitment of participants from various STEAM certified elementary schools may have presented additional insights and information concerning the conceptualizations of elementary educators implementing STEAM education in their classroom setting.

Recommendations for Future Research

Sensemaking is considered a communication-based tool designed to conceptualize knowledge and information to bridge gaps between institutions and the public they serve

(Dervin, 1998). The sensemaking of the participants in this study resulted in the formation of intersubjective knowledge concerning the phenomenon of STEAM education in their classroom setting. This study serves as one step in the formation of collective knowledge concerning the phenomenon of STEAM. As evidenced from the data however, there is a need to complete additional qualitative studies to see how the themes that arose in this case study manifest in different settings, particularly different contexts. How do differing levels of culture, change and context shape the conceptualizations of STEAM education in the classroom setting?

Future studies could also focus on investigating teacher efficacy in STEAM education, and what specific supports help with increasing efficacy. Teacher efficacy involves not only the individual component of self-efficacy, but also a collective component. These work in synergy and affect not only a teacher's ability to be a motivated and accomplished educator, but also student achievement outcomes (Morris et al., 2017). If STEAM education is considered a necessary means for students to be successful within the 21st-century global society, understanding the contributions and impacts to teacher efficacy with respect to implementation is vital.

All STEAM stakeholders must consider both the short- and long-term implications of adopting STEAM education implementation. Therefore, recommendations for future research concerning teacher efficacy in STEAM education could also involve longitudinal studies. This case study was limited in time therefore, longitudinal studies involving STEAM educators in STEAM certified elementary schools over longer periods of time could contribute meaningfully to the body of intersubjective knowledge concerning the phenomenon of STEAM education.

Implications of the Study

The data from this study could potentially be used for improved implementation and practice of STEAM education by sharing the intersubjective knowledge realized in this study to help build a more comprehensive understanding for collective vision for STEAM education in other settings. As Holmlund et al. (2018) suggested, educators and stakeholders within the same school district should "explore the common elements that are being attributed to STEM education and co-construct a vision that provides opportunities for all their students to attain STEM-related goals" (p. 17). Diagnosing your key concepts, categories, and collective conceptualizations for your school and/or district specific to your implementation of STEAM education can result in a map, or a vision, that provides opportunities for all parties to reach STEAM-related goals.

The intersubjective knowledge gained from this study has implications for educators and districts implementing STEAM education by serving as a starting point for their own personalized approach to STEAM education implementation. The concepts, categories, and collective conceptualizations from this data can be used as tools for STEAM advancement including, but not limited to: (a) implementation of effective STEAM-related teaching practices to help booster both teacher and collective efficacy concerning STEAM; (b) fostering professional development and training in specific aspects of STEAM that help educators shift their instructional practices effectively; (c) promoting training on how to specifically integrate the STEAM disciplines through a transdisciplinary approach; (d) supporting STEAM educators professional learning communities by allotting common planning time and plenty of opportunities for collaborations so STEAM can be constructed socially; (e) empowering educators and other stakeholders to recognize and experience STEAM education as a unique approach to instruction which can be considered beneficial for student advancement and success in the 21st century landscape. These steps could help grow and develop a clear vision for STEAM education with attainable objectives leading to STEAM success.

Conclusion

Sabol (2010) noted, “People living in the 21st century face a confluence of unique changes, opportunities, and possibilities that have never existed in the recorded history of human beings” (p. 3). Rapid growth and changes in technology, occupations, and globalization charge todays’ educators to find sufficient pedagogies to impart core competencies constructing adaptable and problem-based learners (Winthrop et al., 2017). Capabilities have increased by millions more than predicted and educators are ill prepared to match the needs of the learners to exist in a world that estimates that by 2020, 50 billion devices will be digitally linked and shaping the world on an instantaneous basis (Winthrop et al., 2017). Educators are charged with the implementation of instructional practices to ready their learners for the exponentially evolving environments and career paths of their 21st century future.

As educators strive to effectively prepare our students to apply both their content knowledge and gained skill sets to exist and thrive within the global community, STEAM education continues to emerge in the K–12 classroom setting as an effective means of achieving the necessary educational results needed to prepare students for the 21st century (Hunter-Doinger & Sydow, 2016). This descriptive case study findings offers intersubjective knowledge for enhanced collective knowledge of STEAM in the elementary classroom setting and develops the understanding that one, singular conceptualization of STEAM implementation in the classroom setting may not be an appropriate goal or target. Instead, the basic tenets of culture, change, and context need to be considered on an individual basis if STEAM education continues to progress as a widely used curricular approach for student success in the 21st century landscape.

References

Adams, M., Falk, J. H., & Dierking, L. D. (2003). Things change: Museums, learning, and research. In M. Xanthoudaki, L. Tickle, & V. Sekules (Eds.), *Researching visual arts education in museums and galleries: An international reader* (pp. 15–33). Kluwer Academic Publishers.

Allen, J., & Rogers, M. (2015). Formulating scientific explanations using the claim, evidence, and reasoning (CER) framework. *Science and Children, 53*(3), 32–37. http://kevincrumpscience.weebly.com/uploads/2/3/2/5/23258800/putting_ideas_on_paper_claims_evidence_reasoning.pdf

Allina, B. (2018). The development of STEAM educational policy to promote student creativity and social empowerment. *Arts Education Policy Review, 119*(2), 77–87. https://doi.org/10.1080/10632913.2017.1296392

Arts Education Partnership, Education Commission of the States. (2018). *ESSA and the arts.* Retrieved from https://www.aep-arts.org/essa/

Arts learning task force. Georgia Council for the Arts. (2021, November 24). Retrieved January 24, 2022, from https://gaarts.org/what-we-do/programs/arts-education/arts-learning-task-force/

Asselin, M. E. (2003). Insider research: Issues to consider when doing qualitative research in your own setting. *Journal for Nurses in Staff Development*, *19*(2), 99–103. https://doi.org/10.1097/00124645-200303000-00008

Bandura, A. (1977). *Self-efficacy: The exercise of control.* W.H. Freeman and Company.

Barbour, B. (2014). *Introducing qualitative research: A student's guide* (2nd ed.). London, England: Sage.

Barakos, L., Lujan, V., & Strang, C. (2012). *Science, technology, engineering, mathematics (STEM): Catalyzing change amid the confusion* (ED534119). ERIC. https://files.eric.ed.gov/fulltext/ED534119.pdf

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544–559. https://doi.org/10.46743/2160-3715/2008.1573

Bequette, J., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art Education, 65*(2), 40–47. https://doi.org/10.1080/00043125.2012.11519167

Berk, S. (2016). Designing for the future of education requires design education. *Art Education, 69*(6), 16–20. https://doi.org/10.1080/00043125.2016.1224844

Berland, L. K. (2013). Designing for STEM integration. *Journal of Pre-College Engineering Research*, *3*(1), 22–31. https://doi.org/10.7771/2157-9288.1078

Blaken-Webb, J. (2014). The difference differentiation makes: Extending Eisner's account. *Educational Theory, 64*(1), 55–74.

Brady, R., & Edelman, L. A. (2012). State of Create global benchmark study: Global benchmark study on attitudes and beliefs about creativity at work, school and home. https://www.adobe.com/aboutadobe/pressroom/pdfs/Adobe_State_of _Create_Global_Benchmark_Study.pdf

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Sciences and Mathematics, 12*(1), 3–11. https://doi.org/10.1111/j.1949-8594.2011.00109.x

Brown, J. (2012). The current status of STEM education research. *Journal of STEM Education, 13*(5), 7–11.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31, 21-32.

Bueno, O. (2013). Perception and conception: Shaping human minds. *Biosemiotics, 6,* 323-336. https://doi.org/10.1007/s12304-013-9170-z

Bush, S. B., & Cook, K. L. (2018). K–12 STEM and STEAM education in the United States: Vision and best practices. *Teachers College Record*, Article 22533. https://www.tcrecord.org/content.asp?contentid=22533

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30–35.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* SAGE Publications.

Committee on Prospering in the Global Economy of the 21st Century (U.S.), & Committee on Science, Engineering, and Public Policy (U.S.). (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* National Academies Press.

Committee of STEM Education of the National Science and Technology Council. (2018). *Charting a course for success: America's strategy for STEM education.* https://www.energy.gov/sites/default/files/2019/05/f62/STEM-Education-Strategic-Plan-2018.pdf

Conradty, C., & Bogner, F. X. (2018). From STEM to STEAM: How to monitor creativity. *Creativity Research Journal, 30*(3), 233–240. https://doi.org/10.1080/10400419.2018.1488195

Corbin, J., & A. Strauss. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. SAGE Publications.

Corkin, D.S., Coleman, S.L, & Ekmekci, A. (2018). Navigating the challenges of student-centered mathematics teaching in an urban context. *Urban Review, 51*. https://doi.org/10.1007/s11256-018-0485-6

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* SAGE Publications.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. SAGE Publications.

Creswell, J. W. 2008. "Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Third Edition". Pearson, NJ

Cypress, B. S. (2017). Rigor or reliability and validity in qualitative research: Perspectives, strategies, reconceptualization, and recommendations. *Dimensions of Critical Care Nursing, 36*(4), 253–263. https://doi.org/10.1097/DCC.0000000000000253

Daughtery, M. K. (2013). The prospect of an "A" in STEM education. *Journal of STEMEducation, 14*(2), 10–15. http://www.uastem.com/wp-content/uploads/2012/08/The-Prospect-of-an-A-in-STEM-Education.pdf

Deboer, G.E. Student-Centered Teaching in a Standards-Based World: Finding a Sensible Balance. *Science & Education* 11, 405–417 (2002). https://doi.org/10.1023/A:1016075805155

DeJarnett, N. K. (2018). Early childhood STEAM: Reflections from a year of STEAM initiatives implemented in a high needs primary school. *Education, 139*(2), 96–110. https://www.ingentaconnect.com/contentone/prin/ed/2018/00000139/00000002/art00006

Dell'Erba, M. (2019). *Policy considerations for STEAM education*. Education Commission of the States. Retrieved from https://www.ecs.org/wp-content/uploads/Policy-Considerations-for-STEAM-Education.pdf

Dervin, B. (1992). From the mind's eye of the user: The sense-making qualitative-quantitative methodology. In J. D. Glazier & R. R. Powell (Eds.), *Qualitative research in information management* (pp. 61–84). Libraries Unlimited.

Dewey, J. (1934). *Art as experience*. The Berkley Publishing Group. http//www.arteducators.org/research/art-education

Dewey, J. (1938). Experience and education. New York: Macmillan.

Dwyer, S. C., & Buckle, J.L. (2009). The space between: On being an insider-outsider in qualitative research. *International Institute for Qualitative Methodology, 8*(1), 54–63. https://doi.org/10.1177/160940690900800105

Eisner, E. W. (2008). The misunderstood role of the arts in human development. In B. Z. Presseisen (Ed.), *Teaching for intelligence* (pp. 111–122). Corwin Press.

Every Child Succeeds Act (2015). Retrieved from https://www.congress.gov/114/plaws/publ95/PLAW-114publ95.pdf

Falk, J. H. (2003). Personal meaning mapping. In G. Caban, C. Scott, J. Faulk, & L. Dierking (Eds.), *Museums and creativity: A study into the role of museums in design education* (pp. 10–18). Powerhouse Publishing.

Falk, J. H., Moussouri, T., & Coulson, D.C. (1998). The effect of visitors' agendas on museum learning. *Curator, 41*(2), 106–20. https://doi.org/10.1111/j.2151-6952.1998.tb00822.x

Flick, U. (2009). *An introduction to qualitative research.* SAGE Publications.

Foreman-Wernet, L., & Dervin, B. (2017). Hidden depths and everyday secrets: How audience sensemaking can inform arts policy and practice. *The Journal of Arts Management, Law, and Society, 47*(1), 47–63. https://doi.org/10.1080/10632921.2016.1229642

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education, 7*(24). https://doi.org/10.1186/s40594-020-00225-4

Ghanbari, S. (2015). Learning across disciplines: A collective case study of two university programs that integrate the arts with STEM. *International Journal of Education & the Arts*, *16*(7), 1–21. http://www.ijea.org/v16n7/v16n7.pdf

Gess, A. H. (2017). Steam education: Separating fact from fiction. *Technology and Engineering Teacher, 77*(3), 39–41. https://www.brightonk12.com/cms/lib/MI02209968/Centricity/Domain/30/STEAM%20Education%20-%20Separating%20Fact%20From%20Fiction.pdf

Georgia Council for the Arts. (2015). *Arts learning task force: Final recommendations to Governor Nathan Deal from the arts learning task force.* Retrieved from https://www.southarts.org/wp-content/uploads/ALTF-Report-Final-with-links-revised.pdf

Gettings, M. (2016). Putting it all together: STEAM, PBL, scientific method, and the studio habits of mind. *Art Education, 69*(4), 10–11. https://doi.org/10.1080/00043125.2016.1176472

Godin, B. (2008). Innovation: the history of a category [Working Paper No. 1]. *The Institute National de la Recherche Scientifique*. http://www.csiic.ca/PDF/IntellectualNo1.pdf

Glasersfeld E. von (1995) Introduction: Aspects of constructivism. In: Fosnot C. T. (ed.) Constructivism: Theory perspectives, and practice. Teacher College Press: 3–7. Available at http://www.vonglasersfeld.com/180

Glaw, X., Inder, K., Kabel, A., & Hazelton, M. (2017). Visual methodologies in qualitative research: Autophotography and photo elicitation applied to mental health research. *International Journal of Qualitative Methods, 16*(1), 1–8. https://doi.org/10.1177/1609406917748215

Guba, E. G., & Lincoln, Y. S. (1994). *Competing paradigms in qualitative research.* In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105–117). SAGE Publications.

Guyotte, K. W., Sochacka, N. W., Constantino, T. E., Walther, J., & Kellam, N. (2014). STEAM as a social practice: Cultivating creativity in transdisciplinary spaces. *Art Education, 67*(6), 12–19. https://doi.org/10.1080/00043125.2014.11519293

Graham, N. J., & Brouillette, L. (2016). Using Arts Integration to Make Science Learning Memorable in the Upper Elementary Grades: A Quasi-Experimental Study. *Journal for Learning through the Arts*, *12*(1), n1.

Greene, M. J. (2014). On the inside looking in: Methodological insights and challenges in conducting qualitative insider research. *The Qualitative Report, 19*(15), 1–13. https://doi.org/10.46743/2160-3715/2014.1106

Gross, K., & Gross, S. (2016). Constructivism, design thinking, and elementary STEAM. *Art Education, 69*(6), 36–43. https://doi.org/10.1080/00043125.2016.1224869

Harper, D. (2002). Talking about pictures: A case for photo elicitation. *Visual Studies, 17*(1), 13–26. https://doi.org/10.1080/14725860220137345

Hartle, L. C., Pinciotti, P. & Gorton, R.G. (2015). ArtsIN: Arts integration and infusion framework. *Early Childhood Education, 43*, 289–298. https://doi.org/10.1007/s10643-014-0636-7

Hatten, K., Forin, T. R., & Adams, R (2013). *A picture elicits a thousand meanings: Photo Elicitation as a method for investigation cross-disciplinary identity development* [Paper presentation]. ASEE Annual Conference and Exposition, Atlanta, GA, United States.

Hawari, A. D. M., & Noor, A. I. M. (2020). Project based learning pedagogical design in STEAM art education. *Asian Journal of University Education, 16*(3), 102–111. https://doi.org/10.24191/ajue.v16i3.11072

Helfferich, D., Dawe, J., Meyers, Z., & Tarnai, N. (2014). STEAM power: Inspiring students, teachers, and the public. *Agroborealis, 44*. Retrieved from www.uaf.edu/snre/research/publications/agroborealis/

Helmane, I., & Briskas, I. (2017). What is developing integrated or interdisciplinary or multidisciplinary or transdisciplinary education in school? *Signum Temporis, 9*(1), 7–15. https://doi.org/10.1515/sigtem-2017-0010

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-measure: Developing an assessment for student collaboration in STEAM activities. *International Journal of STEM education*, *4*(26). https://doi.org/10.1186/s40594-017-0094-z

Hudson, P. B. (2012). Practical insights into curricula integration for primary science. *Teaching Science, 58*(4), 47–50. Retrieved from https://www.asta.edu.au/resources/teachingscience

Hunter-Doniger, & Sydow, L. (2016). A journey from STEM to STEAM: A middle school case study. *The Clearing House, 89*(4), 159–166. https://doi.org/10.1080/00098655.2016.1170461

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K–12 contexts. *International Journal of STEM Education, 5*(32). https://doi.org/10.1186/s40594-018-0127-2

Jamil, F. M., Linder, S. M., & Stegelin, D. A. (2018) Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education, 46*, 409–417. https://doi.org/10.1007/s10643-017-0875-5

Jenkings, K. N., Woodward, R., & Winter, T. (2008). The emergent production of analysis in photo elicitation: Picture of military identity. *Qualitative Social Research*, *9*(3), 95–106. https://doi.org/10.17169/fqs-9.3.1169

Kang, N. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education, 5*(6). https://doi.org/10.1186/s41029-019-0034-y

Katz-Buonincontro, J. (2018). Gathering STE(A)M: Policy, curricular, and programmatic developments in arts-based science, technology, engineering, and mathematics education. *Arts Education Policy Review, 119*(2), 73–76. https://doi.org/10.1080/10632913.2017.1407979

Kasza, P., & Slater, F. (2017). A survey of best practices and key learning objectives for successful secondary school STEM academy settings. *Contemporary Issues in Education Research. 10*(1), 53–66. https://doi.org/10.19030/cier.v10i1.9880

Khine, M.S., & Areepattamannil, S. (Eds.). (2019). *STEAM Education: Theory and practice.*Springer.

LaForce, M., Nobel, E., King, H., Century, J., Blackwell, C., Holt, S., Ibrahim, A., & Loo, S. (2016). The eight essential elements of inclusive high schools. *International Journal of STEM Education*, *3*(21). https://doi.org/10.1186/s40594-016-0054-z

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science, 20,* 547–552. https://doi.org/10.1016/j.procs.2013.09.317

Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education. *Art Education, 69*(6), 44–49. https://doi.org/10.1080/00043125.2016.1224873

Lichtenburg, J., Woock, C., & Wright, M. (2008). *Ready to innovate: Are educators and executives aligned on the creativity readiness of the U.S. workforce?* The Conference Board. https://www.americansforthearts.org/sites/default/files/ReadytoInnovateFull.pdf

Lincoln, Y. S., & Guba, E. G. (2013). *The constructivist credo.* Left Coast.

Lodico, M. G., Spaulding, D. T., & Voegtle, K. H. (2010). *Methods in educational research: From theory to practice.* Jossey-Bass.

Maeda, J. (2013). STEM+Art = STEAM. *The STEAM Journal, 1*(1), 1–3.

Margot, K. C., & Keller, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *Journal of STEM Education, 6*(2). https://doi.org/10.1186/s40594-018-0151-2

Marshall, J. (2014). Transdisciplinary and art integration: Toward a new understanding of art-based learning across the curriculum. *Studies in Art Education, 55*(2), 104–127. https://doi.org/10.1080/00393541.2014.11518922

McClure, M., Tarr, P., Thompson, C., & Eckloff, A. (2017). Defining quality in visual art education for young children: Building on the position statement of early childhood art educators. *Arts Education Policy Review, 118*(3), 154–163. https://doi.org/10.1080/10632913.2016.1245167

McGarry, K. (2018). Making partnerships with STEAM. *Art Education, 71*(2), 28–34. https://doi.org/10.1080/00043125.2018.1414535

Medina-Jarez, W., Dambekalns, L., & Middleton, K. V. (2012). Art and science education collaboration in a secondary teacher preparation programme. *Research in Science & Technological Education, 30*(2), 209–224. https://doi.org/10.1080/02635143.2012.698603

Merriam, S. (2009). *Qualitative research: A guide to design and implementation* (2nd ed.). Jossey-Bass.

Moon, K. (2020). *A case study of the perceptions of education stakeholders of STEAM integration in a K–8 setting* [Master's thesis, Concordia University, St. Paul]. Digital Commons @ CSP. https://digitalcommons.csp.edu/cup_commons_grad_edd/449

Morris, D. B., Usher, E. L., & Chen, J. A. (2017). Reconceptualizing the sources of self-efficacy: A critical review of emerging literature. *Educational Psychology Review, 29*(4), 795–833. https://doi.org/10.1007/s10648-016-9378-y

Nadin, S., & Cassell, C. (2006). The use of a research diary as a tool for reflexive practice. *Qualitative Research in Accounting and Management, 3*(3), 208–217. https://doi.org/10.1108/11766090610705407

National Academies. (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. The National Academies Press.

National Academies. (2010). *Rising above the gathering storm, revisited: Rapidly approaching Category 5.* The National Academies Press.

National Academies. (2014). *STEM integration in K–12 education: Status, prospects, and an agenda for research.* The National Academies Press.

National Research Council (2003). *Beyond productivity: Information technology, innovation, and creativity.* The National Academies Press.

National Research Council (2011). *Successful K–12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* The National Academies Press.

National Research Council. (2013). *Next generation science standards: For states, by states*. National Academies Press.

National Research Council. (2014). *STEM learning is everywhere: Summary of a convocation on building learning systems*. National Academies Press.

Nelson, L. R. (2019). Eliciting a thousand words: A case for photo-elicitation in interpersonal communication research. *Qualitative Research Reports in Communication, 20*(1), 50–57. https://doi.org/10.1080/17459435.2019.1615979

Newson, J., & Newson, E. (1975). Intersubjectivity and the transmission of culture: On the social origins of symbolic functioning. *Bulletin of the British Psychological Society, 28,* 437–446.

Novak, J. D. & Cañas, A. J. (2008). The theory underlying concept maps and how to construct and use them. *Institute for Human and Machine Cognition* http://cmap.ihmc.us/docs/pdf/TheoryUnderlyingConceptMaps.pdf

Odden, T. O. B., & Russ, R. S. (2019). Defining sensemaking: Bringing clarity to a fragmented theoretical construct. *Science Education, 103*(1), 187–205. https://doi.org/10.1002/sce.21452

Osborne, J. (2003). Attitudes towards science: A review of the literature and its implications, *International Journal of Science Education*, *25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Paull, M., Boudville, I., & Sitlington, H. (2013). Using sensemaking as a diagnostic tool in the analysis of qualitative data. *The Qualitative Report, 18*(27), 1–12. https://doi.org/10.46743/2160-3715/2013.1496

Ponelis, S. R. (2015). Using interpretive qualitative case studies for exploratory research in doctoral studies: A case of information systems research in small and medium enterprises. *International Journal of Doctoral Studies, 10*, 535–550. http://ijds.org/Volume10/IJDSv10p535-550Ponelis0624.pdf

Peshkin, A. (1988). In search of subjectivity – one's own. *Educational Researcher, 17*(7), 17–22. http://teaching.up.edu/edresearch/library/Peshkin%20Subjectivity.pdf

Prosser, J. 1998. Image-based research: A sourcebook for qualitative researchers. Ed Prosser, Routledge, NY, NY.

Prosser, J. & Loxley, A. (2008). *Introducing visual methods* [Report]. ESRC National Center for Research Methods Review. http://eprints.ncrm.ac.uk/420/1/MethodsReviewPaperNCRM-010.pdf

Prosser, J. & Schwartz, D. 1998. Photographs within the sociological research process (p 115-130). IN: Prosser (Ed). https://open-tdm.au.dk/patic/wp-content/uploads/2018/02/6-

Pages-from-Prosser-J-1998-Image-based-Research-A-Sourcebook-for-Qualitative-Researchers.pdf

Quigley, C. F. & Herro, D. (2016). Finding the joy in the unknown: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science and Technology, 25*(3), 410–426. https://doi.org/10.1007/s10956-016-9602-z

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics, 117*(1–2), 1–12. https://doi.org/10.1111/ssm.12201

Radziwill, N., Benton, M., & Moellers, (2015). From STEAM to STEAM: Reframing what it means to learn. *The STEAM Journal, 2*(1), Article 3. https://doi.org/10.5642/steam.20150201.3

Rolling, J. H., Jr. (2016). Reinvesting the STEAM engine for art + design education. *Art Education, 69*(4), 4–7. https://doi.org/10.1080/00043125.2016.1176848

Rolling, J. H., Jr. (2017). The challenge of change. *Art Education, 7*(1), 4–6.

Sabol, F. R. (2010). *No child left behind: A study of its impact on art education*. National Art Education Association. https://www.arteducators.org/research/articles/107-no-child-left-behind

Sabol, F. R. (2013). Seismic shifts in the education landscape: What do they mean for arts education and arts education policy? *Arts Education Policy Review, 114*(1), 33–45. https://doi.org/10.1080/10632913.2013.744250

Saldaña, J. (2015). *The coding manual for qualitative researchers*. SAGE Publications.

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher, 68*(4), 20–26. https://www.teachmeteamwork.com/files/sanders.istem.ed.ttt.istem.ed.def.pdf

Scorse, S. A. (2014). *The positive influences arts integration and content integration has on students learning needs* [Master's thesis, SUNY Brockport]. SUNY Education and Human Development Master's Theses. http://hdl.handle.net/20.500.12648/5540

Segarra, V. A., Natalizio, B., Falkenberg, C. V., Pulford, & Holmes, R. M. (2018). STEAM: Using the arts to train well-rounded and creative scientists. *Journal of Microbiology & Biology Education, 19*(1). https://doi.org/10.1128/jmbe.v19i1.1360

Sequeira, A.H. (2014). Conceptualization in research. SSRN Electronic Journal.

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for professional development needs for implementation of integrated approaches to STEM education. *International Journal of STEM education, 4*(13). https://doi.org/10.1186/s40594-017-0068-1

Spurgin, K. (2009) *The sense-making approach and the study of personal information management* [Workshop]. http://pim.ischool.washington.edu/pim06/files/spurgin-paper.pdf

Stahl, N. A., & King, R. A. (2020). Expanding approaches to research: Understanding and using trustworthiness in qualitative research. *Journal of Developmental Education 44*(1), 26–28.

Starks, H., & Trinidad, S. B. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative Health Research, 17*(10), 1372–1380. https://doi.org/10.1177/1049732307307031

Stein, M., & Muzzin, M. (2018). Learning from failure. *Science and Children,* April/May, 62–65.

Stevenson, H. J. (2014). Myths and motives behind STEM (science, technology, engineering, and mathematics) Education and the STEM-worker shortage narrative. *Issues in Teacher Education, 23*(1), 133–146. https://www.itejournal.org/ojs/index.php/ite/article/view/16

Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and techniques*. (2nd ed). SAGE Publications.

Tobin, K and Tippins, D. (1993). Constructivism as a referent for teaching and learning. In Tobin, K. (Ed). *The practice of constructivism in science education,* (pp. 3-21). Washington: AAAS Press. https://sedl.org/pubs/pic02/picbib-output.cgi?searchuniqueid=56

Toplovcan, T., & Dubovicki, S. (2019). The heritage of the Cold War in contemporary curricula and educational reform. *Center for Educational Policy Studies Journal, 9*(2) 11–32. https://doi.org/10.25656/01:17440

Ugras, M. (2018). The effect of STEM activities on STEM attitudes, scientific creativity and motivation beliefs of the students and their views on STEM education. *International Online Journal of Educational Sciences, 10*(5), 165–182. https://iojes.net/Makaleler/20326b8f-f86a-41e4-93c4-15b83293067b.pdf

Ugras, M. (2019). Determination of the effects of problem-based STEM activities on certain variables and the views of the students. *International Online Journal of Educational Sciences, 11*(1), 1–22.

United States National Commission on Excellence in Education (1983). *A nation at risk: The imperative for educational reform*. United States Department of Education. https://edreform.com/wp-content/uploads/2013/02/A_Nation_At_Risk_1983.pdf

United States Department of Education (2015). S*cience, technology, engineering, and math: Education for global leadership*. Retrieved from: https://www.ed.gov/stem

Vaismoradi, M., Tureunen, H., & Bondas, T., (2013). Content analysis and thematic analysis: Implicactions for conducting a qualitative descriptive study. *Nursing and Health Sciences, 15,* 398-405. https://onlinelibrary.wiley.com/doi/pdf/10.1111/nhs.12048

Van Winkle, C. M., & Falk, J. H. (2015). Personal meaning mapping at festivals: A useful tool for a challenging context. *Event Management, 19*(1), 143–150.

Vasquez, J. A., Sneider, C., & Comer, M. (2013). *STEM lesson essential, grades 3–8: Integrating science, technology, engineering, and mathematics.* Heinemann.

Wall, S., & Shankar, I. (2009). Adventures in transdisciplinary learning. *Studies in Higher Education*, *33*(5), 551–565. https://doi.org/10.1080/03075070802373008

Wan, C. (2012). Shared knowledge matters: Culture as intersubjective representations. *Social and Personality Psychology Compass 6*(2), 109–125. https://doi.org/10.1111/j.1751-9004.2011.00418.x

Weick, K. E., Sutcliff, K. M., & Obstfeld, D. (2005). Organizing the process of sensemaking. *Organizational Science, 16*(4), 409–421. https://doi.org/10.1287/orsc.1050.0133

Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. *International Management Review, 15*(1), 45–55. http://www.imrjournal.org/uploads/1/4/2/8/14286482/imr-v15n1art4.pdf

Winthrop, R., McGivney, E., Williams, T. P., & Shankar, P. (2017, February 23). *Innovation and technology to accelerate progress in education*. Brookings. https://www.brookings.edu/research/innovation-and-technology-to-accelerate-progress-in-education/

Wynn, T., & Harris, J. (2012). Toward A STEM+arts curriculum: Creating the teacher team. *Art Education, 65*(5), 42–47. https://doi.org/10.1080/00043125.2012.11519191

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Yakman, G. (2012). Recognizing the A in STEM education. *Middle Ground, 16*(1), 15–16.

Yin, R. K. (2003). *Case study research: Design and methods* (4th ed.). SAGE Publications.

Zhou, M., & Brown, D. (2018). *Arts integration in elementary curriculum* (2nd ed.) Education Open Textbooks.

Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics, 112*(1), 12–19. https://doi.org/10.1111/j.1949-8594.2012.00101.x

APPENDICES

Appendix A

Principal Approval

Dear, ____________________________,

As a follow up to our phone call, I wanted to first thank you for agreeing to allow me access to your classroom teachers in an effort to better understand how they conceptualize STEAM education in their classroom settings. I believe this study is valuable because STEAM education has been identified a means for students to be successful in the 21st century, and gaining a better understanding of what STEAM education looks like according to the classroom educators implementing STEAM is important.

I am requesting that at least one educator from every grade level at your school (K–4) participate in this study so that the results could convey a range of educators' conceptualizations concerning STEAM education. Please see the attached Letter of Interest and Informed Consent forms for your review.

The results of this study could be potentially utilized by myself, Columbus State University, the Georgia Department of Education, and elementary STEAM certified schools wanting to advance STEAM education in the elementary classroom.

I would like to extend my genuine appreciation for your consideration concerning your participation in this study. Please sign below and return the email to officially acknowledge your agreement to allow teachers to decide if they would participate.

Sincerely,
Virginia McCullough

Signature: _____________________________ Date:

Appendix B

Letter of Interest

Dear Educator,

My name is Virginia McCullough, and I am currently a doctoral student at Columbus State University. In an effort to better understand how classroom educators conceptualize STEAM education in their classroom setting I am conducting a qualitative descriptive case study at your school. I have confidence that this study is valuable because STEAM education has been identified a means for students to be successful in the 21st century. Therefore, I believe that gaining a better understanding of what STEAM education looks like according to the educators implementing STEAM education in their classrooms is important?

I am requesting that at least one educator from every grade level at your school (K–4) participate in this study so that the results could convey a range of educators' conceptualizations concerning STEAM education. The results of this study could be potentially utilized by myself, Columbus State University, the Georgia Department of Education, and elementary STEAM certified schools wanting to advance STEAM education in the elementary classroom.

I would like to extend my genuine appreciation for your consideration concerning your participation in this study. Please sign below and return this form through email to acknowledge your agreement to participate in this study. Once I receive this form from you, I will send you an official informed consent form that outlines the specifics of the study and will ask for your signature for official signature to participate. Thank you and please do not hesitate to email me with any questions concerning this study.

Virginia McCullough

Signature: ______________________________ Date:

Appendix C

Informed Consent

Dear, ____________________________

You are being asked to participate in a research project conducted by Virginia McCullough, a student at Columbus State University. Dr. Michael Dentzau, a faculty member at Columbus State University will be supervising the study

I. Purpose:

The purpose of this study is to gain insight concerning how elementary educators in a STEAM certified school conceptualize STEAM education.

II. Procedures: You will be asked to create a personal meaning map (PMM) which entails writing words, ideas, concepts, phrases, thoughts, images, experiences, or any related ideas you may have concerning STEAM education on a piece of paper. You will also be asked to select a photograph from your archives that represents what STEAM education means to you. You will be asked to upload both your PMM and Photo to a Google Shared Drive. In addition, you will be asked to participate in an interview on Zoom concerning your PMM, photograph, and your conceptualization of STEAM education in your classroom.

III. Possible Risks or Discomforts:

There are not any significant risks or discomforts for this study.

IV. Potential Benefits:

There are not any potential benefits for the individual participants; however, this research could impact STEAM education in the elementary classroom setting.

V. Costs and Compensation:

There is no compensation for participants.

VI. Confidentiality:

The research team will ensure that your confidentiality is maintained.

VII. Withdrawal: Your participation in this research study is voluntary. You may withdraw from the study at any time, and your withdrawal will not involve any penalty.

For additional information about this research project, you may contact Virginia McCullough at mccullough-v@harris.k12.ga.us.

If you have any questions about your rights as a research participant, you may contact Columbus State University Institutional Review Board at irb@columbusstate.edu.

I have read this informed consent form. If I had any questions, they have been answered.

I agree to participate in this research project.

Signature: ____________________________

Date:

Appendix D

Personal Meaning Map Instructions and Prompt

On a piece of paper please write STEAM in the center in pencil or ink. Now write or draw anything that comes to mind that relates to or reflects STEAM education in your classroom. STEAM. These can be words, ideas, concepts, phrases, thoughts, images, experiences, or any related information. Any linkage between the ideas can and should be expressed.

Please complete this task within the week and upload your PMM to the Google Shared Drive that has been created.

Appendix E

Photo Elicitation Prompt

Please choose from your archives one photograph of what you believe best represents what STEAM education looks like in your classroom.

Please complete this task within the week and upload your PMM to the Google Shared Drive that has been created.

Appendix F

Semistructured Interview Questions

1) Let's look at your personal meaning map. As we look, please talk to me about the process you used to construct it.

2) Explain to me why you included each aspect in your PMM. And how each aspect relates to STEAM education?

3) Please explain the significance of each aspect included in your PMM. Are there aspects that are more significant?

4) In what way does your PMM reflect your conceptualization of what STEAM education is in your classroom setting?

5) Is there anything else you would like to say concerning your PMM?

6) Could you explain your chosen photograph to me?

7) What about this photograph represents what you think STEAM education is?

8) Is there a specific part of the image that is more important in illustrating what STEAM looks like to you?

9) Keeping your PMM and photograph in mind and thinking more broadly now, what does STEAM education mean to you?

10) If someone, who was not familiar with STEAM education, asked you to explain to them what STEAM education was, what would you say?

Appendix G

Thank You Letter

Dear _____________,

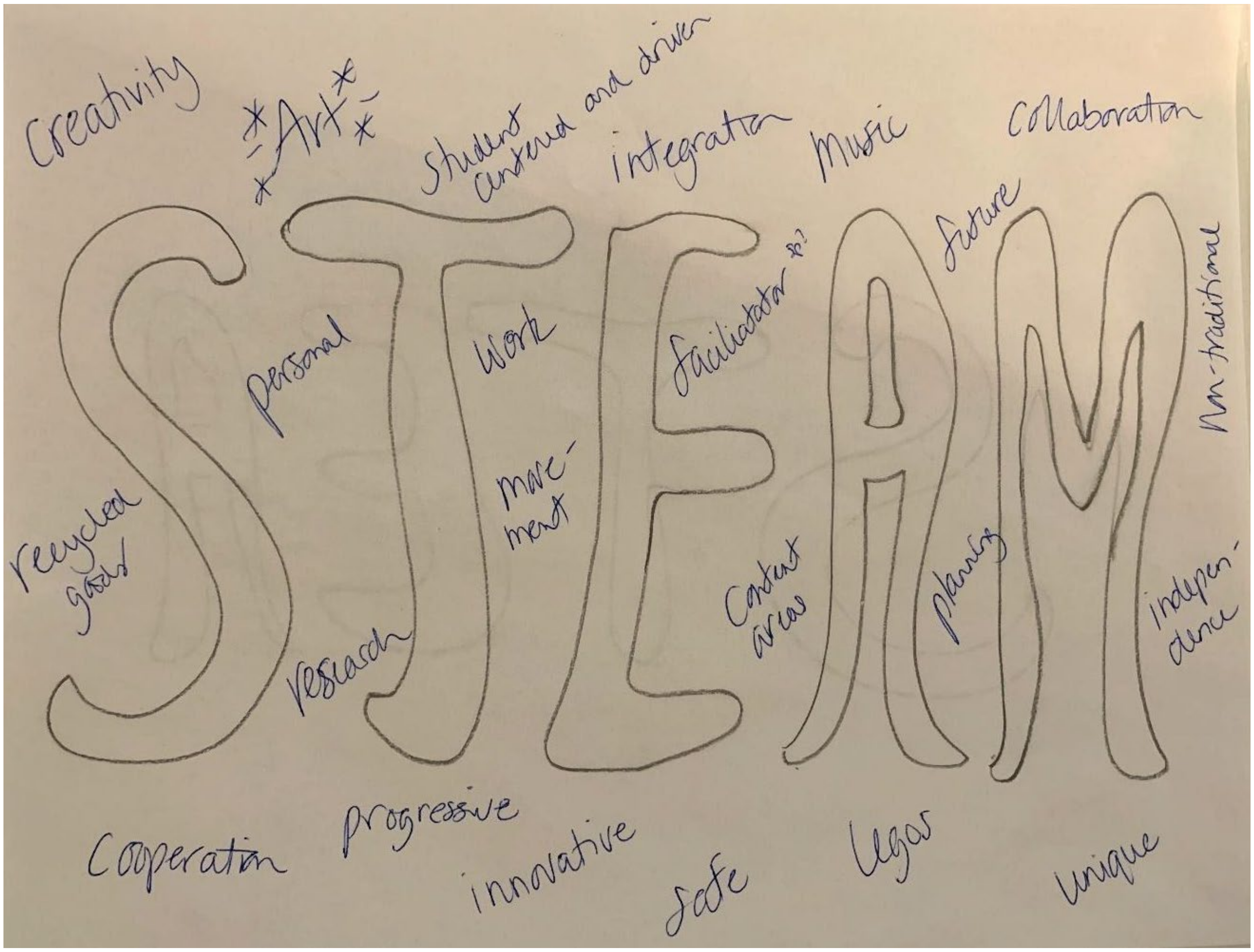
I would like to express my sincere gratitude for your participation in this study. Thank you for your time and your commitment to leadership in your field. Your feedback is vital and will meaningfully impact STEAM education. Thank you for being a change agent in STEAM education for elementary students.

If you have any questions or concerns regarding the study, feel free to contact me at mccullough-v@harris.k12.ga.us

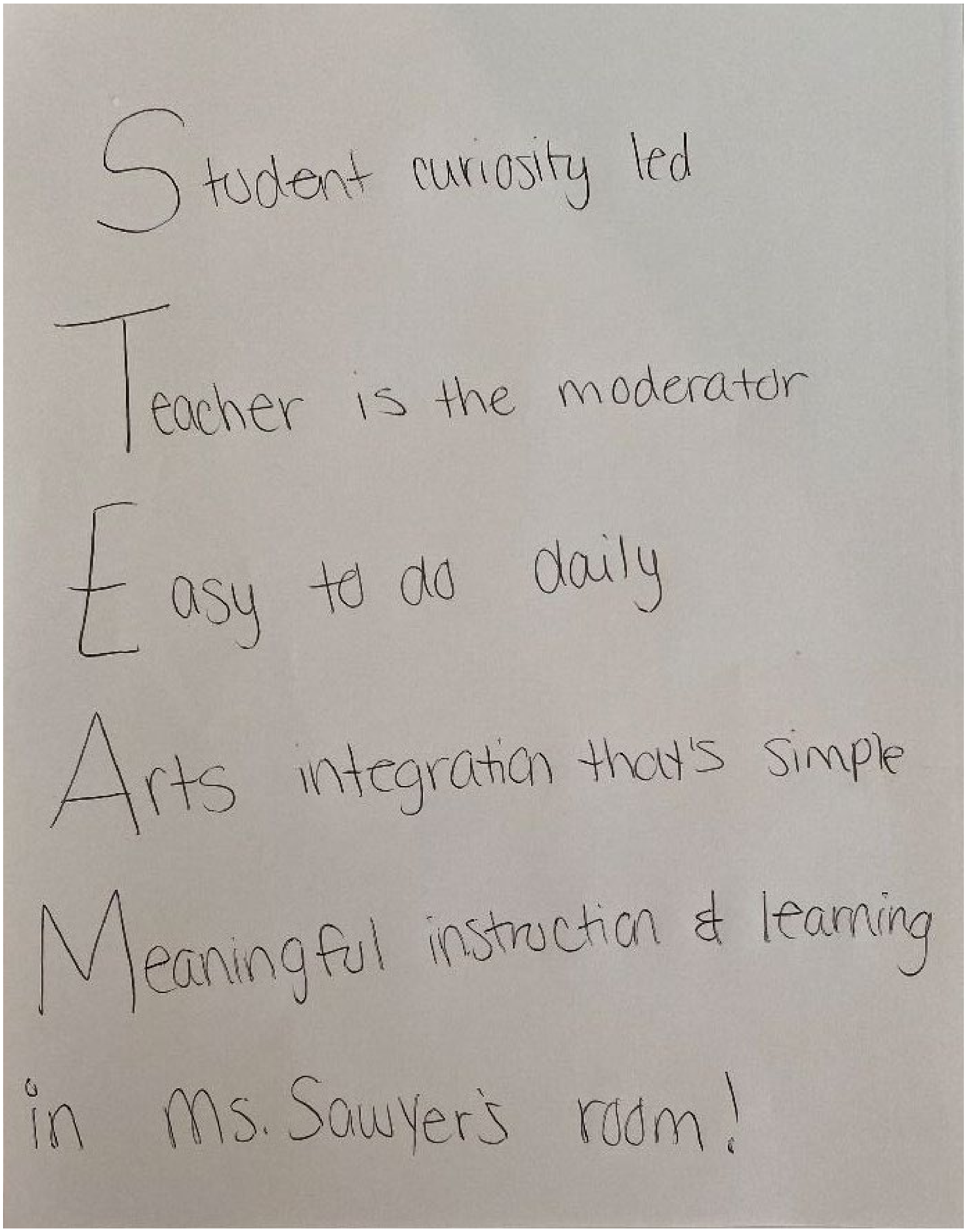
Sincerely,

Appendix H

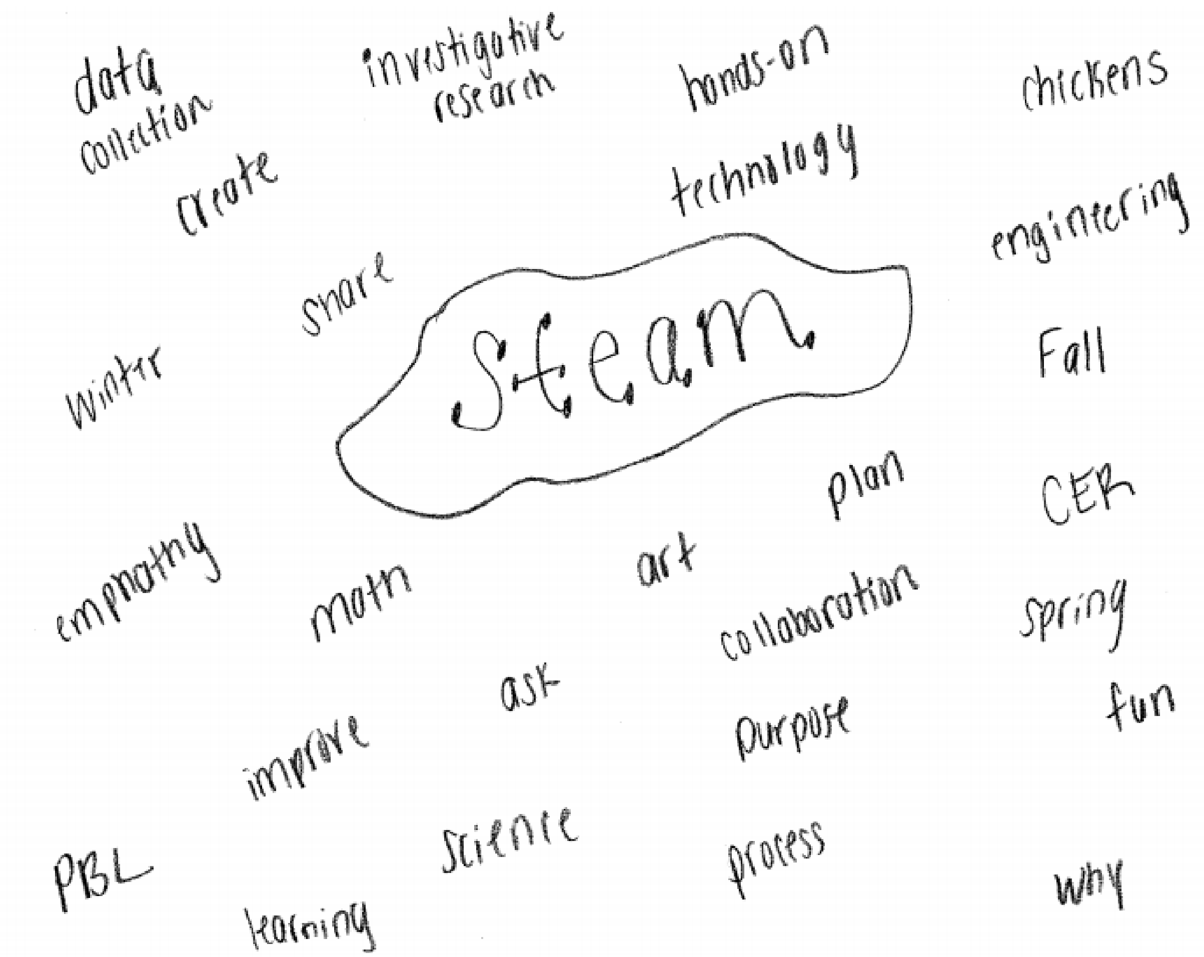
Personal Meaning Maps (PMM)



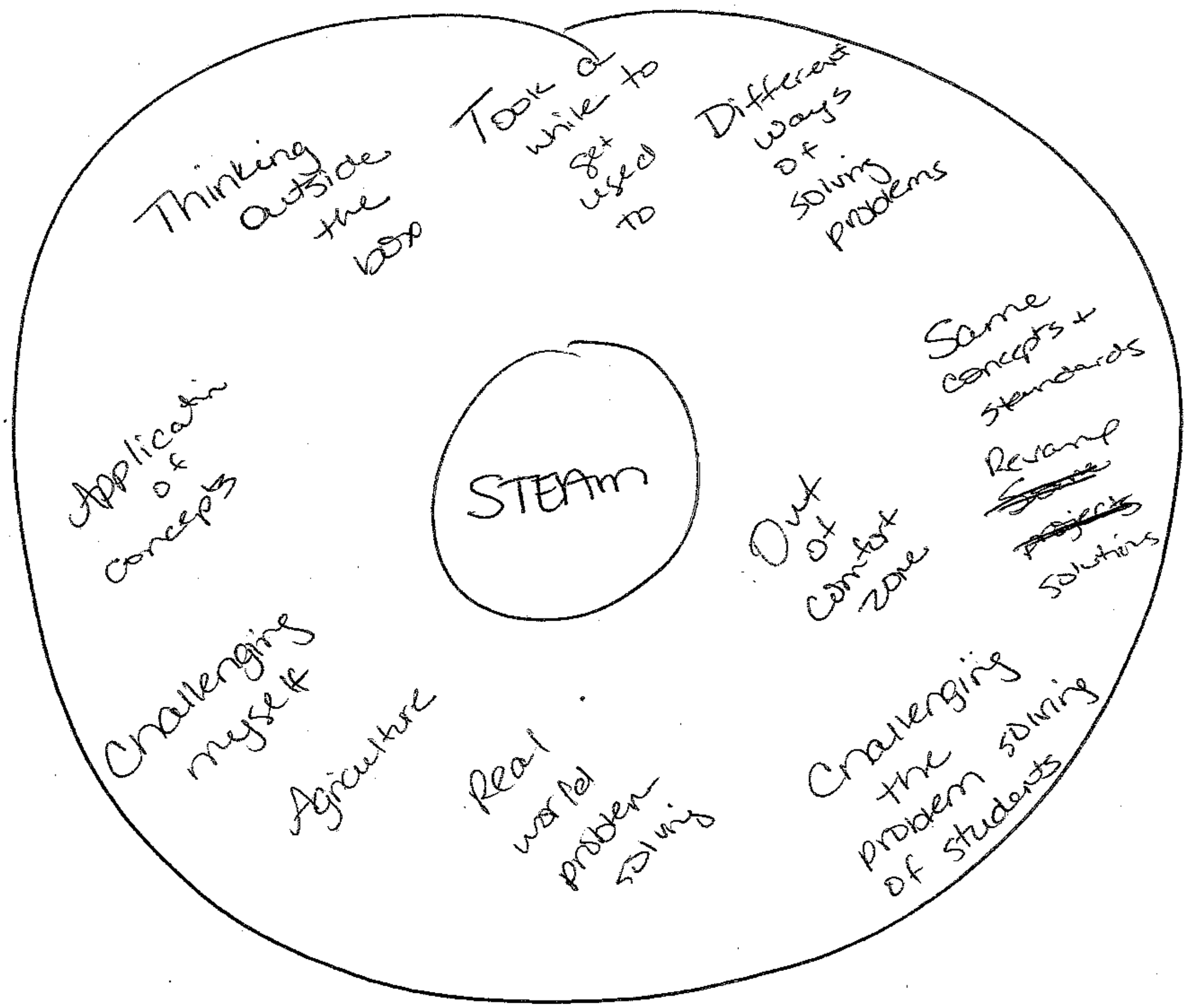
Anne's PMM


Student curiosity led
Teacher is the moderator
Easy to do daily
Arts integration that's simple
Meaningful instruction & learning
in Ms. Sawyer's room!

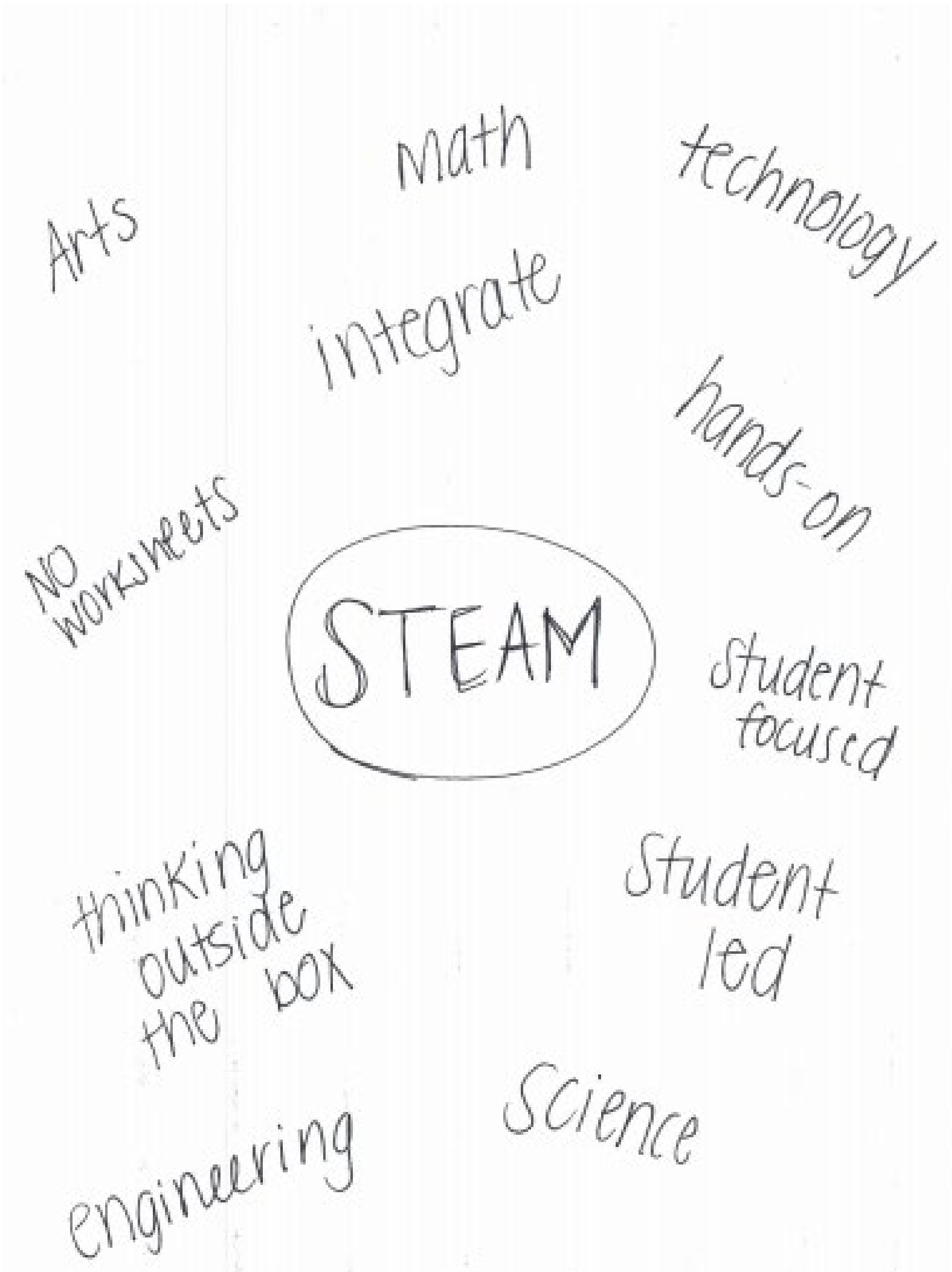
Bette's PMM


data collection
investigative research
hands-on
chickens
create
technology
engineering
share
steam
winter
Fall
plan
CER
empathy
math
art
collaboration
spring
ask
fun
improve
purpose
science
process
PBL
learning
why

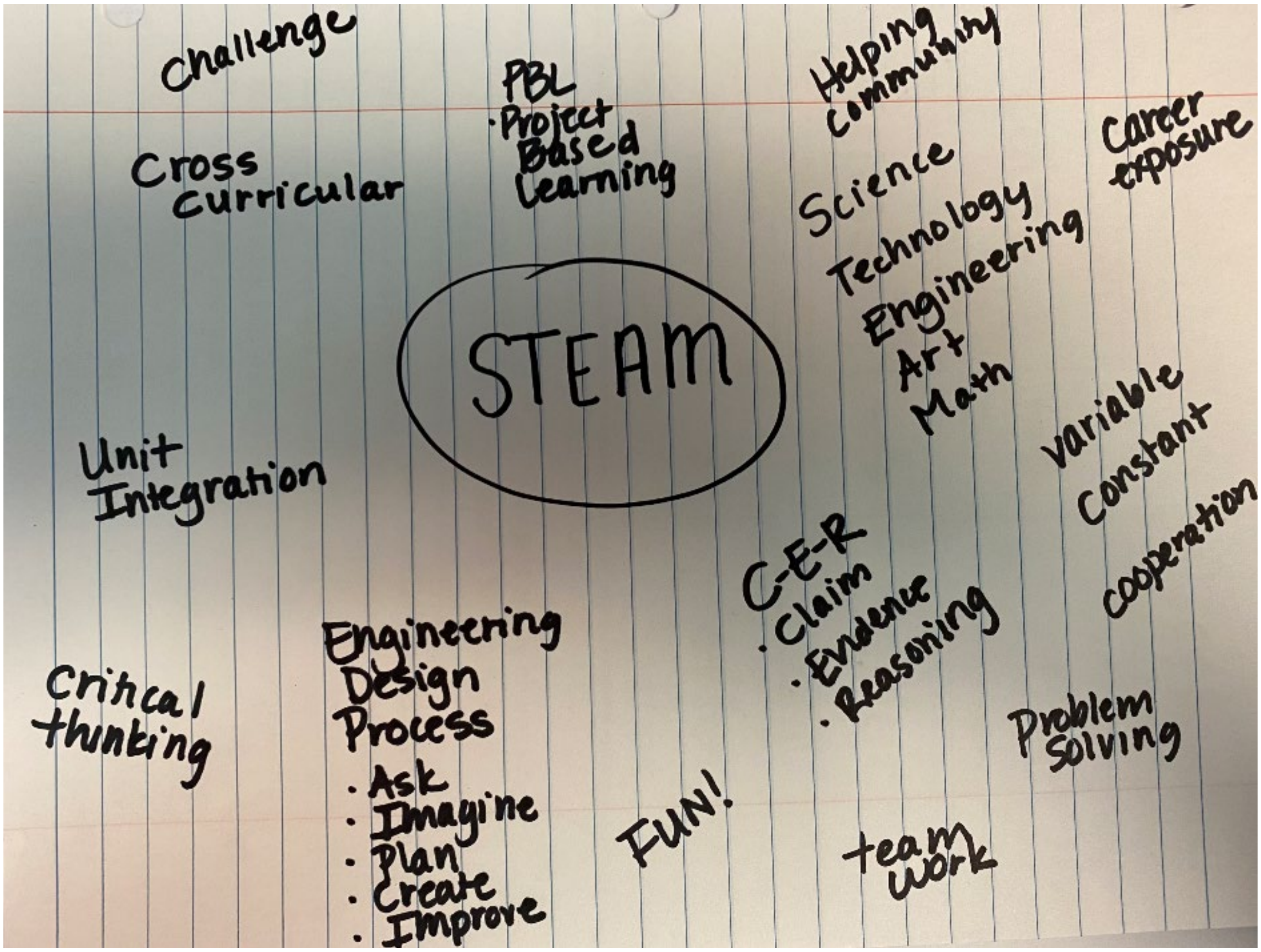
Claire's PMM



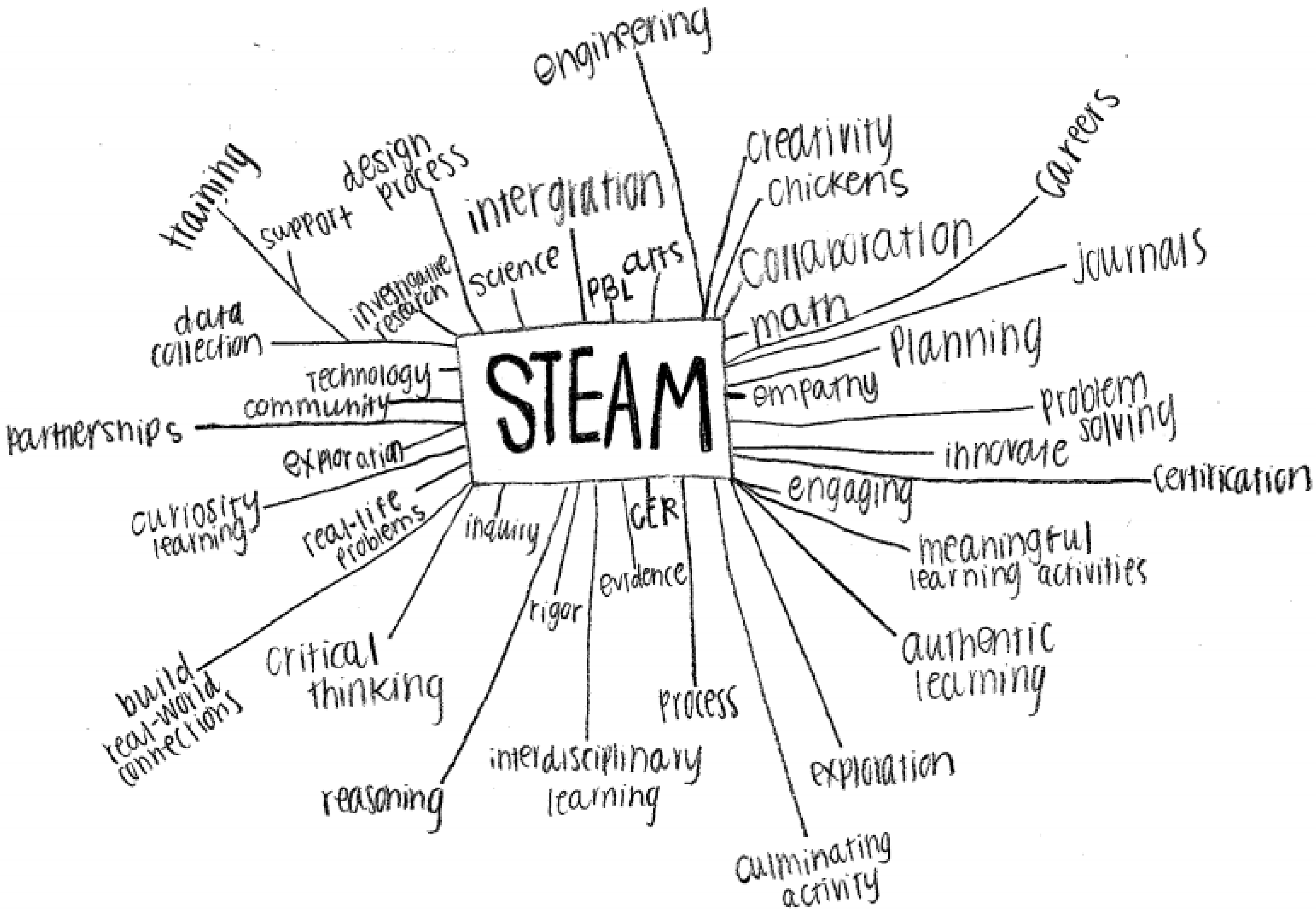
Dorothy's PMM



Elizabeth's PMM


Challenge
PBL
·Project Based Learning
Helping community
Career exposure
Cross Curricular
Science
Technology
Engineering
Art
Math
STEAM
Unit Integration
variable
constant
cooperation
C-E-R
·Claim
·Evidence
·Reasoning
Engineering Design Process
·Ask
·Imagine
·Plan
·Create
·Improve
Critical thinking
Problem Solving
FUN!
team work

Frances' PMM

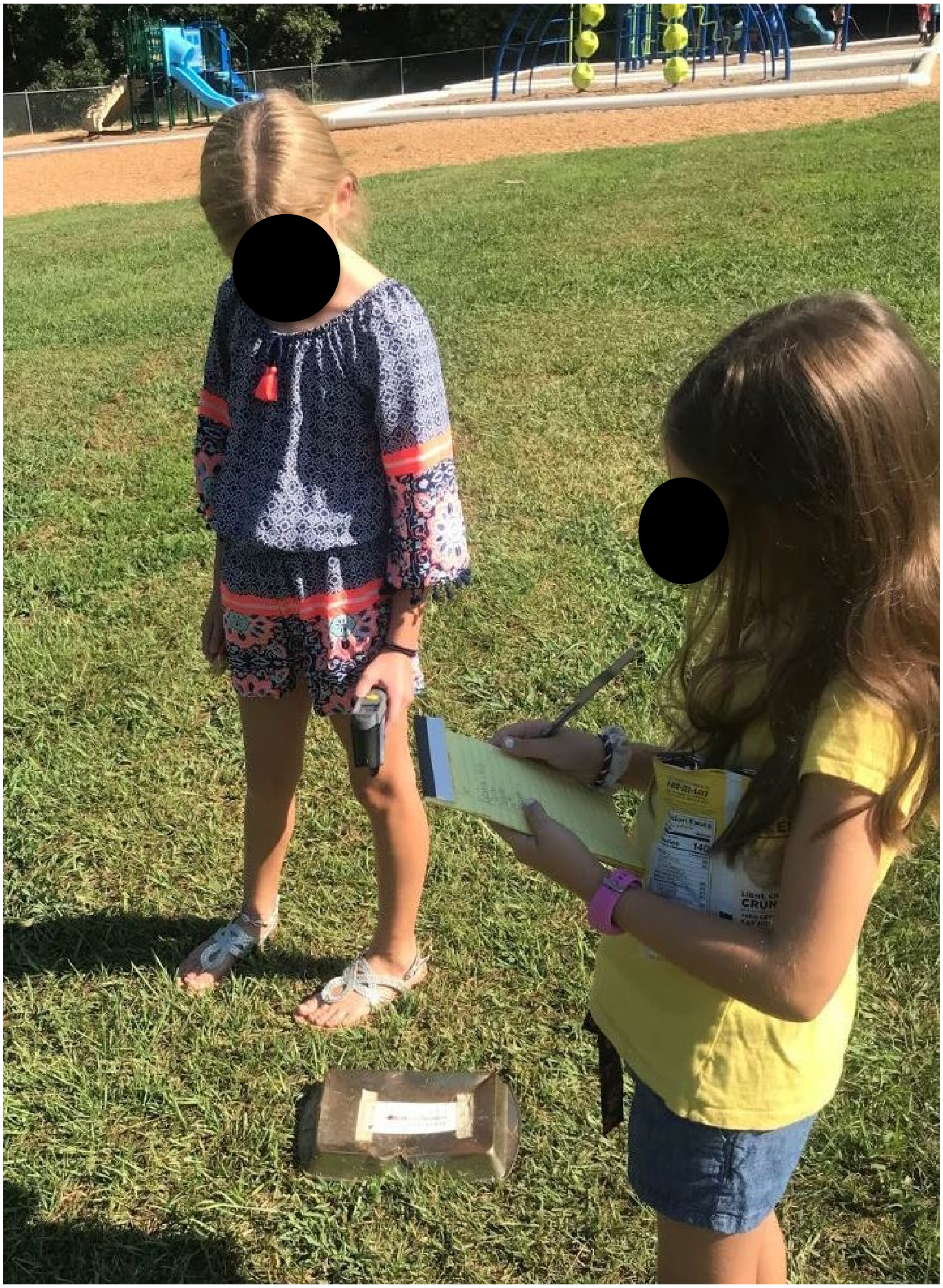

STEAM
engineering
creativity
chickens
collaboration
careers
journals
math
planning
empathy
problem solving
innovate
certification
engaging
meaningful learning activities
authentic learning
exploration
culminating activity
process
interdisciplinary learning
evidence
CER
rigor
reasoning
inquiry
critical thinking
build real-world connections
real-life problems
curiosity learning
exploration
partnerships
community
technology
data collection
support
training
design process
intergration
science
PBL
arts

Ginny's PMM

Appendix I

Photo Elicitation

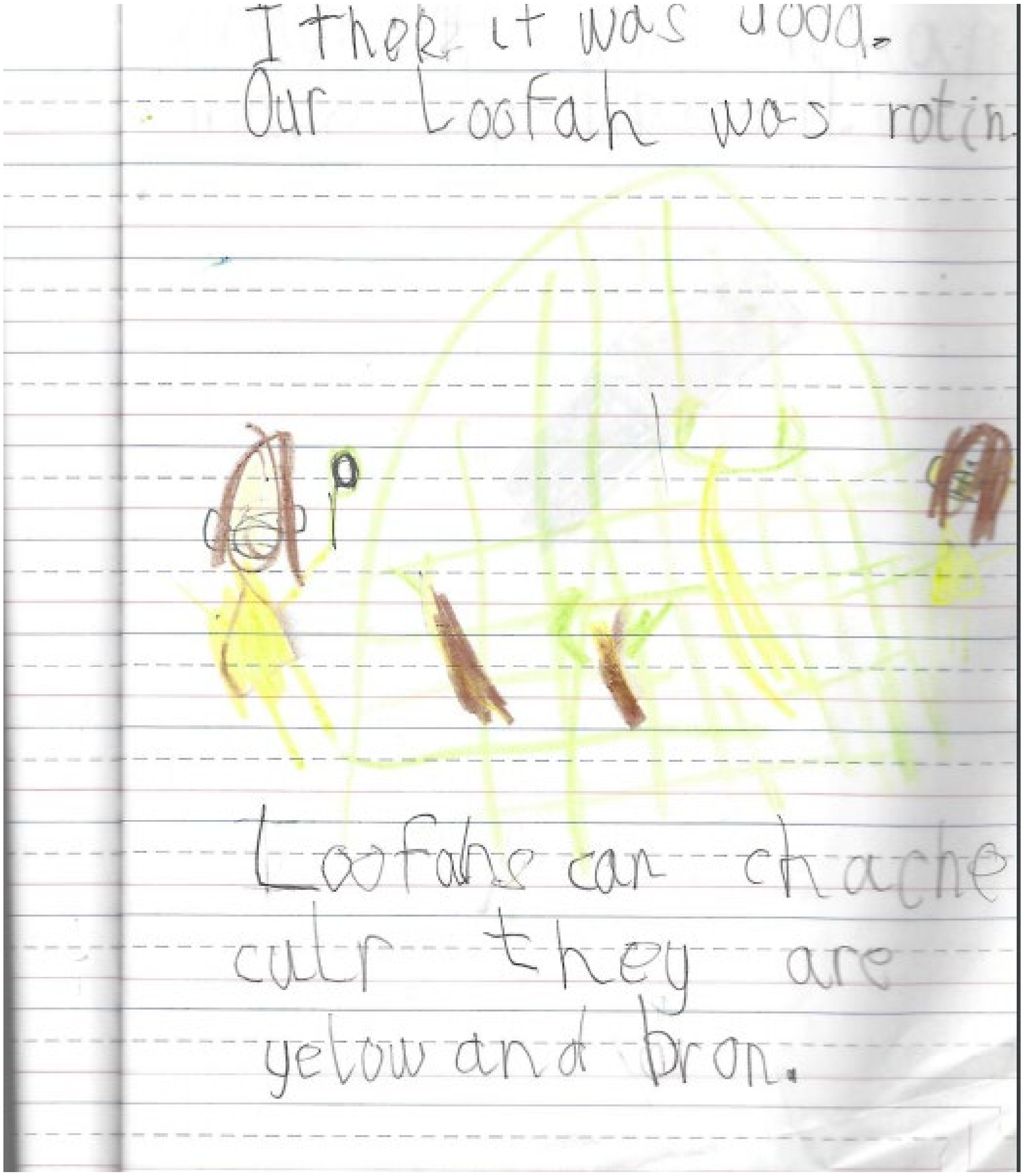
Anne's Photograph



Bette's Photograph

Claire's Photograph

Dorothy's Photograph



Elizabeth's Photograph

Frances' Photograph

Ginny's Photograph

Appendix J

Peer Scrutinized Transcript

Open codes:

Unsure/Ambiguity

Challenges

Strategies

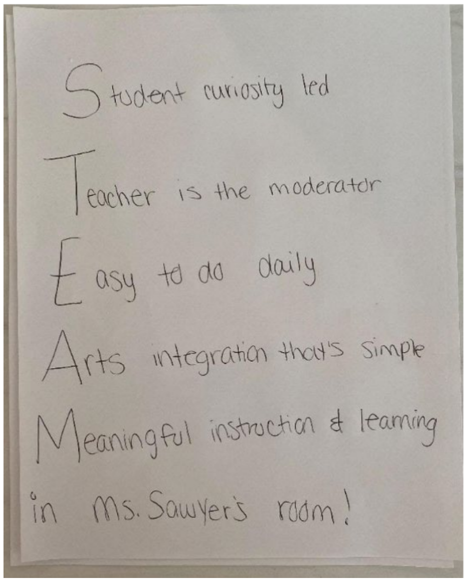
Feedback of process

Inquiry based learning experiences

Relationships with content

Professional Development

Participant # 2 Third Grade Teacher Semistructured Interview Transcript
Speaker 2
So, thank you for participating. I really do appreciate it.
Speaker 1
You are welcome.
Speaker 2
I am going to be asking questions of you to find out what you, as a classroom teacher in a STEAM certified school think STEAM education is or conceptualize STEAM as in your classroom setting. I hope this study will yield data to inform better practice in the future. I just want to remind you that everything you say is completely confidential. You have the option to withdraw any time from the study.
Alright so looking at your PMM, would walk me through what process you used to construct it?



Speaker 1
I don't know. I like acronyms I guess. You know you have your typical breakdown of what the letters in STEAM stand for. Just kind of thinking about what it stands for me and how I use it in my classroom, especially this year when it's been really difficult to get a yearlong PBL off the ground because of the covid restrictions.
Speaker 2
Alright
Speaker 1
But I still found some ways with my class to integrate the arts into STEAM education throughout the year. Because I follow the things that I listed. (in the PMM) Like if they're interested in something I don't worry about whether or not it's a third grade standard, I find ways to make the standards fit whatever they're interested in, because then they're automatically hooked in one up and teaching them.
Speaker 2
Right, so let's start with that. Let's start with S the *student curiosity*
Speaker 1
Yeah, I mean like we are at the beginning of the year we. Would sit outside under this tree. That's right outside my classroom. We read all the time and there were these bugs that were on the trees and there were tons of them. They were like little small bugs and they just kept talking and talking and talking about them and so. Finally I was like OK. Well let's just research it. Yes, and then we just turned it into a little mini STEAM lesson of researching and the teachers to moderate. The teachers *moderated* by assisting when they got to a dead end and couldn't figure anything out. I would kind of help them find more answers and. Just little things like that that don't necessarily take a lot of planning. I'm more fly by the seat of my pants kind of person when it comes to that, because I think if I can do it in the moment and it catches their attention better that way. For me STEAM is going to go 10 times better than if I sit there and plan three weeks in advance notice.
Speaker 2
OK,
Speaker 1

And then once they're interested, and I've got them hooked in there kind of take their kind of taking the lead. Then I can go back, you know, at the end of the day and plan for the next few days kind of plan ahead and see how our math can fit into it and how our science can fit into it. But their initial curiosity is what gets us going down that road.

Speaker 2

Can you walk me through what you think PBL is?

Speaker 1

PBL at our school or are yearlong projects and really a lot of projects at partners have been years long. You know the aquaponics for 4th grade has been years long and it gets passed down from 4th grade class to 4th grade class because there's always a new problem that they need to solve which is great for the teachers because it's something they're familiar with. But then the problems that pop up are new and it's something else the kids need to solve.

And the same thing with the chickens. For kindergarten there's always something new issue that they have to come up with a solution to.

Speaker 2

OK.

Speaker 1

Those are the PBLs.

Speaker 2

What would you say is your definition of PBL?

Speaker 1

It's like our overarching thing that we're working towards like completing or figuring out a solution to that problem and then we'll do the investigative research to figure out one answer and then another one will pop up. So we have to investigate that and then another problem pops up.

Speaker 2

So the PBL is more like your theme. For instance with the tree issue with the insects you were talking about.

Speaker 1

Yeah.

Speaker 2

Let's go on to the *easy to do daily.*

Speaker 1

Because I let the kids. I let them follow the things that they're interested in, and I'm not in the habit of saying that doesn't. We're actually not learning about that, so we can't really talk about it. Then learning just kind of comes out of their curiosity, but like I said, I do have to go back later and figure out how I can take what they're interested in and turn it into something that hits the standards that we are covering. And sometimes it does take a little bit of molding, you know, and tweaking things but.

Speaker 2

Uh huh.

Speaker 1

It makes it easier for me because I'm not fighting some of the behavioral issues because they're engaged in what we're doing.

Speaker 2

OK.
Do you think because you are a seasoned teacher that STEAM is easier for you to implement?
Speaker 1
No, I actually think some people that have been teaching longer have a much harder time with it. I think it's because I'm flexible that it's easier for me to implement STEAM because I'm open minded and I'm easy.
Speaker 2
OK.
Speaker 1
I always, I mean I tell people all the time that I treat my classroom like a lab. I'm willing to try anything with my kids as long as it keeps capturing their attention and their learning. And I think because I'm not afraid to say that I did something wrong, and that's why the learning didn't happen.
Speaker 2
OK.
Speaker 1
You know, I think there's a lot of people who their pride will get in the way, and they're never going to admit that something that they've been doing for 10 years is not working. They can't handle that. I'm just more like, I don't know, it used to work but it is not working with this group.
Speaker 2
Well, so you kind of adopted that kind of fail forward mentality.
Speaker 1
Yeah, I'm just really flexible and I don't get it. I do not get distraught or stressed out easily about things like that in the classroom. It's just kind of like well it's going to keep on going.
Speaker 2
Alright
Speaker 1
I think that's what makes it easier. I feel like I've seen people who have been teaching for a very long time have a harder time with STEAM because they have to adapt and change so quickly and that they're so used to doing everything exactly the same and not changing. Uh, that they might have a harder time.
Speaker 2
Do you think that you have to have a content knowledge base?
Speaker 1
Yeah, I mean, I think that you've got to know. I think to be a good teacher anyways, you got to know what you're supposed to teach your kids. And I say that because my first year in 3rd grade I had no idea that Magnus was a science standard and then they took the CRCT and there was nothing but magnets and science and I. Was like, well sorry gosh, we did not talk about that at all because I didn't know. But after that then I've decided to learn my standards.
Speaker 2
Gotcha
Speaker 1

So yeah, I mean, I think that to be successful, but I think some people know their standards too well and can't separate standards from what a prepis going to do. Too rigid.
Speaker 2
So you would say that STEAM has to have some flexibility to it.
Speaker 1
Yeah, if you're not flexible, you're going to have a really hard time with it.
Speaker 2
How about *arts integration that's simple* Talk to me about that.
Speaker 1
Well, OK, once we worked with a PAIR professional, Sally Baker we started learning about art not just being in visual arts. Not being a Fine Arts teacher when I hear arts integration, I'm thinking like visual arts and that's it and I don't think about anything else. So then working with Sally Baker at her and seeing how all these quick little movement games and things like that can be arts integration it just made me realize, like, OK, it doesn't mean that I have to have them painting something or constructing something all the time. We all had this big fear at the beginning that we were going to have become like master sculptors and things like that for arts integration and so seeing these simple integration tools was really helpful.
Even like visual thinking strategies and just putting up a picture of the board and tying that into what like with John Abbott. And we tie that into our habitats of Georgia study and we talk about all the things that are in the background of his pictures and what habitat does that represent. And all of that and that takes no work on my part.
I plan for math instruction for grade levels that I put pictures up for. Like when we're talking about fractions. Last week I had picked different pictures like a fruit stand and then saw if they could find the fraction in that picture and pictures of different bowls and things like that that caught them.
I had to remind my grade level to remember that it's us doing things like that that integrate the arts.
Speaker 2
So did that professional learning opportunity with PAIR help you?
Speaker 1
Yeah, it looks like it helped everybody realize its way less difficult to manage and more simple than we thought it was.
Speaker 2
So professional learning is important to informing what you this STEAM is?
Speaker 1
Yeah, and so that was the first lab session that I did earlier this month.
It was with Sally Baker, Rebecca Pogue, from Alliance Theater, and then Rachel from the museum it was just they were just giving teachers draft like Low prep, high yield arts integration strategies. And the feedback we got from every single person was we need more training like this.
Speaker 2
Ok
Speaker 1
From the teachers point of view. You're going to have to integrate the arts, especially when you don't know. And even when I felt like I had a hold on it, we would pull a

standard out and put it up to go with something and then Megan and Felicia would come through and say....But no, that's not, that's not what that standard means, so we still were using it and we still weren't necessarily recognizing the right standard. So you do have to get familiar with those standards.

Speaker 1

Yes.

Speaker 2

Alright, now unpack the *meaningful instruction and learning in Ms. Sawyer's Room*

Speaker 1

I just think it goes back to the S. The *student curiosity* is like because when you get to know the "student choice and voice" is like the number one thing in STEAM. It is almost like giving those students the choice to do and the voice to say what they want when they have that they remember what you teach them. And they hold on to it and they retain it. And if we all know anything, kids retaining stuff is hard.

And every time I do a STEAM lesson or a STEAM unit, or a PBL or anything I'm always reminded of how much more meaningful it is then when it's just, "Hey, we're going to read this story for the week" or vocabulary words or like the old school way they are not engaged. And there's some old school things that are wonderful and still work better than anything anybody could create but some of it is just not best practices for kids. It's just what's easiest for teachers.

Speaker 2

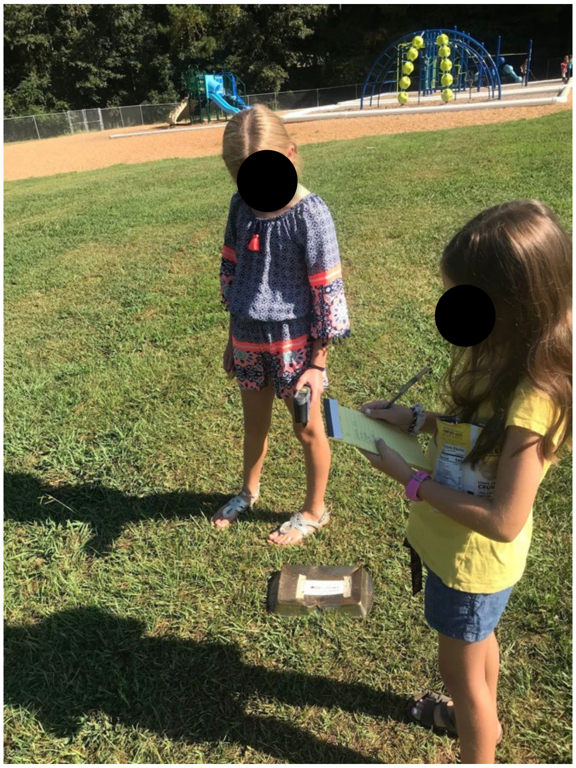
OK. So, do you have anything to add to your PMM?

Speaker 1

Just that it is student led and you got to as a teacher get used to the fact that you gotta let your kids show you what they want to learn, and then you've got to be willing to take what they're naturally curious about and find a way to fit it into your standards. If you do that you will enjoy it more, your behavior issues will go down. It just works better.

Speaker 2

Ok, Let's talk about your selected image.



Speaker 1
It's two students. They're out in the field and they're measuring the temperature of opinion because that was our investigative research at the beginning of last year. It means STEAM to me because it shows STEAM as student led because you don't see anybody else around. It's just the two of them and it just shows the independence to me. And that was our PBL last year.
The PBL came from the students complaining of being hot and we were trying to build a cooling station that was solar powered and we had a lot of issues but we still want to get back to it after Covid because we have no shade on our playground.
So they were measuring the temperature.
Speaker 2
They were measuring the temperature because?
12
Speaker 1
Our investigative research at the beginning of the year was we had a pan for every class, like a metal pan and we tracked the temperature for about two months to see what would be the best spot, which spots were getting them hottest? And then we decided where we would put the structure.
Speaker 2
OK.
Speaker 1
And it would just you know, they were responsible for going out and they were responsible for tracking the data but they wanted to do it because they were always so hot and miserable in the playground. August, you know, through October, is basically miserable and they always want to come inside. So it was something that would benefit them and something that they wanted a solution for as well. But it just showed

independence to me because it's just two people. You don't see anybody else, they're doing it completely on their own. You don't see any adult.

Speaker 2

OK alright so anything else considering the photo?

Speaker 1

Maybe like a picture of their journals where they're collecting the data.

Speaker 2

OK, so thinking more broadly now, what does STEAM education mean to you in your classroom setting?

Speaker 1

It's student-led. And I and I really believe that it's what's best for kids. That doesn't mean it's what's easiest for teachers, but that's not what our job is meant to be anyways.

Speaker 2

OK.

Speaker 1

And I think it opens up school to be a good place for atypical learners because. A lot of times you're atypical learners don't fit into your regular curriculum, but you know, I had a student who loved music and he always loved the day that we got to go to music. But when we started really integrating the arts and we started bringing music into their classroom, he loved it and it helped him so much socially because he could start talking about the things that he already had background knowledge and because he was so interested in it.

Speaker 2

OK.

Speaker 1

And so he got to be a peer leader for the first time ever in school, because he had that background knowledge of music. So I think it gives your atypical learners a chance to be the standout.

Speaker 2

OK good.

Talk to me a little bit about the disciplines of STEAM. How many do you think need to be involved to make it an authentic STEAM lesson, in your opinion?

Speaker 1

Like science, math and well, I take that back. I think you're yearlong PBL you need three.You need science, math and art.But then I think if you're just doing one kind of off the cuff, if you have two, then you're doing a good job.

Speaker 2

OK.

Speaker 1

If you're just integrating two at a time, but I think you'll find when you start really intentionally planning and you sit down and you map out your science standards 1st and then you talk about how your math standards can connect to your science standards and then you talk about how the art standards can connect to those. You'll realize that you can start waving in your social studies and you can weave in your reading and writing so easily and all sudden you'll realize your whole day. You're doing all subjects all the time, and there of course are going to be times where we can't and you have to teach some things in isolation. You just do. But you know, more often than not, you're going to see a lot more connections once you get used to planning that way.

Speaker 2

OK. Talk to me about those connections.

Speaker 1

Yeah, I mean, that's kind of how we've understood it from the get go like you gotta have something that those kids are into. Empathy is part of our engineering design process. Like they've got to have a reason. When we focus on the empathy part, we ask them like how can this benefit other students?

Speaker 2

OK.

Speaker 1

I think a lot of it is that you know STEAM comes naturally to kids. It just doesn't come naturally to teachers cause we compartmentalize. It's harder on teachers than it is on kids 'cause you just have to step back and let them figure it out, and that's hard.Just different from the way we've been doing it for so long.

Speaker 2

Ok. Do you see any kind of correlation between your PMM acronym and your photo that you selected?

Speaker 1

Yeah, I mean the like. I said the students were very interested in solving that problem of how hot it was. On the playground so then so of course they wanted to find out what was the hottest spot which then led to them never being around that spot on the playground, which was funny cause it wasn't like there was a huge temperature difference on the playground anyways. And you know, they taught them a lot about graphing. It taught them a lot about what attracts the sun's heat, and energies are not really not fun to teach anyways, but they were very interested in it last year, so I'm sure they could all tell you about you know insulators and all that kind of stuff.

Speaker 2

So it all goes back to the kids for you?

Speaker 1

Yeah.

Speaker 2

Talk to me how you came to conceptualize or understand what STEAM education in your classroom setting.

Speaker 1

Through a lot of trial and error and then a lot of professional development and then go into schools that were certified and talking to them. The one thing that made it click as far as integrating the curriculum was when Erin came to our school and sat down with us and we wrote out our science standards and then we looked at how our mass standards could fit in with our science standards, and what order would it make sense to teach them?

Speaker 2

OK.

Speaker 1

And then that's when it started just clicking.

Speaker 2

I know that you talked about how the students are interested in things that drive STEAM. Do you have a specific example of this student driven instruction?

Speaker 1

Right now we have a whale Wednesday in my class. We have whale Wednesday to show them a picture of different whales every Wednesday and it's just because I think whales are just so fascinating and so one day I saw this picture and I just had to show them because I knew they had found and so now every Wednesday as well we look at the picture we talked about the picture we talked about what kind of whales it is so I guess it's like a visual thinking strategy with this whale.

Speaker 2

Alright.

Speaker 1

But now we don't miss it and they will remind me. Hey, it's Wednesday. And so then it's led to different conversations and I know they'll be checking out books about whales and from the library, and

they're excited to show me what books they've checked out, so then it's kind of cool. I do that with a lot of things, like anything that I'm interested in. If I can make it child appropriate we do it. Like I read Wonder to my class every year. The book was part of an old Masters assignment years ago and it was like writing and ever since then I've read it to my class as well.

Speaker 2

Considering all that you have shared about STEAM in your classroom setting, what makes the most sense to you about STEAM?

Speaker 1

What makes the most sense is that it's something that keeps students engaged. You hear educators talking about all the time how they can't keep their attention, but STEAM always does. STEAM always keeps them engaged and allows them to choose the way they want to show their knowledge.

Speaker 2

OK.

Speaker 2

Makes the least sense to you.

Speaker 1

Uhm? I mean no, not from the curriculum part of it or anything like that. I think the part that makes the least sense to me. It is from the teacher perspective of when you have people that are so resistant to it. No matter how many positive things they see come from it and just wanna like to continuously go back to the way they used to teach.

That's part that makes least sense I mean.

Speaker 2

OK.

Speaker 1

Lot of it all, it always boils down to people not to generalize, but people just not being able to adapt or reflect and go maybe what I've used.

Speaker 2

OK. Do you think that STEAM Education prepares our students for 21st learning?

Speaker 1

I do. Because I think if you do it correctly then it's allowing them to problem solve on their own.But I don't in a way, because everything is changing so fast that I don't know that we can ever fully prepare them for whatever they're going to be introduced to when we get out because it's changing so quickly anyways.

Speaker 2

Do you think STEAM affects their skillset?

Speaker 1

Oh yeah, I mean, I think it's very true. If you're truly doing STEAM correctly in your classroom, and you're letting them problem solve, then they're going to be way more prepared than people who come from a classroom full of worksheet after worksheet after worksheet after worksheet.

Speaker 2

Can you give me a specific example of a problem solving?

Speaker 1

Yeah, like. It's way more challenging than to them, so anytime they're able to take their learning and put it into an application type, I think it's just benefiting them and getting them ready and it helps them retain their knowledge.

I mean even down like language arts instead of giving him a worksheet and saying you know, put that down in the blank where kids are going to make a 100 on that. Instead it's to create your own sentence. You underline the noun, you find it, and all of a sudden they can do that because it's not done for them. They have to construct it. They have to find it.

Speaker 2

OK. Do you see the students collaborate in your classroom more or less during STEAM?

Speaker 1

More, but I will say this year because we haven't been able to do it as much collaborating. It is interesting because there is much more bickering when they do not have to work together all the time. Bickering is way worse than it was in the last few years when we were constantly working together .

Speaker 2

Who do connect with to collaborate?

Speaker 1

All the grade levels met with the Fine Arts teachers. I think they got two or three days, maybe 2 days of planning to go and meet with all the teachers during their planning times to sit down and look at our curriculum and start making connections.

Speaker 2

Do you think STEAM is here to stay?

Speaker 1

No, unfortunately I just think it's one of those pendulum things.

Speaker 2

OK, why?

Speaker 1

I think it'll stick around for people who really like it, but I do think it's one of the one of the pendulum swings of education. I hope it lasts longer. I like seeing the benefits of it and I hope between that and like CTE programs that people are smart enough to make those decisions.

Speaker 2

Is there anything else you want to tell me about STEAM?
Speaker 1
I don't think so.
Speaker 2
OK. Well, thank you again for your participation. I hope you have a good evening.
Speaker 1
You are welcome and you too.