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Supporting Adult Learners' Metacognitive Development with a Sociotechnical System

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SUPPORTING ADULT LEARNERS' METACOGNITIVE

DEVELOPMENT WITH A SOCIOTECHNICAL SYSTEM

BY

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ABSTRACT

Metacognition is defined as thinking about and reflecting on one's cognitive processes. In learning contexts, strong metacognition leads to retention, academic success, and deep learning. While we know a lot about the metacognition of learners in grades K-12 and college, there are limited studies on adult learners' (24 and older) metacognitive awareness, how to support it, or the role technology can play, particularly since e-learning is quickly becoming the central mode of learning for adult learners. Thus, I have the following motivating research question: How can we support adult learners' metacognitive development in e-learning environments?

To better understand adult learners' needs, I conducted a content analysis of adults' learning ePortfolios and surveyed a cross-section of adult learners to determine their metacognitive awareness. Based on those findings and the literature on designing learning technologies for adult learners, I iteratively designed and developed a web-based application with adult learning, social learning, and persuasive design elements. During two sections of an online course, a treatment group used the intervention and a control group did not. Both groups completed a pre-/post-self report of their metacognitive awareness, developed a learning portfolio that was rated by two raters for evidence of metacognition, and participated in interviews.

This research shows that (a) adult learners are adept at planning and monitoring their learning but need more support in managing information and evaluating their learning; (b) a web-based intervention with social-persuasive design elements supports adult learners in metacognitive development; and (c) social and persuasive design elements, when aligned with adult learning principles, support adult learners' narrative identity, which I argue is a key factor in supporting their metacognitive development. This research aims to provide designers, educators, and learners with a better understanding of adult learners needs and offers design principles and guidelines for development of sociotechnical systems that can promote their metacognitive development in e-learning environments.

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1.1 INTRODUCTION

Metacognition is a learner's ability to monitor, reflect on, and improve upon his or her learning activities and strategies; it is a key factor in successful transfer of knowledge and skills to new learning situations (Flavel, 1987; Bransford, Brown, & Cocking, 2000; Akyol & Garrison, 2011). Twenty-first century employers expect that recent college grads as well as their current employees have strong metacognitive skills so that they can excel in critical thinking, complex problem-solving, judgment and decision making, and active listening (Trilling & Fadel, 2009; Siadaty, Gašević, Jovanović, Pata, Milikić, Holocher-Ertl, Jeremić, Ali, Giljanović, & Hatala, 2012). Thus, metacognitive awareness, practice, and development are a necessity for learners to be effective and efficient in the workplace, school, and everyday life.

However, metacognition and its usefulness in these contexts are often not directly or intentionally explored with adult learners – those who are beyond traditional undergraduate college age - in educational settings or in informal or workplace learning environments. And while pedagogical practices and learning technologies have been developed to support learners' metacognitive development, most research has focused on grades K-12 and developmental scenarios. Very few studies have examined returning adult learners in post-secondary settings or workplace settings, where they need continued support in developing and transferring these knowledge and skills for success (Veenman,

Van Hout-Wolters, & Afflerbach, 2006). Further, studies that have looked at adult learners have done so very broadly and have found that changes in metacognitive awareness continue into adulthood. Research is needed on how to better support adult learners metacognitive awareness (Justice & Dornan, 2001); this dissertation aims to explore this gap in the literature.

It is also important for instructional designers and educators to better understand adult learners' metacognitive needs because adults are a significant portion of the college student population: 40% of the US college student population is made up of adults over 24 years old (National Center for Education Statistics, 2010). Additionally, the frontal lobe of the adult brain, which controls self-regulating and metacognitive skills related to judgment, critical thinking, and decision making, does not full develop until the mid-20s (Powell, 2006), so the goal of understanding and supporting the metacognitive skills of adult learners in particular makes sense. Instructional design principles have been developed for broad-scale learning design, but, again, most research and resources have gone toward designing learning experiences for children and teenagers, not adult learners.

Furthermore, we know that more and more adults are learning and training in online environments (i.e. e-learning); in fact, the average age of an online learner is 33 years old (Kolowich, 2012). However, we do not know much about their metacognitive practices or strategies while learning or training online or how to support them in these environments. A 2013 Sloan study of online education growth reports that "over 6.7 million students were taking at least one online

course during the fall 2011 term, an increase of 570,000 students over the previous year" and "thirty-two percent of higher education students now take at least one course online." However, the study also reports that retention, students' lack of discipline, and unfavorable views of online learning by employers were barriers to the success of online programs and courses (Allen & Searman, 2013). Contributing to the retention and discipline issue is the fact that adults, while strong in metacognitive awareness, often lack the metacognitive regulation skills, such as time management, planning, and strategizing for learning, that are needed to succeed in online learning environments (Artino & Stephens, 2009; Michinov, Brunot, Le Bohec, Juhel, & Delaval, 2011). While some of these studies look at traditional-aged undergraduates (18-22), they also look at graduate students who fall in the 24 and older age range that is under investigation in this research. Graduate students tended to do better with metacognitive awareness and knowledge of cognition than undergraduates, but still lacked transfer and regulation skills.

In the e-learning landscape, researchers have also found that success in online environments is due to "high levels of participation, a supportive facilitator style, and ample opportunities for metacognitive reflection" (Cacciamani, Cesareni, Martini, Ferrini, & Fujita, 2012). Educators, designers, and researchers have made strides in recent years to scaffold this type of learning within and beyond the classroom. Learning systems and technologies have been developed to support learners in participating in and integrating authentic and personally-meaningful learning experiences and gaining adaptive expertise (Bransford,

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Brown, & Cocking, 2000; Shaffer & Resnick, 1999). Additionally, research on learners and learning in digital environments has shown that participation in digital learning environments supports metacognition because of the opportunity for learners to connect with each other via social networks and construct representations of their identities and knowledge so they can then critically reflect on them (Bers, 2001; Akyol & Garrison, 2011; Cambridge, 2008). These studies support that technological interventions that scaffold metacognition should not only draw from educational practices concerned with metacognition, but also from social constructionist learning theory and a learner-centered design framework. In other words, the support needs to be a sociotechnical system.

Yet, many of the technologies and practices that claim to support learning and cognitive development tend to perpetuate teacher/teaching-centered rather than learner/learning-centered principles and tools, for example, learning management systems (Dalsgaard, 2006; Dohn, 2009; Wegemer & Leimester, 2012). For metacognitive development, several existing metacognitive support technologies have been tested on grade school, high-school, and college-aged students (18-24 years old), and they are primarily for assisting learners in particular domains, e.g. math, biology or chemistry, that require structured problem-solving rather than across multiple contexts (e.g. Veenman et al., 2006; Azevedo, Johnson, Chauncey, & Burkett, 2010; Rau, Aleven, Rummel, & Rohrbach, 2013; Roll, Baker, Aleven, McLaren, & Koedinger, 2005). The research on technologies and e-learning systems that specifically support adult learners and their metacognitive development is limited.

Considering the gaps in existing research on adult learners' metacognition and technologies to support them, particularly in e-learning environments, my motivating question is, "How can we support adult learners' metacognitive development in e-learning environments?" To answer this question, I have explored three research questions:

1. How can we characterize adult learners in terms of their metacognitive abilities?

2. What are the important design parameters (elements and features) for e-learning technologies that support adult learners' metacognitive development?

3. How do specific design elements and features aid in supporting adult learners' metacognitive development?

1.2 REVIEW OF LITERATURE

Individuals require metacognition skills – such as reflection on practice, planning, integrating, and strategizing - for deep learning, learning transfer, and adaptive expertise inside and outside of school and the workplace (Bransford, Brown, & Cocking, 2000). This is especially important for adult learners who have a much more varied set of experiences on which to draw from when engaging in learning. Yet, formal education practices and existing educational technology fall short in supporting metacognitive development for adult learners in the workplace as well as those who have returned to college, especially in e-learning environments. However, there are some areas of research that can provide guidance when considering solutions that address this problem.

Research has shown that participation in e-Learning environments supports metacognition when learners have an opportunity to socially construct representations of their identities and knowledge; they can then critically reflect on their work using digital design and development tools (Bers, 2001; Akyol & Garrison, 2011; Cambridge, 2008). Research on adult learning suggests that there are several principles educators and designers can follow when designing for adult learners (Knowles, Holton, & Swanson, 2012). Finally, research on persuasive design also offers considerations for metacognitive development due to its design principles for behavior modification. A learning intervention that supports metacognitive development for adult learners can draw from these principles and frameworks.

1.2.1 Supporting Metacognitive Development

Metacognition, or knowledge about one's own cognitive processes, is a core-learning outcome in liberal education (Ottenhoff, 2011). Learners' ability to understand and analyze themselves as learners and regulate their learning processes, leads to strengthened transfer of knowledge and skills to new learning situations (Bransford, Brown, & Cocking, 2000). For example, when developing writing skills in a writing course, a learner's awareness and understanding of key self-regulating processes like planning, drafting, and revising is an example of metacognition (Perry, 1998). Metacognition is also one's understanding of what it means to be a learner and how to leverage his/her learning in a collaborative learning community, sometimes referred to as a "Community of Inquiry" (Akyol & Garrison, 2011).

While demonstration of metacognition is somewhat elusive in educational situations, researchers have used a variety of methods to identify and assess metacognition, such as analysis of self-reports, think-aloud protocols, reflective journals, transcripts of online discussions, and other written assignments (Lai, 2011). To this end, Schraw and Dennison (1994) developed a Metacognition Awareness Inventory (MAI) that includes 52 prompts to help with assessment of three metacognition components: knowledge of, monitoring, and regulation of cognition (see Table 1 below for a subset of the MAI prompts). According to Schraw and Dennison, a learner in a particular domain would demonstrate metacognition awareness by answering questions about: (a) the degree to which he understands and reflects with others about what it means to learn in that field or domain; (b) what learning is; (c) how to become a better learner; and (d) what is important to question and discuss when interacting with a community of other learners. Each of these questions falls under one of the components or the other (knowledge, monitoring, regulation of cognition), so learners and educators can identify where more development of metacognitive ability is necessary. This inventory has been found as both reliable and valid (Akin et. al, 2007; O'Neil & Abedi, 1996).

Table 1. A subset of Schraw & Dennison's (1994) Metacognitive Awareness Inventory.

	True	False
I ask myself periodically if I am meeting my goals.		
I consider several alternatives to a problem before I answer.		
I try to use strategies that have worked in the past.		
I pace myself while learning in order to have enough time.		
I understand my intellectual strengths and weaknesses.		
I think about what I really need to learn before I begin a task		
I know how well I did once I finish a test.		
I set specific goals before I begin a task.		
I slow down when I encounter important information.		
I know what kind of information is most important to learn.		

While pedagogical practices and learning technologies have been developed to support learners' metacognitive development, most research has focused on grades K-12 and developmental scenarios. Only a few studies have examined returning adult learners in post-secondary settings or workplace settings, where they need continued support in developing and transferring these knowledge and skills for success (Veenman, Van Hout-Wolters, & Afflerbach, 2006).

When it comes to adult learners specifically, research indicates that adults whose metacognitive skills are well developed are:

- better problem-solvers, decision makers, and critical thinkers

- more able and more motivated to learn

- more likely to be able to regulate their emotions (even in difficult situations), handle complexity, and cope with conflict" (Dawson, 2008).

One study showed that nurses and electronics technicians considered excellent at their jobs were found to have greater metacognitive awareness and strategy use than workers who were average performers (Baker, 1989; Hadwin, Wozney, Pontin, 2005). Furthermore, studies that have looked at adult learners' metacognition have found that changes in metacognitive awareness continue into adulthood, especially with regard to metacognitive regulation, and they are correlated with achievement and GPA (Young & Fry, 2008; see Table 2). Self-regulation (a component of metacognition) continues over a lifetime (Winne & Hadwin, 1998), and "self-regulatory and motivational processes persist into adulthood and determine occupational goals individuals set for themselves" (Kuiper, 2002).

Table 2. Young and Fry (2003): Correlation between MAI scores and broad measures of achievement.

	Course Grade	GPA	MAI Total	Regulation Factor	Knowledge Factor
Grade	1.00	0.36**	0.19*	0.19*	0.20**
GPA	0.36**	1.00	0.23**	0.20*	0.26*
MAI Total	0.19*	0.23**	1.00	0.97**	0.87**
Knowledge Factor	0.20**	0.26**	0.86**	0.73**	1.00
Regulation Factor	0.19*	0.20**	0.97**	1.00	0.73**

** Correlation is significant at the 0.01 level
*Correlation is significant at the 0.05 level

While adults demonstrate better awareness of their cognition than children, there is no correlation of regulation of cognition and age (Schraw,

1998). While experts tend to be good at planning before completing a task, "even skilled adults are poor monitors under certain conditions" (Schraw, 1998, p. 90); they are also not good at explaining it to others or transferring it to new situations. Since adults are switching careers and engaging in continuing education and workplace training at an increasing rate, they will require support in transferring their metacognitive skills to new domains (Glaser & Chi, 1988; Gick & Holyoak, 1980; PEW, 2006). Even though highly-skilled professionals may excel in their discipline, many of them avoid failure and proceed to repeat discipline-specific strategies that have worked in the past; they defend these tried and true strategies even when they do not work. Professionals' lack of reflection on their learning, knowledge, and strategies, aka their metacognition, affects their growth and progress as learners, which affects the organization, which, in the end, affects the success of the organization in the marketplace (Argyris, 1991).

Studies have shown that adults' proficiency at monitoring their learning/tasks is likely independent of intellectual ability and domain knowledge, but it can improve with practice (Schraw, Wise, & Roos, 2000). According to Dawson (2008), "Although metacognitive skills, once they are well-learned, can become habits of mind that are applied in a wide variety of contexts, it is important for even the most advanced adult learners to 'flex their cognitive muscles' by consciously applying appropriate metacognitive skills to new knowledge and in new situations" (p. 3).

According to one study, metacognition is the most important strategy for knowledge construction in a self-paced corporate learning environment for adult

learners. Dobrovolny (2006) found that adult learners completed a "metacognition loop" during a self-paced online course and used metacognitive strategies such as self-correction and self-assessment to complete the course. As a result, she states that "instructional designers need to create frequent opportunities for adults to self-assess and self-correct", particularly through "interactivity" such as providing feedback and alternative ways to address problems or consider concepts and ideas (p. 166).

In an effort to better support learners' metacognitive development in the 21st century classroom, technologies that facilitate development of, critical reflection upon, and representations of learning have developed rapidly in the last ten years in terms of their scope and reach. In both educational and corporate settings, digital spaces such as online courses, identity construction environments (ICE), and distributed learning environments have become sites where learners can engage and question their own and others' beliefs, knowledge, learning processes, values, and expand their understanding of society and their role in it in an academic environment.

Another practice that researchers claim facilitates metacognition and critical reflection is a learner's development of an educational portfolio or learning portfolio. Helen Barrett (2007) notes that "an educational portfolio contains work that a learner has collected, reflected upon, selected, and presented to show growth and change over time, work that represents an individual's or an organization's human capital. A critical component of an education portfolio is the learner's reflection on the individual pieces of work (often called artifacts) as

well as an overall reflection on the story that the portfolio tells about the learner"

(p.436). A portfolio developed in a digital, and oftentimes networked,

environment, is known as an "ePortfolio." The ePortfolio is a digital space for a

student to identify, track, and share her learning experiences, skills gained, and

knowledge developed before, during, and after attendance at an educational

institution (Yancey, 2009). Researchers have asserted that ePortfolio development

in higher education is valuable for metacognitive development because it helps

learners track and reflect on their learning (Barrett, 2007; Blackburn & Hakel,

2006). ePortfolio tools are championed as metacognitive tools that allow learners

to digitally construct, analyze, and synthesize their experiences across the

curriculum, connect them with learning experiences outside of the classroom, and

share them with instructors, other learners, and outside organizations in a way that

print-based portfolios and other identity construction environments cannot

(Cambridge, 2008). Studies have shown evidence of metacognition in ePortfolios

by focusing on analysis of text-based reflective artifacts within the ePortfolio and

post-ePortfolio-development self-reports (Meyer, Abrami, Wade, Aslan, &

Deault, 2010; Dalal, Hakel, Sliter, & Kirkendall, 2012).

      An intelligent tutor system (ITS) is another tool that has been used for the

purposes of supporting metacognition. Self-regulated learning (SRL), which is a

form of metacognition, has been measured as an event in domain-specific

hypermedia environments like online biology courses; SRL has been a subject of

recent study and has led to the development of intelligent tutors like MetaTutor

that provide live support while students are interacting with online biology course

material and quizzes (Azevedo et al., 2010). These studies have also shown that metacognition is an event that "takes place during learning" and can be traced (Azevedo, Moos, Johnson, & Chauncey, 2010). Another ITS was built to help learners when they make errors in solving math or foreign language problems by suggesting they ask the intelligent tutor for help and intervening when the ITS believes they are trying to "game the system" by guessing the correct answer (Roll et al., 2005). While ITSs are particularly useful for supporting students in their metacognitive activities while they are in formal learning situations and in a specific domain, there is a lack of research into how they can assist adult learners in learning metacognitive skills and developing metacognition over a long period of time, across domains, in contexts that do not always have one "correct" answer or require deeper interpretation, or with attention to the various spaces and situations in which adult learners work and learn. Indeed, Rau et al. (2013) noted that Interactive Learning Environments (ILEs) like Cognitive Tutors can be designed to reach various stakeholders with competing goals, as they demonstrated with an Cognitive Tutor for children learning fractions. However, in the college setting, they will likely require highly-tailored designs due to the numerous domains and courses wherein cognitive and metacognitive support is needed (Rau et al., 2013).

Researchers and educators can look to studies like these to see that strategies to support and assess metacognitive development need to be approached differently to address the diversity of learners, learning environments, and

domains. In summary, these studies are valuable for this research because they show that:

(1) metacognition is a lifelong learning skill needed for deep transfer and adaptive expertise;

(2) an adult learner's metacognitive skills can be assessed using (a) Schraw and Dennison's Metacognition Awareness Inventory, which has been shown to be both valid and reliable, and (b) ePortfolios, which are good sources of evidence for learners' metacognitive abilities; and

(3) learning technologies such as intelligent tutoring systems have been found as potential supports for metacognitive development, but research is limited on their role for broader metacognitive support for adult learners in particular.

1.2.2 Designing for Adult Learners

Due to the increasing opportunities for adults to learn online, more attention has been paid to developing tools and practices that support adult learning in online environments and draw from established principles of adult learning and teaching (or "andragogy"). When considering ways to support adult learners' metacognition, it is necessary to review these principles and recent research on how adult learners learn online.

The conversation around learning and education for adults in particular, also known as "andragogy," is not a new one. One key thinker in this conversation is Malcolm Knowles. Knowles and others have argued that teaching adults is different from teaching children, and that there is a "continuum of learning",

where a learner with more experiences to draw upon will have more independence and self-direction when it comes to learning. Henschke and Cooper (2006) conducted a review of the literature to support the foundation for andragogy. They found several practice-based empirical studies in andragogy including Savicevic (1999), Suanmali (1981), Billington (1998, 2000), and Johnson (2000) that demonstrate how adults' independence, understanding of self, and previous experience are common factors in andragogy. Based on this previous research as well as his own studies, Knowles states that adult learners can be characterized according to the following due to their higher exposure to more situations and experiences than children and teenagers (Knowles, Holton, & Swanson, 2012):

1. **Need to know:** adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know

2. **Self-concept:** adults are responsible for their lives and appreciate the opportunity to be self-directed with regard to their learning

3. **Prior experience:** adults come to learning situations with a variety of prior life experiences on which they draw and make meaning

4. **Readiness to learn:** adults are ready to learn what is most relevant to them at a given time

5. **Learning orientation:** adults learn best in real-life, authentic contexts

6. **Motivation to learn:** adults may be externally or internally motivated to learn, but the most influential motivation tends to be intrinsic.

In the 1980s, when computer-aided learning was rapidly growing, Knowles
applied some of these adult learning principles to a computer-aided learning
context for adults:

1. Explain the reasons specific things are being taught (e.g., certain
    commands, functions, operations, etc.).

2. Instruction should be task-oriented instead of memorization -- learning
    activities should be in the context of common tasks to be performed by
    the others.

3. Instruction should take into account the wide range of different
    backgrounds of learners; learning materials and activities should allow
    for different levels/types of previous experience with computers.

4. Since adults are self-directed, instruction should allow learners to
    discover things for themselves, providing guidance and help when
    mistakes are made.

    (Knowles, Holton, Swanson, 2012)

These principles have also been applied to instructional design for adult learners
in 21st century online environments. Cercone (2001) and Blondy (2007) in their
reviews of the adult learning literature note that instructional designers need to be
attentive to an adult learner's independence, self-directedness, prior experience,
and need for respect as an expert and as mature individuals with a great number of
external responsibilities and limited time and resources. This means that there
should be intentional goal toward facilitation rather than instruction or "banking"

of knowledge – the teacher, educator, or collaborator should not tell the learner what to do and how to do it (Friere, 1970). Instead, adult learners should be provided with space to transform and have control over their own learning with ample opportunities to seek support if they require it (Knowles, Holton, Swanson, 2012). Learning design should also be process-based, interactive, and collaborative. Cercone (2001) states that for adult learners,

> […] the learning process is more than the organized acquisition and storage of new information. The learning process involves learning about oneself and transforming not just what one learns, but also the way in which one learns. It is also about sensing, visualizing, perceiving, and learning informally with others. Interaction and collaboration should occur in the learning environment to facilitate adult learning. (p. 151-152)

Finally, while the greater number of adult learners in online education has increased interest in online learning, motivating students to persist and complete experiences such as self-paced online courses and Massive Open Online Courses (MOOCs) has been a challenge (Park & Choi, 2009). Again, making the content and usefulness of the learning experience relevant to them and providing the support they need when they need it are key to their persistence (Park & Choi, 2009).

Knowing more about adult learners' characteristics both as adults and as online learners will inform the decisions made when designing learning interventions and metacognitive support tools for them. Adult learners require

online interventions that provide opportunities for self-direction, collaboration, authenticity, and relevance.

1.2.3 Social Learning Design:

Social Constructionism & Legitimate Peripheral Participation

Since interaction, collaboration, authenticity, and personal relevance are important parts of designing for adult learning, it makes sense to review the literature on social constructionism and legitimate peripheral participation. Social constructionism is an extension of Piaget's constructivism, a philosophy that suggests individuals construct meaning and knowledge through their unique social experiences via assimilation and accommodation (1983), and Vygotsky's zone of proximal development (ZPD), a concept that suggests individuals' ability to learn and do things with and without collaboration and scaffolding provided by a teacher or other facilitator (1978). Building on these, social constructionism is a learning theory that suggests that learning happens when the individual reconstructs knowledge in a situated, public way ("situated learning") and by building or doing things that are personally meaningful to the learner and in the real-world with experts and models as guides (Papert & Harel, 1991). As opposed to "instructionism", social constructivism is about ways of knowing (epistemologies) rather than acquisition of knowledge (Rogoff, 1994). Many learning technologies have been developed to support social constructionist learning design.

In her research, Marina Bers showed how ten specific features of constructionist-inspired sociotechnical systems called identity construction

environments (ICEs), e.g.,'Zora' (2001) and 'Project Inter-Actions', can be useful in supporting positive youth development (PYD). Her theoretical model, rooted in social constructionist theory, demonstrated how the role of learners' multifaceted identity and their ability to represent that identity in computer-constructed, project-based learning situations can augment integrative learning and support metacognition. One ICE that she designed and studied was Zora; it is an identity construction environment that allows children to create objects such as avatars, buildings, signs, symbols, food, books, events, institutions. Zora objects represent elements that make up an identity in a virtual community; Bers investigated Zora objects as a means of gaining a better understanding of the role of personal and moral values in a community.

The design of Zora followed a constructionist approach because it not only allows students to create real artifacts to represent themselves and discuss real issues with others, but it also allows students to construct their own curricula. In other words, students work together to construct projects that are personally meaningful to them. Features of Zora that support project-based, constructionist learning include: (a) an object-oriented system allowing users to create representations of identity such as avatars, photo albums, and environmental elements that support personal narrative/storytelling; (b) collaborative tools for creation and participation in a community; (c) an authoring layer that is easy to use for novices; (d) evaluation tools; and (e) a 3D interface similar to video games.

Project-based learning environments such as Zora also support social constructionism and motivate students because learners are engaged in solving real problems, creating authentic and public artifacts, and socializing with others about these problems and projects. Zora supports both the cognitive (content and skills) as well as the metacognitive (Blomenfeld & Soloway, 1991). However, sustaining motivation is only possible through careful pedagogical planning and understanding. Teachers need to support students in learning ways of thinking, assess what they already know, scaffold academic and cognitively challenging tasks, and maintain an environment that encourages risk-taking rather than getting it right. Technology also plays an important role in constructionist project-based learning because it provides access to information and people/community, allows for greater choice and control, is interactive, and can be manipulated for different skill levels via scaffolding (Blomenfeld & Soloway, 1991).

The role of the expert, apprentice, and the communities in which they participate, are also key factors in a social constructionist view of learning. With roots in Vygotsky's zone of proximal development, social constructionist theory suggests that learning happens through interactions with others, typically an expert, and through gradual scaffolding (Chaiklin, 2008). Experts not only have more knowledge but also can access knowledge, apply knowledge, organize and maintain flexibility with knowledge and concepts, and are able to identify patterns more easily than novices (Donovan & Bransford, 1999). Suggestions for helping novices gain expertise include coaching by experts, activities that include models of how experts handle problems, focus on "conditionalized knowledge"

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(applications of knowledge), and being metacognitive about their learning (p. 49-50).

Lave and Wenger (1991) observed tailors, butchers, and recovering alcoholics in their respective learning communities and found that novices learned not through direct instruction and "how-to", but through exposure to experts' practices in the communities in-situ. Through this exposure, novices learn the meanings, practices, and rules of the communities. Although the novices are not fully participating in the community, this legitimate peripheral participation (LPP) is a form of learning. Rogoff (1994) encountered similar learning through LPP when observing Mayan mothers and their children, noting that their introduction to practice in the community was not through one-on-one didactic instruction from mom, but through exposure to authentic practices, rules, and community interactions on a daily basis. Taking this concept to the classroom, educators and researchers have implemented "design experiments" to help children learn strategies, become experts, and apply strategies to solve real problems. In this design-based learning situation, each student becomes an expert and shares knowledge with a group and then designs teaching artifacts and ways to test understanding--a design environment (Brown, 1992).

Similar to legitimate peripheral participation, cognitive apprenticeship refers to the application of workplace-apprentice-type learning but in traditional schooling environments. The goal is to place more emphasis on the methods and processes that experts understand and use when solving problems and carrying out tasks in specific domains so that learners can apply the same

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methods/processes when they encounter problems or situations; this differs from textbook problems and issues students encounter in the classroom (Collins & Brown, 1989). Teachers should aim for "externalization of processes that are usually carried out internally" (p. 457). This type of teaching, reflecting Vygotsky's (1978) zone of proximal development, involves (a) modeling (observation of the "master" using cognitive and metacognitive processes and comparison to one's own practice), (b) coaching (practice of those processes with guidance and feedback from the "master"), and (c) gradual "fading" of the master's intervention.

In summary, learning is not a transmission of information from one source to another, limited to a classroom environment, which is processed and stored in the brain, and then ready for use when needed. Instead, it is a dynamic social activity that occurs in diverse situations, in a variety of ways, and with diverse players, with an understanding that and different people learn differently. While there is not one single explanation for how people learn best, there are several established best practices involved in the learning process that align with adult learners in online environments, including: (a) identity construction and problem solving in authentic situations; (b) opportunities for participation in communities of experts; (c) modeling of and reflection upon processes and strategies; and (d) scaffolding of higher-level/expert ways of thinking about common situations and problems. These best practices should be applied in the development of systems to support metacognitive development for adult learners.

1.2.4 Persuasive Design for Modified Behavior

When talking about learning, researchers often mention "habits of mind" and "active thinking" (Louis & Sutton, 1991). The words "habit" and "active" are also frequently used in the health industry, a place where persuasive technology made its' debut. Persuasive technology is technology developed to help users make attitude and behavior changes in their everyday lives (Fogg, 1998). Persuasive technologies also have an emphasis on the intersection of behavior and social aspects. Since metacognition is technically a habit of mind, it is important to consider ways that persuasive design might support adult learners in developing metacognition.

Lifestyle and behavior changes via persuasive technology invoke various foundational psychological and sociological theories, including Locke and Latham's goal-setting theory, Prochaska and DiClemente's transtheoretical model of behavior, Goffman's Presentation of Self in Everyday Life, and Festinger's cognitive dissonance theory (Consolvo, McDonald, & Landay, 2009). With persuasive technology, users should be able to recognize a disconnect between their current attitudes and behavior (cognitive dissonance); track progress, receive incentives, and be challenged (goal setting); and control others' impressions of them (Goffman's Presentation of Self in Everyday Life). Prochaska's transtheoretical model also suggests that persuasive technology should take different approaches depending on where a user is in her behavior modification process: pre-contemplative, contemplative, active, or maintaining (Consolvo et al., 2009). These approaches include educating, overcoming barriers, focus on

patterns and consistency, keeping track, social interaction, invoking coping strategies when problems arise, and helping users see their progress toward a new self.

As mentioned previously, the most popular area of research for persuasive technology is currently in the health field. For example, several mobile apps use behavior modification and persuasive technology theory to help users – typically adults - lose weight, reduce calorie consumption, and take more steps in a day. There are also apps that use persuasive means to help people reduce their carbon footprint (Bang, Torstensson, & Katzeff, 2006) and reduce the amount of TV they watch per day (Nawyn, 2006). In developing a fitness system called UbiFit, researchers formed and tested design guidelines that follow these persuasive technology theories and research. In their quest for design guidelines in the development of persuasive systems like these, Consolvo et al. (2009) found that persuasive technology needs to be:

(1) Abstract and reflective: Display information in an abstract way rather than as raw data so that the user can reflect on its relevance to his/her goals

(2) Unobtrusive: Make information available so the user can access it but not in a way that interferes with his/her everyday lifestyle and actions

(3) Public: Allow personal data to be presented in public so that others may see it without making the user comfortable

(4) Aesthetic: Match the user's aesthetic expectations to keep his/her interest and sustained use

(5) Positive: Use positive reinforcement to motivate change

(6) Controllable: Allow user to control his/her data to support goals as he/she deems suitable

(7) Trending/Historical: Provide information about user's past behavior and trends as it relates to his/her goals and allow user to access to this information freely

(8) Comprehensive: Do not limit data collection to the scope of behaviors that the technology captures; allow user to enter/modify data as it relates to his/her goals and lifestyle

Researchers and developers could apply these same theories and guidelines to learning "behaviors"; however none have applied these theories to metacognitive development. Existing systems that claim to strengthen your brain, such as BrainAge® and Lumosity®, use games and repetitive exercises to try to improve attention and memory – both cognitive processes. However, they do not focus on higher-level thinking processes and human awareness of those processes for more effective and efficient learning. Combining persuasive technology design guidelines and the structures and concepts used in existing learning practices in digital environments will provide support that learners' need to improve their metacognitive skills.

1.3 OVERVIEW OF RESEARCH

In this dissertation, I will discuss the methods I used to answer my research questions, the results of those studies, and the implications of the research for adult learners and educators as well as the e-learning industry.

To answer my research questions, I used a mixed methods approach in conducting (a) Portfolio Study: a content analysis of adult learners' learning portfolios for evidence of their metacognition, (b) Metacognitive Awareness Study: a cross-sectional survey of adult learners about their metacognitive awareness, and (c) ReflectCoach Studies (two iterations): an experimental product that I designed, created, and re-designed based on a review of the literature and with user-centered research. See Figure 1 for a chronology and progression of these studies. I explored the efficacy of ReflectCoach as an intervention to support adult learners' metacognitive development through quasi-experiments that used iterative design methods. Content analysis, a survey, and a quasi-experiment with iterative design were appropriate methods to answer these questions because I asked what adult learners need (content analysis and survey), for a technology intervention to support them (iterative experiment), and how that intervention supported them (log files and interviews). This mixed methods approach is appropriate for educational design research because it afforded an exploration into the needs of the learners and helped to determine whether and how an intervention supports those needs (Reeves, 2006). See Table 3 on the next page for an overview of each Research Question I will address with this research, the associated Data Collection and Data Analysis Methods I will use, as well as the potential Outcomes and Implications of the research. This information is discussed in more detail in the next section, "Methods Overview," as well as within later chapters.

Figure 1. Research flowchart.
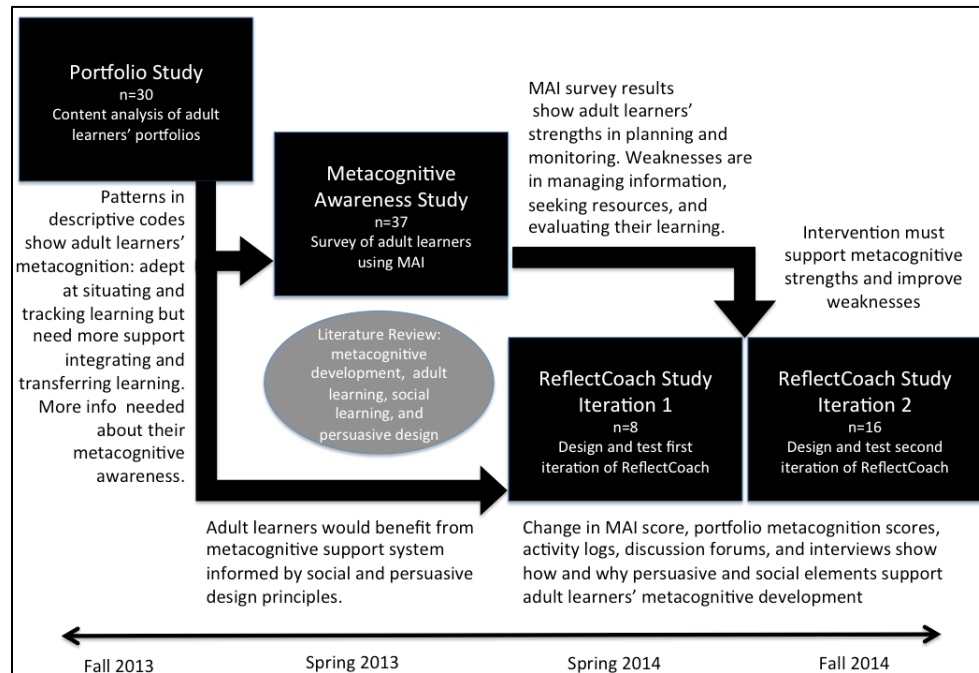
Table 3. Overview of research questions, methods, and outcomes.

Research Questions	Data Collection	Data Analysis	Outcomes/Contributions
RQ 1: How can we characterize adult learners in terms of their metacognitive ability?	**Portfolio Study** Content analysis of adult learners' ePortfolios for evidence of metacognition, *n=30*	• Process coding	**Expand personas for adult learners**: expanding personas of adult learners so they reflect adult learners' metacognitive abilities and needs
	Metacognitive Awareness Study Survey adult learners using the Metacognitive Awareness (MAI) survey, *n=37*	• Descriptive statistics • Contingency table	**Expand adult learning principles**: expanding principles about adult learners and learning to include their metacognitive abilities and needs
RQ 2: What are the important design parameters (elements and features) for e-learning technologies that support adult learners' metacognitive development? **RQ 3**: How do specific design elements and features aid in supporting adult learners' metacognitive development?	**ReflectCoach Study** Design and test ReflectCoach system o *Iteration 1*, Summer 2014, *n=8* • MAI (pre/post) survey • ReflectCoach activity log • ReflectCoach discussion forum • ePortfolio metacognition scores • Follow-up interviews o *Iteration 2*, Fall 2014, *n=16* • MAI (pre/post) survey • ReflectCoach activity log • ReflectCoach discussion forum • Follow-up interviews • ePortfolio metacognition scores	• Descriptive statistics • Student's t-test • Descriptive coding	**Design guidelines** for scaffolding and supporting adult learners' metacognitive development: • Social design • Persuasive design • Support narrative identity • Align with adult learning principles **eLearning system** to support metacognitive development that follows the above design guidelines while being: • Ubiquitous • Low-maintenance • Free • Cross-discipline/domain

Methods Overview

The 91 participants for this research were aged 25 to 59 and were pursuing their bachelor's degree via a program offered only to returning adult students, 24 and older, at a DePaul University, which is a private university in Chicago, Illinois. Thirty-seven percent of the undergraduate student body at DePaul self-reports as a minority and 53 percent reports as female.

All participants in the studies were enrolled in a section of a required introductory writing course that is part of a bachelor's degree program designed for adults 24-years and older. The introductory writing course focused on developing one's writing skills in order to describe, analyze, synthesize, and reflect upon academic scholarship and personal experiences. The course is designed for adult learners, so it incorporates many of the adult principles discussed in this chapter, such as allowing learners to write on topics personally relevant to them, giving them opportunities to incorporate their expertise, and making connections between academic writing, workplace writing, and writing for personal reasons (need-to-know, readiness).

The assignments in the course included weekly readings on writing process, discussing exposition, analysis, research, components of essays, and argumentation, drafting four academic essays, writing self-evaluations for each draft, and developing an electronic learning portfolio (an ePortfolio) using software called Digication. For the ePortfolio, instructors directed learners to include essays they wrote in the course, a writing philosophy, and reflections on their writing and development as writers, but also welcomed other artifacts and

elements and encouraged them to explore all the features of the software to demonstrate both their writing competence as well as their reflections on their learning and development as writers. Other than this, the instructors gave no explicit requirements for how to organize and label the learning portfolio contents or types of new media elements to include. I asked the learners to participate in the study in Week 1 of the course, after they enrolled, so they had no prior knowledge that the study was taking place in the course in which they were enrolling.

I chose this specific introductory writing course because it was offered only to adults 24 and older, both in-person and online, and is a required course in the program. The online version consists of master content that is consistent across sections, including the required assignment that asks learners to develop a learning portfolio to pass the course; recall, e-learning portfolios have been proven to display evidence of and encourage metacognition (Abrami, Wade, Pillay, Aslan, Bures, & Bentley 2008; Cambridge, 2008). Additionally, the learners in this course tend to be at the beginning of their program, and therefore are around the same stage of learning at the college level. After obtaining permission from the coordinator of the program to conduct the study, I recruited participants via a link to an online informed consent information sheet and form. After reading the information sheet, potential participants entered their name and the date on the form to confirm if they wanted to participate and clicked a "Submit" button to provide their consent. For the ReflectCoach experiment, I controlled for who received treatment and who did not, rather than a completely

random assignment (Gribbons & Herman, 1997). In this case, I selected the course in which the participants were enrolled. After receiving learners' consent to participate, I then selected who would receive the treatment and who would not by choosing every other participant from an alphabetical list by last name.

I controlled for confounding variables by ensuring that the context and environment in which the study takes place were as consistent as possible. Accordingly, the targeted population for the ReflectCoach experiment involved adult learners in two sections of an introductory-level online writing course where the course content, instructor, assignments, frequency and style of instructor feedback, and frequency of interaction are similar in every section. The instructor was also informed of the research taking place with students in their course and was given information as to how it would be conducted. The instructor was not required to contribute to any aspects of the studies, so no further training or interaction was necessary. The instructor also had no knowledge of who participated in the study and who did not, so the student feedback and grades would not be affected.

These studies resulted in three main findings about adult learners' metacognition and the means by which it can be supported in online learning environments:

In Chapter 2, I address my first research question (RQ1), "How can we characterize adult learners in terms of their metacognitive abilities?" I discuss how an analysis of adult learners' learning portfolios and their metacognitive self-assessment reveals that they are adept at planning and monitoring their learning

and need more support in managing resources and information and evaluating

their learning. These findings served as the basis for my development of my

designed intervention to support metacognition (ReflectCoach), which is

discussed in the next chapter.

Chapter 3, which begins to answer my second research question (RQ2),

"What are the important design parameters (elements and features) for e-learning

technologies that support adult learners' metacognitive development?", includes

details on the web-based intervention I created, ReflectCoach, based on the

findings from Chapter 2 and the literature on learning design. I also present

empirical evidence that ReflectCoach supported adult learners in their

metacognitive development when they used it while completing their regular

coursework for college and discuss the results across two iterations of the system.

In Chapter 4, I address my final research question (RQ3), "How do

specific design elements and features aid in supporting adult learners'

metacognitive development?" I discuss my analysis of interviews and activity log

data and compare them to the metacognition scores discussed in Chapter 3 to

show how ReflectCoach's social and persuasive design elements allowed adult

learners to integrate metacognitive development into their narrative identity. I

argue that narrative identity is particularly important for adult learners since they

are most concerned with the relevance of learning something new to their own

lives. Helping them to understand the importance of metacognition while self-

assessing and self-directing to improve it allows them to absorb it into this

ongoing narrative of learning and life rather than something "just for school" or

"just for work". Logs of learners' usage and follow-up interviews with the learners indicated that the affordances of ReflectCoach for self-directed learning, privacy, instant feedback, and peer support were valued by the adult learners' and contributed to their improved metacognition. These allowances align with existing adult learning principles as well as online learning design principles more broadly.

Finally, in Chapter 5, I argue that these three findings are key factors in supporting adult learners' metacognitive development and should be strongly considered when designing online learning experiences more broadly for the adult learner population. In a world where metacognition is imperative for success in any context, and where the Internet is quickly becoming the primary space wherein adult learning takes place, educators, trainers, and the e-learning industry must stay cognizant of its adult learner population when designing for their success in learning.

CHAPTER 2: ADULT LEARNERS' METACOGNITIVE PRACTICES

Recall, in Chapter 1 I discussed how metacognition leads to deep learning, retention in higher education, and academic success. While metacognition has been examined in a broad range of domains, it has not been examined with adult learners to the same extent, nor in terms of e-learning environments specifically. It is particularly important to explore the role of metacognition, and support for metacognitive development, in e- learning environments since adult participation in online learning opportunities is on the rise, both in academic contexts such as online courses and in workplace contexts such as webinars and training (Sloan, 2013).

My first research question is, "How can we characterize adult learners with respect to their metacognitive development?" To answer this question, I used two methods. First, I conducted a content analysis of a sample of adult learners' learning ePortfolios for evidence of their metacognition. Then, I surveyed a cross-section of adult learners using Schraw and Dennison's (1994) Metacognitive Awareness Inventory (MAI) questionnaire to gauge their metacognitive awareness. Together, these findings revealed that adult learners tended to be adept in the metacognitive activities of identifying and situating themselves in learning contexts, planning, and monitoring their cognitive processes for learning, but needed more support than they were already receiving in integrating their varied

learning experiences, managing resources and information, and evaluating themselves and their strategies.

2.1. CONTENT ANALYSIS OF ADULT LEARNERS' LEARNING ePORTFOLIOS

To further understand adult learners' metacognitive capacities, I conducted a qualitative content analysis of 30 learners' ePortfolios developed in the introductory college writing course for adults at the end of the term, intentionally seeking evidence of metacognition. I implemented a method of data collection and analysis that would allow me to encompass the textual as well as the new media aspects of the ePortfolios since prior research does not take into account this affordance of ePortfolios that differentiates it from print- and text-based portfolios.

I chose content analysis as the method because it offers an opportunity to analyze static documentation (usually transcripts) to evaluate group learning, deep learning, cognitive skills, and metacognition (Newman, Webb, & Cochrane, 1995; Akyol & Garrison, 2011; Saldana, 2009). I also wanted to quantify this qualitative data in order to determine categories and identify the metacognitive patterns that were occurring in the learners' portfolios, if any, which involves a process of reducing, segmenting, identifying and mapping the data to a coding scheme, and finding patterns in those mapped "formalisms" (Chi, 1997). However, I wanted to intentionally look for evidence beyond text-based artifacts since the learners can incorporate new media, so, in the first pass of content analysis, I conducted a descriptive page-by-page inventory of all new media ePortfolio contents, segmenting them into text, image, embedded documents, forms, video, links,

commentary, and organization schema. In essence, I created descriptive annotated site maps for each portfolio that reflected the learners' choices of new media content for each page as well as their arrangement of that content across and within pages (see Figure 2).
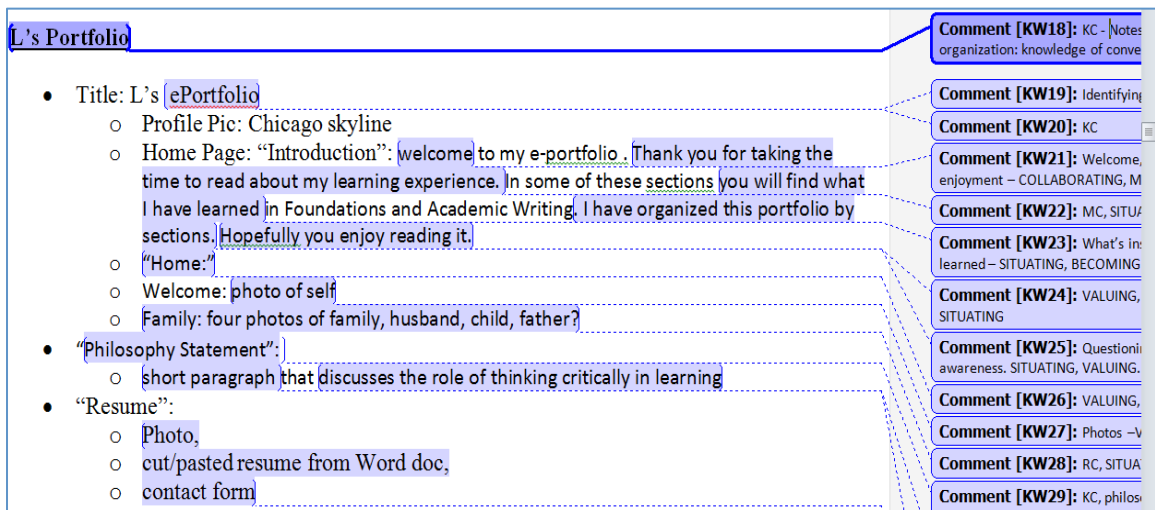
Figure 2. Descriptive annotated site map.

After creating these annotated site maps, I recruited a member of the adult learning program faculty at DePaul University who had experience assessing student work for evidence of metacognition. Together we individually and then collaboratively used process coding (Saldana, 2009) to code for places in these descriptive site maps where we felt learners demonstrated metacognition in the form of self-regulation, self-monitoring, and reflections on their learning processes in the writing course, going back to the actual content of the ePortfolios for additional context when necessary. Process coding, a method of coding actions (codes are typically gerunds ending in "–ing"), was useful here because metacognition is often defined with action-based criteria as in Akyol and Garrison's (2011) metacognition construct in Table 4 below (i.e. commenting,

questioning, setting goals). Thus, the first codebook we developed included these words as process codes as well as any others we felt were not captured by the construct, such as "welcoming questions and comments," "demonstrating knowledge of community," "connecting learning experiences," "recognizing new learning," and "sharing learning." For example, if a learner chose to embed a contact form on a particular page within the portfolio, we coded this as "seeking support" and "inviting comments from community." If a learner organized his pages and constructed a menu that reflected steps in the writing process, we coded this as "monitoring" and "demonstrating knowledge of process."

Table 4. Akyol & Garrison's (2011) metacognition construct for a community of inquiry.

Metacognition in a Community of Inquiry		
Knowledge of Cognition (KC)	**Monitoring of Cognition (MC)**	**Regulation of Cognition (RC)**
(Entering Knowledge/Motivation)	(Assessment/Task Knowledge)	(Planning/Strategies)
Pre-Task Reflection	Reflection on Action	Reflection in Action

• Knowledge of the inquiry process
• Knowledge of critical thinking and problem solving
• Knowledge of factors that influence inquiry and thinking
• Knowledge of self as a learner
• Entering motivational state
• Knowledge of discipline
• Knowledge of previous experiences
• Expectancy of success
	• Declarative; judging
	• Commenting on task, problem or discussion thread
	• Asking questions for confirmation of understanding
	• Commenting about self's and others' understanding
	• Making judgments about validity of content
	• Commenting on or making judgments about the strategy applied
	• Asking questions about progression or stalling
	• Expressing emotions during learning
	• Assessing motivational state and effort required
		• Procedural; planning
		• Setting goals
		• Applying strategies
		  o Providing/asking for support
		  o Challenging self or others
		  o Asking questions to deepen thinking
		  o Asking for clarification
		  o Request information
		  o Self questioning
		• Questioning progression, success
		• Taking control of motivation and effort
		• Facilitating/directing inquiry

The coder and I then did the following:

(1) compared our codes across the 30 portfolios,

(2) combined codes that we felt were redundant,

(3) categorized the remaining codes under the three headings that Akyol & Garrison constructed (knowledge of, monitoring, regulation),

(4) discussed and came to an agreement on any instances of codes in the portfolios where we differed in interpretation,

(5) counted the frequency of each of these final codes across the 30 portfolios,

(6) identified patterns that would suggest common manifestations of metacognition in the ePortfolios' verbal and new media data (Saldana, 2009; Chi, 1997).

2.1.1 Findings

The final list of 14 codes and the frequencies for each code across the 30 portfolios are in Table 5 below. These results show that the text and new media contents of the learners' portfolios demonstrated the "knowledge of cognition" codes the most frequently (76 total instances) and demonstrated the "regulation of cognition" codes the least frequently (52 total instances). The individual codes with the highest frequency were as follows:

- knowing self as learner

- knowing relevant experiences

- commenting on task/process

- inviting comments from others

- planning

- setting goals

Table 5. Frequency of metacognition codes for content analysis of ePortfolios.

Category	Code frequency*
Knowledge of Cognition	
Knowing self as learner	21
Knowing learning community	9
Knowing relevant experiences	31
Knowing discourse/discipline expectations	15
Total	**76**
Average	**19**
Monitoring of Cognition	
Commenting on self/others' understanding	13
Commenting on task/process	36
Asking questions to confirm understanding	1
Inviting comments from others	17
Judging	6
Total	**73**
Average	**14.6**
Regulation of Cognition	
Questioning	3
Applying strategies	10
Planning	22
Setting goals	11
Seeking support	6
Total	**52**
Average	**10.4**

*one coded unit = sentence or group of sentences reflecting code - or - new media decision reflecting code

After an analysis of the process codes, we went back to the portfolios to find a few examples for each of the three higher-level metacognition factors (Knowledge of, Monitoring of, Regulation of) so we would have a better sense of how to assess adult learners' portfolios for metacognition in the future. For Knowledge of Cognition, the learners situated themselves within a learning community by posting new media that represents their learning or writing identity. For Monitoring of Cognition, the learners understood themselves as learners/writers and navigate the learning process as evidenced in their images, navigation, and supporting textual content. For Regulation of Cognition, the learners demonstrated what they valued with regard to learning, at times doing the bare minimum requirements for the portfolio assignment, and how this impacts the evidence in the ePortfolio. All three of these metacognitive factors were evident in the textual and new media elements the learners chose to include in the ePortfolio as well as in how they structured, labeled, and linked these elements in the context of their learning in the course and within the learning community.

A. Knowledge of Cognition

As noted above, the process codes that appeared under the Knowledge of Cognition factor were: (a) Knowing self as learner, (b) Knowing learning community, (c) Knowing relevant learning experiences, and (d) Knowing discourse/discipline expectations, with codes a and c appearing most frequently. We identified these elements in their decisions relative to homepages, images and videos that represent their identities, and comment and contact forms that they had the option to include as a function of the software.

All 30 learners chose to include a Welcome page or About Me page as the ePortfolio landing page. Some learners only included text-based signifiers of identity, such as a general greeting, name, age, location, job, and explanation of the purpose of the portfolio. However, other learners also chose to include images, videos, and links that reflected the topic of the course (writing) or some aspect of the learner's identity (see Figure 3). By choosing to include these elements in their "Welcome" page or "About Me" page, learners situated themselves within the learning community in non-textual ways.

Figure 3. Images and videos that reflect the course topic and learners' identities as learners and professionals.

Instructors did not require learners to include a Welcome/About Me page or integrate new media elements reflecting their identities as learners. Thus, it is more than likely that learners' intentionally chose to include new media elements in this way because not only are they conventional elements for other digital representations of self such as personal homepages and social media, but also

because these were common elements they identified in other learners' ePortfolios in the system through the directory. While the learners were following the lead of other learners in this regard, their unique choices of new media content for these pages gave them an opportunity to show others what they valued and had to contribute to the community. This demonstrates their knowledge of strategies for identifying with other learners in the ePortfolio community via image and video. This is a metacognitive characteristic because it shows that learners are intentionally and independently thinking about what the discipline of writing entails, building their ethos, and recognizing what it takes, on an individual level, to enter the larger learning community.
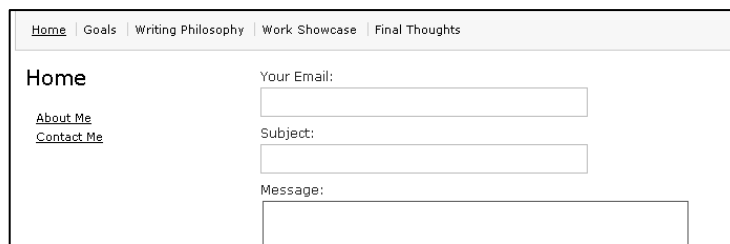
B. Monitoring of Cognition

Recall that the process codes for Monitoring Cognition included: (a) Commenting on self/others' understanding, (b) Commenting on task/process, (c) Asking questions to confirm understanding, (d) Inviting comments from others, and (e) Judging. Codes b and c occurred most frequently in the portfolios.

The first example of learners' monitoring of their cognition was their comments on their understanding and engaging with others to help them monitor their learning. On their welcome pages and introduction to other pages, learners invited the community to connect with them and join them in discussion about the ePortfolio contents, asking that they "enjoy this ePortfolio", "leave a comment," "contact me" or "provide feedback". By default, every page within the ePortfolio system has a comment form that allows others to write to the author in the context of a specific page. The learners receive an email notifying them that someone has

left a comment, and the learners have the option to make the comment public.

Learners demonstrated metacognition by showing their awareness of the

possibilities of this feature for soliciting feedback and encouraging other

community members to use it. One learner stated in his portfolio, "As a techie,

[this portfolio] really allows me to have fun in creating it but also as a place to see

my work in an open space where others can comment as well for great feedback."

Another learner chose to make a commenter's message public, that of her teacher,

and points it out to her audience: "I am also including feedback from my

professor for the essay drafts to show the progression of my writing."

In addition, many learners independently discovered the "Contact Me"

form offered by the software as an option to embed on any page. Again,

instructors did not specifically discuss or require use of this feature of the

software; they only encouraged learners to explore what the software had to offer.

While some learners created a separate "Contact" page at the end of the menu, as

would be found on any commercial or personal website, many learners included it

in their Welcome or About Me page, suggesting that a form of contact should not

be an afterthought, but a first consideration for the audience (see Figure 4).

Figure 4. Learner embeds a Contact Me form within her Home page,

below her About Me page.

The inclusion of the contact form and reference to the comment feature

reflected learners' awareness of the value of feedback and communication in

learning and that the community is an important part of their learning. This "first

look" at the learner's identity and their "first contact" with others in this

community provides important insights into learners' metacognition: they are

showing an understanding of what it means to be part of the learning community

and situate themselves as learners (and writers) within it. They show an

understanding of their audience, the community in which they are participating,

the purpose for their participation, and their unique role, authority or ethos, and

potential contribution to it.

Additionally, how a learner decided to organize and label their ePortfolio

menu hyperlinks and navigation structure was the second type of evidence for

how the learners were becoming writers and reveals, in a symbolic way, how they

"navigate" or monitor their own learning. Since learners had complete freedom to

choose how to organize, how to label, and what to include in the sections and

menu items for the ePortfolio, their choices in this regard often aligned with the

learning process they characterized in their writing philosophy, final plan, or other

reflective pieces required for the course. In the majority of ePortfolios, learners

created, labeled, and organized menu items that reflected a chronological

progression through the course (see Figure 5) and the drafting process (Figure 6).

About Me | Writing Plan (Start of the Term) | Philosophy Statement | Work Showcase | Resume | Writing Plan (End of the Term)

Figure 5. Top level navigation shows progress from
"Start of the Term" to "End of the Term."

Work Showcase

Expository First Draft
Expository Second Draft
Expository Final Draft
Comparative First Draft
Comparative Second Draft
Comparative Final Draft

First Drafts
Expository
Comparison
Analytic
Persuasive
Final Drafts
▼ Expository
▼ Persuasive

Persuasive Essay

Draft 1
Draft 2
Draft 3
Teachers Comments
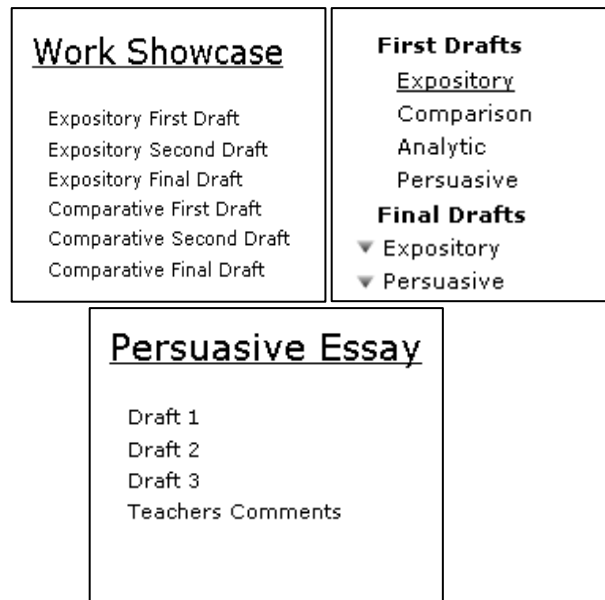
Figure 6. Sub-section navigation shows chronological progression through the drafting process.

In essence, the type and organization of the ePortfolio menu items reflected their process as writers and their intentions to move from novices (first drafts or beginning of the course) to experts (final drafts or the end of the course). Even if learners were simply reiterating the order of assignments in the course syllabus (which followed the drafting process) or following the structure they saw in another portfolio, their deliberate choice to "re-mix" the labels and organization of the pages in this way demonstrates metacognition in the sense that they recognize that these are strategies inherent and important in the expert process of writing—they were taking ownership of and monitoring them.

Additional evidence of learners' move away from novice status as learners and writers, and their monitoring of their cognition, was noticeable in their choices and arrangement of quotes, images, and videos in the context of their

early reflections compared to their final reflections. In their early reflections, learners included quotes, images and videos about writing from perceived authorities (authors, writers, scholars). In the learners' writing philosophies and final reflections, learners generated their own quotes or theories on writing, as "emerging authorities," with images that support this theory (see Figure 7). In neither case were learners instructed to include or organize these elements in this way. For example, on her Welcome page, a learner quotes a professional writer: "'We do not write in order to be understood; we write in order to understand.'-- Robert Cecil Day Lewis." She also included a link to a video titled, "Writers on Writing" in her second page of the portfolio titled "Goals". Later, she writes in her final reflection, "I was able to reflect on my ability to target my audience, identify my writing task, and effectively reach the goal of my writing. I then concluded that I am a writer."

Figure 7. Images and videos show learners' thoughts on being a writer and aspects of the writing process

In addition, these reflective artifacts that demonstrate monitoring of cognition appeared in separate sections before (to the left of/above) or after (to the right of/below) draft sections. In a few cases, learners embedded these reflections

as introductions for each draft section, demonstrating their self-monitoring at a higher level (see Figure 8).

Expository Essay

Expository Essay - Draft 1
   Feedback - Draft 1
Expository Essay - Draft 2
   Feedback - Draft 2

This essay was my first writing assignment for class. The instructions were to write about a recent challenging experience in my life. In this draft, I basically just put everything out there and tried to make sure it read smoothly. Because this was a personal experience, I felt the essay was slightly easier to write.

Figure 8. Arrangement of reflections as introductions to drafts.

While some of these written reflection artifacts were assignments in the course, learners' decision to post and place them in specific locations within the portfolio demonstrated their recognition of self-monitoring in the learning process as well as an audience, or community, that values this type of reflective practice or reflection-in-action. Again, learners made these choices independently; they were not instructed to post or locate them in a specific area of the portfolio.

C. Regulation of Cognition

Regulation of cognition was the final metacognition factor with process codes including: (a) Questioning, (b) Applying strategies, (c) Planning, (d) Setting goals, and (e) Seeking support. The adult learners demonstrated codes c and d most frequently.

While the portfolios included evidence of learners' planning and goal-setting processes as noted previously, the learners did not provide evidence of deeper questioning of their learning, application of specific learning strategies, or intentional support-seeking mechanisms beyond inviting comments in their portfolios. In fact, in more than half of ePortfolios, learners cut and pasted their drafts from Microsoft Word docs, did not change the format (including the MLA

paper heading of name, date, instructor at the top), and only sometimes provided

context for how a particular draft or set of drafts made a contribution to their

learning or the learning community (see Figure 9). This lack of "re-mediation"

and minimal context was a sign that learners were appealing to the requirements

for the course--doing what matters to the teacher with little focus on connecting,

questioning, transferring, or pursuing support from the community on specific

learning goals or plans. This lack of follow-through and failure to apply strategies,

especially at the end of the course when the final learning portfolios were due, is

commonly seen with adult learners who often do minimal requirements to pass if

they have prioritized other things in their lives.
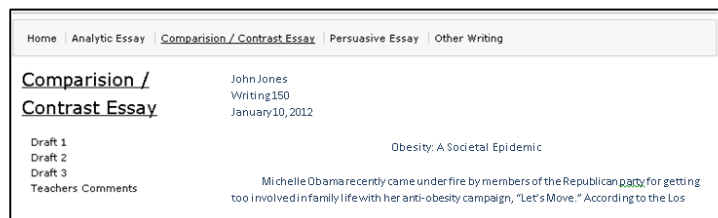
Figure 9. Essay not re-mediated and no introduction or connection to other

ePortfolio contents provided.

On the other hand, after exploring other elements of the learners'

portfolios, it became apparent that the topics of the essay drafts oftentimes

reflected something related to the learner's interests and, in a few cases,

connected to signifiers of identity in their About Me and Welcome pages. Many

of the essays assignments that teachers assigned in the course encouraged learners

to write about something that interests them or with which they had experience,

and a few learners did make these connections explicit for the community in the

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digital environment of the ePortfolio. They did this by adding reflective statements at the top of pages that connected one page to the next, removing print-based formatting elements like headings, embedding links to information on the web when relevant in the body of their writing, and embedding images that support the content of their essays, all without guidance from the instructor. So while many learners were good at setting goals and plans at the beginning of the course, only a handful were able to demonstrate their overall ability to apply their strategies and show their learning over time and across contexts independently.

2.1.2 Discussion

What is most interesting about the content analysis of an ePortfolio community is how much the adult learners revealed, beyond text and across media, about their metacognitive ability to situate themselves within a learning community, track their learning process, and monitor and evaluate their understanding and value of the discipline (writing, writers). However, it also shows that they can benefit from further support in following through with applying and transferring their learning strategies while independently pursuing their learning and seeking further support.

In the Knowledge of Cognition pattern of behavior, learners' selection and presentation of new media artifacts in their "About Me" and "Welcome" pages were evidence of how they understand and situate themselves as learners in this learning community. These elements not only reflected what the learners value about themselves and their own experiences, they also reflect how learners perceive the learning community's values and what contributions they may be

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able to make when participating in it. In other words, this was evidence of learners' understanding that they need to situate themselves, albeit peripherally, in a community of learners. The arrangement and organization of artifacts via hypermedia (menus, submenus, navigation schema) and the progression from citing others' perspectives on writing to crafting their own presentation of what it means to write and be a writer showed that learners were thinking about their learning process; they were thinking about the underlying concepts and recognized strategies for becoming an expert writer and monitoring their cognition. And, finally, the obvious cut-and-pasted document format and lack of providing context between essay drafts, as well as the underlying connections that learners could have made among ePortfolio elements, signals a metacognitive focus on what learners did or didn't value and how this reflects their need for more support in regulation and transferring their cognition across domains and contexts. On the one hand, many learners were doing what was "required" of them at a bare minimum, signaling that the conventions noted by the teacher were important to follow. On the other hand, learners also were signaling the importance of their representations of learning in the ePortfolio, but did not feel it was necessary to make a connection between these elements apparent to the community. While this evidence suggests that metacognition is fairly weak for many of these learners, it is still evidence of metacognition nonetheless. It suggests that strategies to improve metacognition for adult learners may need to be approached differently.

Finally, in many cases, the learner's connection between identity as a learner, the learning experience, and the community could have been better prompted and supported in an intentional and direct way. This suggests the need for an intentional approach to metacognitive development in the classroom and within learning communities such as this one. Since a few learners demonstrated strong metacognitive ability through the creation, organization, and integration of ePortfolio content and their connection with the online community, it is important to continue to explore approaches to metacognitive development with a focus on learners' participation in identity construction and collaborative learning environments.

2.2 ADULT LEARNERS' METACOGNITIVE AWARENESS INVENTORY (SELF-ASSESSMENT)

In the term following the content analysis of portfolios, I aimed to better understand adult learners' own assessment of their metacognitive awareness. I wanted to see if there was any alignment with the learning portfolio evidence mentioned previously to see how we can characterize adult learners in terms of their metacognitive ability in order to better support them, especially in e-learning environments.

For this study, I asked a group of adult learners to respond to 52 prompts about their metacognitive awareness. The prompts were developed by Schraw and Dennison (1994) as the "Metacognitive Awareness Inventory (MAI)", discussed in Chapter 1, which asks learners to identify their metacognitive practices. For each prompt in the MAI, adult learners were asked to check a box as to whether

the prompt applied to them "Rarely" or "Most of the time". They were also given an "N/A" option. In addition to completing the MAI, they were asked to select whether they take their courses primarily online or on-campus (in-person) and their age. I asked learners to identify whether they learn primarily online or on-campus to see if there was any difference in these two types of learners, especially since e-learning is becoming the primary mode for adult learners in both formal and informal learning contexts.

I distributed the MAI to 81 adult learners actively enrolled in the same bachelor's degree program for adult students 24 and older at DePaul University as discussed in the previous section. I made an effort to obtain responses from a mix of online and on-campus learners by sending it to 43 learners enrolled in at least one online course in the term in which they were surveyed, and 38 enrolled in at least one in-person course. I also controlled for participants' expertise level by sending the survey only to students who were enrolled in a section of the introductory writing course for adult learners (described in previous section), which means they were in the early stages of the program.

The MAI was distributed to the students via a link to a Qualtrics survey in an email message sent in the middle of the 10-week fall term (DePaul is on an academic calendar divided into 10-week quarters rather than 15-week semesters). Of the 81 students who were sent the link to the inventory, 37 responded and gave their consent to participate. Nineteen of those who responded reported that they take their courses primarily online (OL), and 18 reported taking their courses primarily in-person (IP). The average age of participants was 43 years old.

The participants' responses to the MAI were analyzed using descriptive statistics to determine patterns in metacognitive awareness. The prompts most frequently selected for "Most of the time" and for "Rarely" were noted, as well as the type of metacognition the prompt reflected (Knowledge of Cognition or Regulation). Then, the responses were compared using a contingency table to see if there were significant differences between the OL and the IP groups.

2.2.1 Findings

The participants (both OL and IP) selected the following prompts as applying to them "Most of the Time":

- I ask myself periodically if I am meeting my goals.
  (Regulation: Comprehension Monitoring)
- I use different learning strategies depending on the situation.
  (Knowledge of Cognition: Conditional)
- I periodically review to help me understand important relationships.
  (Regulation: Comprehension Monitoring)
- I think of several ways to solve a problem and choose the best one.
  (Regulation: Planning)
- I can motivate myself to learn when I need to.
  (Regulation: Planning)
- I create my own examples to make information more meaningful.
  (Regulation: Information Management)
- I reevaluate my assumptions when I get confused.
  (Regulation: Debugging strategies)

On the other hand, the participants selected the following prompts as applying to them (both OL and IP) "Rarely":

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- I know when each strategy I use will be most effective.
  (Knowledge of Cognition: Conditional)
- I ask myself if I have considered all options after I solve a problem.
  (Regulation: Evaluation)
- I focus on overall meaning rather than specifics.
  (Regulation: Information Management)
- I draw pictures or diagrams to help me understand while learning.
  (Regulation: Information Management)

The IP participants only selected the following prompts as applying to them "Rarely":

- I know how well I did once I finish a test.
  (Regulation: Evaluation)
- I am good at organizing information.
  (Regulation: Information Management)

The following prompt was selected by the OL participants most frequently as applying to them "Rarely":

- I know what a teacher expects me to learn.
  (Knowledge about Cognition: Declarative Knowledge)

To determine if there were significant differences between the responses of participants who identified as OL and IP, I analyzed the total responses for each prompt with a Fisher's Exact 2 x 2 contingency table. The following were significant differences ($p < 0.05$) between OL and IP participants, all of them for "Most of the Time" responses:

Table 6. Significant differences in OL and IP MAI responses.

MAI Prompt	OL	IP	p-value
I try to use strategies that have worked in the past. (Knowledge of Cognition: Procedural)	19	10	0.001
I understand my intellectual strengths and weaknesses. (Knowledge of Cognition: Declarative)	16	9	0.04
I find myself pausing regularly to check my comprehension. (Regulation: Comprehension Monitoring)	18	12	0.04
I ask myself how well I accomplish my goals once I'm finished. (Regulation: Evaluation)	15	8	0.05
I stop and reread when I get confused. (Regulation: Debugging)	19	10	0.002
I ask myself if I learned as much as I could have once I finish a task. (Regulation: Evaluation)	10	16	0.03

Of these 37 adult learners who completed the MAI survey, all demonstrated strengths and weaknesses in both their knowledge of cognition as well as their regulation of cognition. Both online and on-ground adult learners felt they engaged in metacognitive practices such as monitoring learning, comprehension strategies, and planning most of the time, while they less frequently engaged in the metacognitive practices of managing resources and information, knowing when to apply learning strategies, and evaluating their strategies for learning. An unexpected result from the MAI was that OL learners tend to more frequently use strategies from the past, understand their strengths and weaknesses, assess comprehension, and assess goals than the IP learners. The only area where IP learners more frequently engaged in metacognitive practices than OL was regarding reflecting on the success of completion of a task.

2.2.2 Discussion

These studies suggest that these adult learners have strengths and weaknesses in their metacognitive practices, and require scaffolded support for developing their weaknesses and leveraging their strengths, no matter if they are primarily in-person or online learners. I hypothesized that an intervention that supports adult learners' metacognitive development would help students leverage their strengths in identifying and situating themselves in learning contexts, planning, and monitoring their cognitive processes for learning. Further, I hypothesized that an intervention should support them in improving their weaknesses. Based on this study, the sociotechnical system that supports learners should support them in managing resources and information, integrating their varied learning experiences to strategize for the future, and evaluating themselves as learners and their learning strategies.

When considering the metacognitive differences between online and in-person learners that the first two studies revealed, it appears that learners who learn primarily online or who interact in a digital environment were stronger in their metacognitive abilities on several points. I can hypothesize that learners who frequently learn and interact in an online environment are either pre-disposed to stronger metacognitive ability and so feel more comfortable in online courses or perhaps they may develop their metacognitive abilities by nature of participating in the online environment, which tends to require more independent, self-directed, self-regulated participation. However, I cannot make cause and effect conclusions about this information, since asking learners whether they learn primarily online

or in-person in this survey had its limitations. Many factors influence a person's decision to learn online versus in-person, and many of these factors may be out of the learners' control, such as their company cannot afford to send them to a trade workshop or their family obligations require them to take their college courses online. Additionally, while a person identifies as taking courses primarily online, as I asked them to do in this study, many may have varying experiences and preferences with online learning environments. Due to these multiple confounding factors, I felt that I should not be too hasty in drawing conclusions about the metacognitive differences between OL and IP participants, but with this study's results, we know that this is a topic to investigate in the future. In any case, it is clear there are many factors with which adult learners need support, no matter whether they learn primarily online or in-person. A sociotechnical system must leverage these strengths and weaknesses through scaffolding, self-assessment, and peer interaction, especially if some learners are stronger are some key metacognitive factors than others.

2.3 SUMMARY

These two studies have provided insights relative to my first research question (RQ1), "How can we characterize adult learners' metacognitive abilities?" The content analysis of adult learners' portfolios shows that they are adept at situating, monitoring, and tracking their learning and their identities in a learning community. It also showed that they need more scaffolding in evaluating and integrating their various experiences and identities, which would ultimately lead to deeper learning and transfer. The MAI survey supported the content

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analysis results in that adult learners reported that they are most adept at the metacognitive monitoring and tracking and need more support in managing information and resources and evaluating their learning strategies, experiences, and practices.

In Chapter 3, I will discuss how I used these findings about adult learners' metacognitive needs and requirements to design a sociotechnical intervention to support adult learners in their metacognitive development called "ReflectCoach". I will also discuss the results of two iterative designs and tests of ReflectCoach with adult learners in an effort to answer my second research question, "What are the important design parameters (elements and features) for e-learning technologies that support adult learners' metacognitive development?"

CHAPTER 3: SUPPORTING ADULT LEARNERS' METACOGNITIVE

DEVELOPMENT WITH A SOCIOTECHNICAL SYSTEM

Adult learners need additional support with metacognitive factors of

managing resources and information, integrating their varied learning experiences

to strategize for the future, and evaluating themselves as learners and their

learning strategies (see Chapter 2). They are already engaged in metacognitive

practices of identifying and situating themselves in learning contexts, planning,

and monitoring their cognitive processes for learning. What are the important

design parameters (elements and features) for e-learning technologies that support

adult learners' metacognitive development? This is my second research question.

Recall, in Chapter 1 I discussed research on adult learners that suggests

that this population learns best through critical reflection on their prior learning

and experiences from a variety of venues, such as work, school, community, and

family (Knowles, Holton, Swanson, 2012). Additionally, designers need to be

mindful of adult learners' need for relevancy, attention to intrinsic motivation, and

respect as experts and as a mature individuals with a great number of external

responsibilities and limited time and resources (Cercone, 2001; Blondy, 2007;

Knowles, Holton, Swanson, 2012). Pedagogical practices and tools that are

intended to support metacognitive development, like learning ePortfolios and

intelligent tutoring systems (ITSs), either need to offer scaffolding to improve

learners' integration of identities, prior learning experiences, and content

knowledge or require more authentic, personally relevant contexts (Wozniak &

Zagal, 2012, Wozniak & Zagal, 2013). This is especially the case for adult

learners 24 and older who have many more experiences than traditional college-aged learners on which to reflect, many of which are not part of formal learning structures and systems. The intervention also needs to incorporate authentic social or peer interaction, which adult learners tend to prefer (Huang, 2002, Snyder, 2009).

Based on the findings described in Chapter 2 and the principles for metacognitive development, adult learning, social learning, and persuasive design discussed in Chapter 1, I hypothesized that adult learners' metacognitive awareness would improve through intentional scaffolding and support for metacognitive development via a sociotechnical system with required weekly use. In short, a sociotechnical system involves interactions of technology, users, other people, subsystems, environment, and social structures. Whereas user-centered design can focus on a sole user's interaction with technology, the focus with sociotechnical systems is on multiple users and the environment around them as they engage with systems, such as, but not limited to, technology (Fox, 1995). In education contexts, a "socio-technical systems approach to learning integrates curriculum, teaching, assessment, and technology that go beyond task-specific practice and one-time summative assessments, whether in the workforce or in education" (Richey, Nance, Hanneman, Hubbard, Madni, & Spraragen, 2014). With that in mind, I hypothesize that a sociotechnical system that supports adult learners' metacognition will be most effective if it offered:

    a. Guidance in the tracking, analysis of, and reflection upon one's own learning, invoking principles of ubiquitous persuasive

technology such as weekly reminders to complete system

activities, an interactive element to demonstrate the learners'

progress with different types of metacognitive development, and

tips (content) for improving their metacognitive practice;

b. Opportunities to effectively reflect upon and develop one's

metacognitive skills weekly through self-assessment metacognition

quizzes, open-ended reflection activities involving authentic,

personally relevant experiences and learning

c. Access to learning communities and communities of practice to

explore and learn from others metacognitive development through

a discussion forum where users can post and search tips/strategies

for metacognitive development in field-specific or discipline-

specific situations that are relevant to them.

In this chapter, I will describe the sociotechnical system I created based on
these hypotheses and the studies discussed in Chapter 2, called "ReflectCoach",
and the two iterative experiments I conducted to test its effectiveness in
improving adult learners' metacognitive ability over ten weeks. I designed,
iteratively tested, and revised ReflectCoach with a treatment group of adult
learners enrolled in an introductory online writing course and compared their
metacognitive development to a control group in the same course who did not
interact with ReflectCoach. There were a total of 24 participants in this study: 8 in
the first iteration and 16 in the second iteration. After conducting the experiment

with the treatment group, and analyzing pre-test/post-test MAIs and learners'

portfolios for evidence of metacognition for both the control group and the

treatment group, I found that a sociotechnical system with these aspects does, in

fact, support adult learners' metacognitive development.

3.1 THE REFLECTCOACH INTERVENTION

I designed ReflectCoach based on the findings from Chapter 2 as well as

the literature on designing for adult learners, social learning, persuasive design,

and based off of the advantages of existing metacognitive development support

systems. I chose to make ReflectCoach a responsive, web-based application; a

web application was chosen over a desktop application due to its ubiquity and

accessibility: it can be accessed anytime by anyone with a computer and Internet.

My findings from Chapter 2 also suggested that ReflectCoach needed to support

the learners across four areas of metacognitive practices:

- Planning and Organizing:

  While adult learners are fairly strong at planning and organizing,

  research shows that they need support in leveraging these strengths

  and knowing when to apply and change them in different contexts.

- Monitoring and Integrating:

  The Portfolio Content Analysis and the MAI Study showed that

  learners were fairly strong in monitoring but need more support in

  integrating and transferring their learning across contexts and

  domains.

- Seeking Support and Managing Resources:

  Both the Portfolio Content Analysis and the MAI Study showed that learners were weak in seeking support and managing resources and thus need support in strengthening them and learning new strategies.

- Evaluating:

  Again, both the Portfolio Content Analysis and the MAI Study showed that learners were weak in intentionally evaluating their cognition - their successes and failures - and thus need support.

These four areas became the main navigation in the system (see main navigation in right sidebar of Figure 10 below).
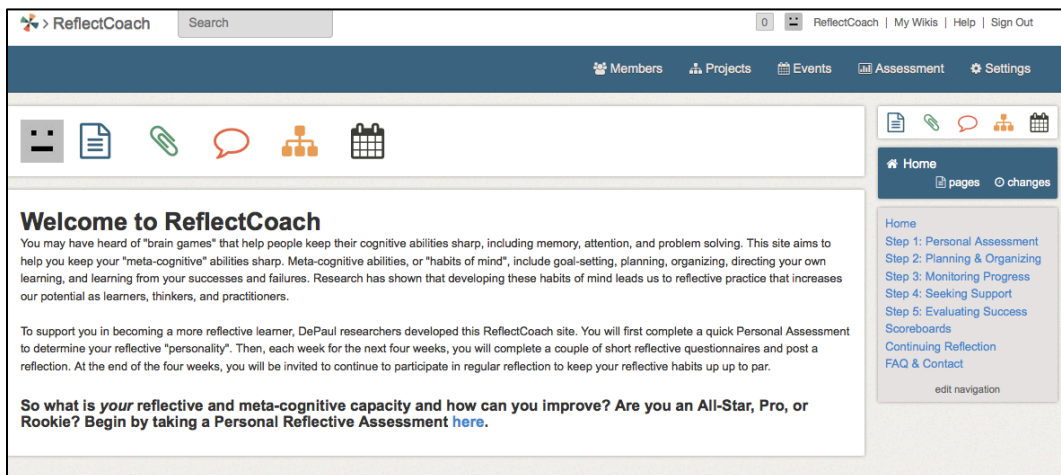
Figure 10. ReflectCoach home page; main navigation on right.

I designed ReflectCoach so that learners would explore these four areas through a combination of *three key persuasive and social design features that align with adult learning principles* to facilitate their metacognitive development:

(1) *Classroom wiki* that facilitates social learning through *membership* and participation in *weekly reflection forums* with other learners. A social learning environment like a wiki supports adult learners in recognizing the value of what they are learning in the context of a broader community of learners while allowing for self-direction. A wiki with membership privileges, versus a highly formalized learning management system or ITS, also gives them the opportunity to participate in learning in a scaffolded, low stakes, and informal manner where they have control, which aligns with the principles of both adult learning, metacognitive development, and persuasive design. The high-level navigation in the wiki walks the participants through each of the four metacognition areas described above over the course of ten weeks (see Figure 10 above). Within each of the four menu items are weekly reflection forums, where learners posted in response to prompts about their metacognition relative to the four areas. For example, in Week 1, learners participated in a forum about Planning & Organizing where they responded to a prompt that asked them to, "Describe a goal you have set for yourself this month. How do you plan to reach it? What strategies will you use?"

(2) *Self-scoring metacognition awareness questionnaires* aid adult learners in self-assessing their metacognition within each of the four main areas in the ReflectCoach navigation. Based on the results of the portfolio content analysis, the questionnaires were designed to prompt learners to consider their regulation of cognition and how they transfer strategies with questions like, "How often this

week did you consider whether a strategy you used was appropriate for the situation?" The questionnaires are also designed to prompt learners to think about the MAI questionnaire topics that both in-person and online learners felt applied to them "Rarely" as described in Chapter 2: conditional knowledge of cognition, information management, evaluation. An example question for information management was: "How often in your current course have you drawn diagrams or pictures to help you understand a concept?" Participants scores on these questionnaires automatically display on a public score page so users can see their own and others' scores (as shown in Figure 11 below) and benefit from iterative weekly self-assessment (persuasive), competitive group identification as Rookie, Pro, or All-Star (both social and persuasive), as well as intrinsic and extrinsic motivation (adult learning principle).

Figure 11. ReflectCoach public scoreboard.

(3) *An automated email agent* that reminded learners of weekly activities and progress (see Figure 12 below). The automated email agent serves to remind users

of next steps and updates each week and lets them know when another user has responded to a discussion post. This encourages a persuasive "habit" of reflection on metacognitive strategies each week and supports continued participation. The email agent also helps adult learners to prioritize and know what needs to be done, which aligns with the adult learning principles discussed earlier.
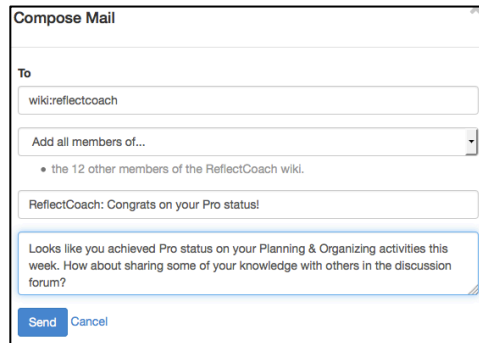
Figure 12. ReflectCoach automated email agent.

A learner who first joins ReflectCoach is prompted to complete an auto-scored personal assessment that tells him/her the starting level of metacognitive awareness: Rookie, Pro, or All-Star. This personal assessment uses a random selection of prompts from Schraw and Dennison's (1994) Metacognitive Awareness Inventory (MAI), such as "I ask myself every so often if I am meeting my goals." The learners see their assessment results in a public scoreboard where they can also see others' scores for comparison. For privacy reasons, scores were shown using a secret numerical code rather than names. Personal assessments like these encourage metacognitive activity and identity development for learners– they are beginning to develop an identity in relation to metacognitive awareness. While the "Rookie", "Pro", and "All-Star" score categories are arbitrary and

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superficial, they help learners tell the story of their learning and can help them see a trajectory of their development (Clark & Rossiter, 2008).

As noted above, for the next several weeks, participants complete similar self-scoring questionnaires on the four metacognition topics and contribute to discussion forums with prompts that encourage their reflection on metacognitive awareness and strategies. The reason for the questionnaires and discussion prompts was not whether the learners' answers are wrong or right; the reason was to use persuasive design so the learners engage in key metacognitive practices on a regular basis and get used to thinking about them, even if they were not actively aware of the metacognitive practices. Responding to the questions created an opportunity for self-assessment and reflection, which has been shown in previous studies to increase learners' metacognition (Bannert & Mengelkamp, 2013). Persuasive design, social learning, and adult learning principles are evident in the other features of the system, along with a meta-level engagement with metacognition, since learners are telling their learning stories and beginning to identify with the concept of metacognition in the assessments and discussion forums while tracking and monitoring their own and others' progress via the scoreboard and discussion forums.

3.1.1 Changes to ReflectCoach Iteration #1

ReflectCoach Iteration #1 was modified based on the results of user-centered research methods of conducting and analyzing interviews as well as analyzing log files.

During interviews with participants who used this first iteration of

ReflectCoach, participants stated that they felt the automated emails were helpful

reminders but were impersonal and that the questionnaires were somewhat

repetitive:

> "I sort of liked getting the regular reminders in my inbox, but I knew they
>
> were generic so I didn't actually open them and read them. But it was good
>
> to get the reminder anyway."

> "…there were a lot of questionnaires each time and I was wondering why
>
> there wasn't just one main one each week. Some of them were repetitive."

Additionally, three participants made reference to the need for more information

about seeking resources, knowing when to ask for help, and knowing what type of

help to look for, which was also a finding from the MAI and content analysis

discussed in Chapter 2. The metacognition scores of the learning portfolios

(discussed later) also demonstrated that participants in both the treatment group

and control group were weak in the metacognitive factor of evaluating. The log

file data for the Iteration #1 of ReflectCoach suggested that learners were not

using the discussions as often as expected; to that end, three interview participants

mentioned the forums, expressing concerns about no one reading what they

posted or about issues with privacy (since the wiki membership feature required

them to enter their email).

Based on these findings, I made the following changes in the second iteration of ReflectCoach: (a) sent more individualized automated weekly emails with a summary of the learner's completed tasks and a link to the next set of ReflectCoach activities as well as notices of any replies to their posts; (b) combined some questionnaires as learners felt these were too repetitive and unnecessarily parsed; (c) added more tips/tricks about metacognition in scoreboard pages so that learners could think of new ways to improve, especially on areas of seeking support and evaluation, and (d) did not require users to become "Member" of the site (they could participate as a Guest). ReflectCoach in its second iteration now incorporated the features described in Table 7 below, which also shows the alignment of social learning design, persuasive design, and adult learning principles for each feature.

Table 7. Aligning Persuasive and Social Design to Adult Learner Principles

ReflectCoach Design Element or Feature (persuasive or social)	Associated Adult Learner Principle(s)
Initial Personal Assessment Form (auto-scoring)	
--Learner takes inventory (form) of what he does and does not know about his metacognitive ability (persuasive) --instant feedback (persuasive) --unlimited attempts/"game the system" (persuasive)	Prior experience: adults come to learning situations with a variety of prior life experiences on which they draw and make meaning Readiness to learn: adults are ready to learn what is most relevant to them at a given time Need to know: adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know Self-concept: adults are responsible for their lives and are self-directed
Weekly, auto-scoring self-assessment questionnaires about metacognition	
--Multiple questionnaires (forms) on topics of each category allow learner to take inventory of what he does and does not know and gets into the "habit" of reflecting on metacognition each week (persuasive) --Instant feedback (persuasive) --Unlimited attempts/"game the system" (persuasive)	Prior experience: adults come to learning situations with a variety of prior life experiences on which they draw and make meaning Readiness to learn: adults are ready to learn what is most relevant to them at a given time Need to know: adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know Self-concept: adults are responsible for their lives and are self-directed
Scoreboard w/Achievement Levels and Tips	
--Learner sees score and realizes what he "needs to know" to become an All-Star (persuasive) or to meet their peers where they are (persuasive and social) --Score with tips (instant feedback) provide direct information on where the learner can improve based on	Readiness to learn: adults are ready to learn what is most relevant to them at a given time Need to know: adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know Motivation to learn: adults may be externally or internally motivated to learn, but the most

their score (persuasive)	influential motivation tends to be intrinsic
	Self-concept: adults are responsible for their lives and are self-directed
Peer forums with prompts encouraging discussion of personal metacognition	
--Learners are prompted to share a story about a real experience that relates to a concept of metacognition and reply to others with a comment (persuasive and social) --Learners can seek feedback or tips from their peers, which mimics instant feedback despite asynchronous setting (persuasive and social)	Prior experience: adults come to learning situations with a variety of prior life experiences on which they draw and make meaning Need to know: adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know Motivation to learn: adults may be externally or internally motivated to learn, but the most influential motivation tends to be intrinsic Learning orientation: adults learn best in real-life, authentic contexts
Privacy levels/settings	
(All aspects are both social and persuasive) -Learners can join as guest or user --Can choose username --Can choose anonymous code for scoreboard results --Other users do not know other identifying information	Learning orientation: adults learn best in real-life, authentic contexts Self-concept: adults are responsible for their lives and are self-directed
Email reminders/notifications	
--Learners receive emails to remind them of next steps to improve metacognition (persuasive) --Learners receive notifications when another user has responded to their prompt (social)	Need to know: adults want to know why they need to learn something or have a real-life experience that has resulted in their need to know Self-concept: adults are responsible for their lives and are self-directed Readiness to learn: adults are ready to learn what is most relevant to them at a given time

3.2 REFLECTCOACH EXPERIMENT

As with the previous studies, the 24 adult learners who participated in this study were enrolled in a section of a required introductory-level 10-week online writing course in a four-year bachelor's degree program for adult learners (age 24 and older) at DePaul University. The ReflectCoach experiment was conducted over two terms with a control and treatment group in each term. Thus, there were four test groups, two per term, taking a section of the same online writing course, as follows:

- Summer Term Adult Intro. Writing Course (ReflectCoach Iteration 1):
    - Control Group, n=4
    - Treatment Group, n=4
- Fall Term Adult Intro. Writing Course (ReflectCoach Iteration 2):
    - Control Group, n=8
    - Treatment Group, n=8

I asked half of the learners to interact with ReflectCoach during the course and half to participate as a control group. The average age of participants across both groups was 41. To measure metacognitive development before and after the course and learn more about their experiences, all participants (control and treatment) took a pre- and post-course Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994), developed and submitted a learning portfolio (a regular required assignment in the course that includes criteria for metacognition), and agreed to be interviewed at the end of the course. Accordingly, the independent variable was the use of ReflectCoach on the experimental group

while they were taking the online course. There were two dependent variables: (a) participants' change in metacognitive awareness score on the MAI and (b) control and treatment group participants' metacognition scores on their learning portfolios. The portfolios and the scores of the pre-/post-test were analyzed for significant differences between the treatment group and control group; they were also compared to log files and interview data to determine whether and how particular features of ReflectCoach supported metacognition. Nineteen participants (combined from both iterations) participated in follow-up semi-structured interviews – these were transcribed and analyzed separately for supporting information to contextualize the quantitative results. The instructor of the course was aware of the study being conducted, but did not know who agreed to participate and who did not. She taught the course as usual and did not interact with ReflectCoach at any point in the study.

I controlled for confounding factors when possible by ensuring that participants in both groups were adult learners (24 and older), taking the same course, with the same course content, and with the same instructor. Participants in the treatment group were prompted to begin interacting with ReflectCoach in Week 1 of the course via an email with a hyperlink. I then set up an automated agent that followed up with treatment group participants via email each week to encourage them to continue participating.

3.2.1 Measuring Metacognitive Development

To measure metacognitive development over the 10-week term, I used three instruments: a pre/post self-assessment, the participants' learning portfolios,

and 30-minute interviews. All learners completed an online 52-question MAI in the first and last weeks of the class – this was the pre-test and post-test for gauging any change in participants' metacognitive awareness. This inventory was then scored for frequency of "yes" responses for each participant (e.g. 40 yes/52 statements = 76% score). I used a Mann-Whitney test to determine whether the difference between the average score changes for the treatment group and control group was significant.

Additionally, as with the Content Analysis study discussed in Chapter 2, the learners completed a learning portfolio in which they tracked and reflected upon their learning during the course. For this study, these portfolios were used as instruments to measure both the control and treatment group participants' metacognition since the research discussed in the previous chapter and in other scholarship shows that learning portfolios can provide evidence of learners' metacognitive development over time (Abrami et al., 2013; Cambridge, 2008; Wozniak & Zagal, 2013). The participants were told in the existing portfolio assignment for the course that the portfolios would be assessed on how well they met writing-related criteria, such as rhetorical awareness, organization, and mechanics, as well as on how well the portfolios revealed participants' metacognitive capacities according to the three higher level factors of metacognition that were drawn from Akyol & Garrison's (2011) metacognitive construct and appeared in adult learners' portfolios in the Portfolio Content Analysis Study in Chapter 2: Knowledge of Cognition, Monitoring of Cognition, and Regulation of Cognition. These three criteria relative to metacognition are

listed in Table 8 below. The participants were given a scoring guide that listed and described each of these criteria.

At the end of the course, two raters, who were previously trained for assessing metacognition in learning portfolios as part of annual program development, blindly scored the participants' portfolios to determine the degree to which they demonstrated metacognition via the criteria in Table 8. The raters did not know if the portfolios they rated were in a control or treatment group. For each portfolio and each of the criteria in Table 8, raters chose "does not meet" when learners did not discuss or show any evidence of metacognition, "meets" when learners included text, images, or links demonstrating metacognition, or "exceeds" when evidence of metacognition went beyond a broad description to a specific application or self-evaluation. For example, the following would receive a "meets" score: "I plan to use peer review in the future". An "exceeds" score would be applied to: "I found that peer review gave me new perspectives, so I will bring my earlier drafts to the writing center." The raters' scores were analyzed for inter-rater reliability and then averaged across all three criteria for one "Overall" score for each participant's portfolio. The Overall scores between the control and treatment group were averaged and then tested for difference.

Table 8. Portfolio assessment criteria for metacognitive awareness.

Metacognition Criterion 1: Knowledge of Cognition	Learner demonstrates metacognitive awareness by discussing strengths, weaknesses, strategies, and tools with regard to his/her writing and writing process
Metacognition Criterion 2: Monitoring of Cognition	Learner demonstrates metacognitive awareness by evaluating their demonstration of the competence: points to specific strengths/weaknesses with writing
Metacognition Criterion 3: Regulation of Cognition	Demonstrates metacognitive awareness with a plan and goals to continue to develop writing

After the course, I conducted 30-minute semi-structured interviews with 19 participants (6 from the control group, 13 from the treatment group). I asked each participant about metacognition and, for those in the treatment group, about ReflectCoach. I asked members of both groups, "What are your thoughts on metacognition?" to gauge their understanding of the concept and their self-awareness. I also asked the treatment group, "What was your experience with ReflectCoach?" I analyzed these interviews using descriptive coding (Saldana, 2012) and then analyzed the codes to determine if any patterns aligned with the quantitative findings.

3.2.2 Findings

Twenty-four adult learners participated in the study (n=24). Iteration 1 had 8 participants: 4 participants in the treatment group and 4 participants in the control group (n=8). Iteration 2 had 16 participants: 8 participants in the treatment group and 8 participants in the control group (n=16). With each iteration of

ReflectCoach, adult learners who interacted with the web-based intervention received higher scores for metacognitive ability on their course learning portfolios and their post-course MAI than the control group who did not interact with ReflectCoach. The treatment group's posts to the ReflectCoach discussion forums also demonstrate that ReflectCoach was effective at prompting them to consider their metacognitive awareness and their existing or potential metacognitive development.

A. MAI Pre/Post Test Results

I calculated the average change in pre/post-test MAI score for the treatment and control groups for each iteration/term to determine if their metacognitive awareness improved after ten weeks in the course. I hypothesized that the treatment groups would improve due to their interaction with the intervention. This was the case in both iterations, though there were two outliers and two participants' scores that went down instead of up. I describe how I treated these data points below.

a. Iteration 1

As shown in Table 9 below, the average point change for the treatment group (15.5% increase) was higher than for the control group (6% increase). A statistical test for significance was not conducted because the sample size was too small. However, what is important to note here is that the score for both groups increased, which suggests that simply introducing the concept of metacognition by having learners self-assess with the MAI can lead to metacognitive development.

Table 9. Iteration 1: Treatment & control participants' pre-test, post-test, and change in MAI score.

Participant (T=treatment, C=control)	Pre-Test Score (%)	Post-Test Score (%)	Change (%)
T1	85	96	11
T2	71	80	9
T3	68	90	22
T4	72	92	20
		Average Change	15.5
C1	66	74	8
C2	70	79	9
C3	83	85	2
C4	73	78	5
		Average Change	6

b. Iteration 2

Surprisingly contrary to the results in Iteration 1, in Iteration 2, the average point change for the control (5.36% increase) was higher than for the treatment (1.34% increase) (see Table 10 below). However, the mode increase for the treatment group was 11% and the mode increase for the control group was 4%. There was one outlier in the control group (increase of 29%) and one outlier in the treatment group (decrease of 29%) that skewed the averages in both. With these outliers removed, the average change for the treatment was a 5.61% point increase, and 2.29% for the control, which means that the treatment group's change was 3 points greater than the control. However, a Mann-Whitney U-test shows that the difference between the groups was not statistically significant.

Table 10. Iteration 2: Treatment & control participants' pre-test, post-test, and change in MAI score.

Participant (T=treatment, C=control)	Pre-Test Score (%)	Post-Test Score (%)	Change (%)
T1	79	89	11
T2	82	82	0
T3	89	93	4
T4	64	86	21
T5	96	89	-7
T6	75	86	11
T7	93	93	0
T8 (Outlier)	89	61	-29
		Average Change	1.34
		Average Change w/ outlier removed	5.61
C1	96	96	0
C2	93	96	4
C3	71	75	4
C4	96	100	4
C5 (Outlier)	62	90	29
C6	71	71	0
C7	57	61	4
C8	86	86	0
		Average Change	5.36
		Average Change w/outlier removed	2.29

Also worth noting is that two participants' scores in the treatment group unexpectedly went down in their post-course self-awareness score instead of up. Based on interview data, these treatment group participants said they believe they were more honest with themselves in the post-course MAI about how often they actually engage in these practices and probably would have scored themselves lower on the MAI in the pre-test in the first place. When treatment participants

whose scores increased were asked about their scores, two mentioned that they would have scored themselves lower during the pre-test now knowing more about metacognition and its role in their lives. However, they stated that they were more aware of their metacognition and had already begun implementing some of the strategies and tips they learned from ReflectCoach in their daily work. However, since self-reports can result in potential validity issues like this, I also had two external experts rate the participants' portfolios to see if, in fact, treatment group participants' metacognitive ability was greater than that of the control group.

B. Portfolio Score Results

At the end of the course, each participant's portfolio was rated on the three metacognitive criteria (see Table 7 above) by two raters who had previously been trained to assess learning portfolios for metacognition.

a. Iteration 1

The raters' inter-rater reliability for Iteration 1 was 83.3% with a Cohen's Kappa of 0.744, which is considered "Good" in the Fleiss-Kappa benchmark scale (see Table 11).

Table 11. Portfolio raters' inter-rater reliability for Iteration 1 participant portfolios.

Percent agreement	Cohen's Kappa	N Agreements	N Disagreements	N Cases	N Decisions
83.30%	0.744	20	4	24	48

The raters' scores for the three metacognitive criteria were averaged into one "Overall" score for each portfolio. Table 12 shows that the treatment group Overall Mean Score of 2.17 out of 3 is higher than the control group Overall Mean Score of 1.58 out of 3. To further support these findings, the portfolio scorers found that treatment group participants' learning portfolios demonstrated stronger evidence of all three criteria than the control group. Additionally, the treatment group portfolios scored a full point higher than the control group on Criterion 2 (evaluation of one's own competence with writing). The statistical difference between the two groups cannot be calculated due to small sample size.

Table 12. Iteration 1 participants' portfolio scores on metacognition criteria (1=does not meet, 2=meets, 3=exceeds)

Participant	Metacognition Criterion 1	Metacognition Criterion 2	Metacognition Criterion 3	Overall
T1	3	2	1	2.00
T2	3	1.5	1.5	2.00
T3	2	3	3	2.67
T4	1	3	2	2.00
Group Average	2.25	2.375	1.875	2.17
C1	2	1	1	1.33
C2	2	1	1	1.33
C3	2	2	1	1.67
C4	2	1.5	2.5	2.00
Group Average	2	1.375	1.375	1.58

b. Iteration 2

For portfolio scoring during Iteration 2 of the ReflectCoach experiment, the raters'

inter-rater reliability was 85.4% with a Cohen's Kappa of 0.762 (see Table 13),

which is considered "Very Good" in the Fleiss-Kappa benchmark scale.

Table 13. Portfolio raters' inter-rater reliability for Iteration 2 participant

portfolios.

Percent Agreement	Cohen's Kappa	N Agreements	N Disagreements	N Cases	N Decisions
85.40%	0.762	41	7	48	96

The scores for the three metacognitive criteria were averaged into one

"Overall" score for each participant (see Table 14 below). The control group

Overall mean score was 1.75 out of 3. The treatment group Overall mean was

2.27 out of 3. The difference between the control and treatment group for Iteration

2 was significant (Mann-Whitney U=15, n_1= n_2= 8, $p < 0.05$).

Table 14. Iteration 2 participants' portfolio scores on metacognition criteria

(1=does not meet, 2=meets, 3=exceeds)

Participant	Metacognition Criterion 1	Metacognition Criterion 2	Metacognition Criterion 3	Overall
T1	2	2.5	2	2.17
T2	3	3	3	3
T3	2	2	2	2
T4	2	2	2	2
T5	3	3	2	2.67
T6	2	2	2	2
T7	3	3	2	2.67
T8	1	2	2	1.67
Treatment Average Score	2.25	2.4375	2.125	2.27
C1	1	2.5	2.5	2
C2	3	2.5	2.5	2.67
C3	1	2.5	2	1.83
C4	2	2	2.5	2.17
C5	1	2	2	1.67
C6	1	1	1	1
C7	1	2	2	1.67
C8	1	1	1	1
Control Average Score	1.375	1.9375	1.9375	1.75

C. Interview Results

Participants' interview responses also highlighted the above trends. I

asked members of both the control group and the treatment group, "What are your

thoughts on metacognition?" to gauge their understanding of the concept and their

self-awareness. Members of both groups grasped the concept of metacognition

and understood its value. However, the treatment group better connected

metacognition to their personal experience and actively demonstrated

metacognition when asked this interview question (see Table 15). For example, a control group member simply defined metacognition as "when you keep track of goals and assignments and see whether you follow through" and then referenced the pre/post tests as the reason why he knew this. Conversely, a treatment group member internalized and applied the concept of metacognition to her life and considered ways to improve: "Sometimes I get so stuck in work and school and family responsibilities that I don't recognize why I'm doing well or poorly. I just usually attribute it to stress or too much on my plate. There are actually ways I could make it better, by setting goals and planning stuff out more. And knowing when and how to ask for help." This pattern of describing by the control group versus applying by the treatment group was consistent across participants' interview responses.

<u>Table 15.</u> Participants' responses to interview question: "What are your thoughts

on metacognition?"

Control Group	Treatment Group
"I didn't really know what metacognition was or why it is important before I took this class. It's sort of like knowing whether you do things effectively, and then stopping to think on that to make it better next time." "It's important to be able to think about how you approach problems and the ways you go about doing your job so you can improve or just be more aware of it. I never think about that in depth too much, and the inventories we took before and after the course got me thinking." "Knowing how I learn best. I think that's what metacognition is." "Metacognition is when you keep track of goals and assignments and see whether you follow through. The questionnaires we took at the beginning and end of the class were asking about whether I do these things on a regular basis. Honestly, I don't do this, but I probably should." "It's like when you have strategies for doing well in school, right?" "I don't really have any thoughts on it."	"We do a lot of self-evaluations in my classes, so this gave me some practice with that. But this time I got to think about stuff other than my classes and kind of reflect on how it is similar or different" "With the [ReflectCoach] site, I did not get to use it as much as I wanted. This semester has been very difficult for me to even get my assignments turned in. Later once I found out that this is a weekly thing it was a bit tough to fit it into my schedule, thus causing my delays. I guess that's very metacognitive of me to realize that (laughs)." "Sometimes I get so stuck in work and school and family responsibilities that I don't recognize why I'm doing well or poorly. I just usually attribute it to stress or too much on my plate. There are actually ways I could make it better, by setting goals and planning stuff out more. And knowing when and how to ask for help." "Well, metacognition is sort of like reflection on how you plan, monitor, and analyze the things you do in life. Like I tend to have trouble asking for help when I need it. I've been like that my whole life and I just never really stopped to think about it." "I think I'm pretty strong with metacognition and reflection, and it seemed like the others in the [ReflectCoach] discussions were, too. We don't take the time to sit and think about it much, I guess, but we have all this stuff at work and at home that makes us have to plan and keep up with how things are going."

3.2.3 Discussion

I hypothesized that the treatment group would improve due to their interaction with ReflectCoach. This was the case with both iterations, as demonstrated by both the MAI scores and the learning portfolio scores, with a significant difference in Iteration 2. The interview results also suggested that the treatment group was much better at articulating the importance of metacognition, its role in their lives, and how they perceive their level of metacognitive ability, which is additional evidence of metacognitive development.

Since the MAI pre/post test scores improved slightly for the control group, I concluded that simply asking learners to complete the MAI and introducing the concept of metacognition helped them to understand its relevance in the learning process and also improves their metacognitive awareness and practice. This leads me to conclude that, at a minimum, adult learners should complete the MAI at some point in their learning experience in order to recognize the importance of metacognitive development and consider their existing metacognitive practices.

However, the control group's metacognition scores on their learning portfolios tell a different story. Their scores here were significantly lower than those in the treatment group who interacted with ReflectCoach. Since the portfolios were scored by trained raters, they provide stronger evidence for measuring metacognition than the MAI self-report. Even so, taken together, it is clear that the treatment group improved more than the control group in their metacognitive development.

An additional concern raised by the control group's learning portfolio scores is that not only were they lower than the treatment group, they were below the "meets expectations" level on the grading rubric that is regularly used in the course. In other words, if we assume these results are similar for the larger population of adult learners, the learners in the course are generally not meeting expectations for metacognitive development on a regular basis, or at least not as they are demonstrating in their portfolios. This suggests that the online writing course by itself does not provide the tools students need to improve their metacognitive practices in a ten-week term.

Furthermore, students' pre-test MAI scores were all over the board. It is not a surprise that this is the case, since adult learners do have varied backgrounds and experience and may be at different points in their learning trajectory. We shouldn't assume that all individuals have the same metacognitive awareness anyway, or that they should all score 100% on the MAI. However, this variation in scores is further evidence that adult learners need support in their metacognitive development and that they need support in articulating and demonstrating their metacognitive development for purposes of assessment. Educators and educational interventions need to meet adult learners where they are in their metacognitive development and help them to recognize its important on an individualized basis.

3.3 SUMMARY

Returning to my second research question (RQ2), "What are the important design parameters (elements and features) for e-learning technologies that support

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adult learners' metacognitive development?" Together, the results from the

ReflectCoach experiment provide further evidence that adult learners benefit from

additional support in their metacognitive development. A sociotechnical system

like ReflectCoach that caters to adult learners' metacognitive needs with social

and persuasive design elements that align with adult learning principles, when it is

implemented alongside their regular coursework (or similar learning experience),

can aid in this regard. Not only did treatment group participants' report that their

metacognitive awareness increased, it did so at a higher rate than the control

group participants. Furthermore, external assessors confirmed that treatment

group participants in the second iteration had significantly higher metacognitive

scores on their learning portfolios than the control group.

So why exactly did ReflectCoach support these learners in their

metacognition? How did specific design elements and features aid in supporting

adult learners' metacognitive development? This is my third and final research

question and is explored in Chapter 4.

CHAPTER 4: DESIGNING FOR ADULT LEARNERS'

METACOGNITIVE DEVELOPMENT

ReflectCoach was created with persuasive and social design elements since these have been shown to be effective in learning as well as behavior modification in both commercial and academic contexts (Snyder, 2009; Fogg, 2009). The four most important persuasive and social design elements in ReflectCoach were the (1) scoreboards, (2) discussion forums, (3) sports-themed achievement levels, and (4) weekly email notifications about next steps and replies to posts. My goal in incorporating these elements was to encourage what I am calling "metacognitive behavior modification" for those who interacted with ReflectCoach. The behavior to-be-modified, in this case, was the thought process or habit of mind relative to one's own metacognitive awareness. Together, these persuasive and social elements supported learners' metacognitive development as demonstrated in the treatment group's improved MAI score and higher learning portfolio scores. But there was additional evidence that helps to understand "why" and "how" ReflectCoach supported adult learners' metacognitive development.

4.1 REFLECTCOACH INTERVIEWS, ACTIVITY LOGS, AND DISCUSSION FORUMS

As described in Chapter 3, after conducting the experiment with ReflectCoach, I conducted 30-minute semi-structured interviews with 19 participants from both iterations (seven from the control group, twelve from the treatment group). I asked members of both the control and treatment groups, "What are your thoughts on metacognition?" to gauge their understanding of the concept and their self-awareness. I also asked the treatment group, "What was

your experience with the ReflectCoach app?" I analyzed these 19 interviews using descriptive coding (Saldana, 2012) to determine if any patterns aligned with our quantitative findings. I also analyzed the treatment group interviews for frequency of statements related to any of the features of ReflectCoach (scoreboard, discussions, etc.). In the previous chapter, I discussed the responses from the control and treatment groups to the first interview question. In this chapter, I will discuss the responses from the treatment group to the second question. In addition to the interviews, I also tracked treatment group learners' activity in the ReflectCoach site, including their chosen usernames, page hits, timestamps, and repeat visits to pages by the same user. I also reviewed their responses in the discussion forums to see if any of their posts supported or aligned with the interview and activity log findings. The following is a discussion of relationships among these data.

4.1.1 Findings

There were several expected and unexpected findings from the interviews and activity logs. Since ReflectCoach was intentionally built with persuasive and social design principles to align with adult learning principles, it was not surprising to find that:

- A tally of the number of hits per page throughout ReflectCoach demonstrated that learners most frequently visited the scoreboards (36% of total hits for the site) and the discussion forums (42% of total hits for the site), both of which had the strongest presence of both persuasive and social design elements.

- In the 19 follow-up interviews with the participants, nine of treatment group participants referenced the sports-themed skill levels for metacognitive awareness assigned in the ReflectCoach scoreboard: Rookie, Pro, or All-Star. This model of achievement was familiar and memorable for them, which suggests that it is also a valuable persuasive design element in the intervention.

- Participants liked to see where they fell in comparison to others in the class on the scoreboard. They also remembered the categories where they received Rookie levels more than where they received Pro or All-Star. Together, the signaling that the scoreboard and skill levels were persuasive in that they created a sense of competition and a need to improve to meet their peers or their own personal standards.

- A few mentioned the scoreboard "tips" that were tailored to their skill level/ability/context; they tended to pay more attention to these when they achieved Rookie level on the associated questionnaires.

To further investigate whether participants' use and discussion of these features were actually related to their improved metacognition, I compared each treatment group participant's portfolio score, MAI score increase, interview data, and log file data, computed a Pearson Product-Moment Correlation Coefficient, and tested for significance. There were several significant correlations between variables (see Table 16 below).

Table 16. Relationships among experiment, interview, and log file data.

Pearson product-moment correlation coefficient	MC1	MC2	MC3	MO'ALL	MAI	Interview Achv Level	Interview AutoMsg	Interview PeerFdbk	Interview Privacy	Interview Scoreboard	Interview Tips	Discuss Rep	Quest. Rep	Scrbd Rep	#Complete
MC1	0.054	-0.139	0.582*	0.032	-0.067	0.333	0.059	0	0.49*	-0.2	0.059	-0.176	-0.176	0.266	0.266
MC2	0.054	1	0.615*	0.768*	0.064	0.271	0.09	0.818*	-0.387	0.552*	-0.451	0.502*	-0.607	-0.607	0.583*
MC3	-0.139	0.615*	1	0.642*	0.041	0.232	-0.417	0.557*	0.114	0.057	-0.046	-0.095	-0.258	-0.258	0.309
MO'ALL	0.582*	0.768*	0.642*	1	0.065	0.185	0.063	0.661*	-0.128	0.583*	-0.353	0.225	-0.502	-0.502	0.569*
MAI	0.032	0.064	0.041	0.065	1	0.54*	-0.046	0.303	0.501*	0.225	0.251	0.439	0.166	0.166	0.631*
Achv Level	-0.067	0.271	0.232	0.185	0.54*	1	0.333	0.293	0	0	0.333	0.293	-0.098	-0.098	0.697*
AutoMsg	0.333	0.09	-0.417	0.063	-0.046	0.333	1	0.098	-0.408	0.408	-0.333	0.488*	0.098	0.098	0.19
PeerFdb	0.059	0.818*	0.557*	0.661*	0.303	0.293	0.098	1	-0.12	0.478*	-0.293	0.657*	-0.371	-0.371	0.649*
Privacy	0	-0.387	0.114	-0.128	0.501*	0	-0.408	-0.12	1	-0.25	0.408	-0.12	0.598*	0.598*	-0.078
Scoreboard	0.49*	0.552*	0.057	0.583*	0.225	0	0.408	0.478*	-0.25	1	-0.816	0.478*	-0.239	-0.239	0.31
Tips	-0.2	-0.451	-0.046	-0.353	0.251	0.333	-0.333	-0.293	0.408	-0.816	1	-0.293	0.098	0.098	0.19
Discussion Rep	0.059	0.502*	-0.095	0.225	0.439	0.293	0.488*	0.657*	-0.12	0.478*	-0.293	1	-0.029	-0.029	0.538*
Question Rep	-0.176	-0.607	-0.258	-0.502	0.166	-0.098	0.098	-0.371	0.598*	-0.239	0.098	-0.029	1	1*	-0.464
Scoreboard Rep	-0.176	-0.607	-0.258	-0.502	0.166	-0.098	0.098	-0.371	0.598*	-0.239	0.098	-0.029	1*	1	-0.464
Number of Activities Complete (out of 20)**	0.266	0.583*	0.309	0.569*	0.631*	0.697*	0.19	0.649*	-0.078	0.31	0.19	0.538*	-0.464	-0.464	1

* $N=14$, $p<0.05$

These findings suggest the following connections:

- Participants with the highest scores for Metacognition Criterion 1 in the portfolio (strengths/weaknesses) frequently mentioned the scoreboard in their interviews.

- Participants with the highest scores on Metacognition Criteria 2 & 3 (evaluation, planning, strategy use) frequently mentioned the peer feedback and scoreboard in their interviews. The log file data also showed these participants had repeat visits to at least one of the discussion forums.

- Participants with the highest overall portfolio score mentioned both peer feedback and the scoreboard in their interviews.

- Participants with the greatest increase in MAI score mentioned the achievement levels and privacy in their interviews and also had repeat visits to at least one of the discussions.

- Log files showed that participants who had repeat visits to the
  questionnaires always also had repeat visits to the scoreboards,
  suggesting that learners may be trying to increase their score to change
  their achievement level and/or game the system.

- Participants who mentioned the automated messages in their
  interviews also repeatedly visited the discussions. Since the
  discussions and feedback are tied to higher metacognition portfolio
  scores as well as higher MAI, this suggests that encouraging learners
  to go back to the discussions through automated messages will support
  their metacognition.

- Participants with lower scores on Criteria 1, 2, & 3 on portfolios
  frequently missed activities.

These results suggest that learners who were strong in the "Knowledge of
Cognition" metacognition factors tended to use the scoreboards and reference the
achievement levels the most. Learners who were strong in the "Regulation of
Cognition" metacognition factors tended to use the discussions and reference peer
feedback in addition to the independent activities like the questionnaires and
scoreboards.

While the above were expected patterns, there were also a few unexpected
connections between the activity logs and patterns in the interview. These
connections suggested that learners valued the following ReflectCoach elements:
privacy, instant feedback, and opportunities to game the system to learn best
practices for metacognition. I argue that these features, many of which tie back to

the social and persuasive design principles, also align well with Knowles's adult learning assumptions, and allow adult learners to integrate metacognitive development into their narrative identity. I argue that this alignment also led to the learners' improved metacognitive development.

A. Anonymity and Lurking

Participants who interacted with ReflectCoach often mentioned engaging in "self-talk" or introspection, which makes sense since metacognition is introspective:

Participant T4: "I had to stop and really think about the questions. It's not stuff I think about everyday. It's pretty deep and in there, so I had to ask myself what I really do and how I think about things. And then I wondered whether I was being honest with myself when I answered, but I guess only I know if I was lying [laughs]."

They also felt that metacognition is a fairly private and personal topic, stating that sharing one's strategies, strengths, and weaknesses when it comes to metacognition can be "uncomfortable" or perhaps something they'd "rather not share" with their classmates – or anyone at all.

To allow learners privacy and customizable notification settings, ReflectCoach has two levels of membership: guest or user. This feature was intentionally incorporated in the system as both a persuasive and social design feature so that learners can (a) review content and participate in the questionnaires without having to create an account or (b) sign up and receive reminder emails about new activities, notifications when something in the site changes or someone

responds to their post, or private messages when another user wants to contact them directly. Most (75%) of treatment group participants signed up to be users. But no matter which of these two user levels they chose, the learners did not have to reveal their identity to each other at any time. They only had to pick a three-digit code by which they could identify their scores on the scoreboard, and, if they participated in the discussions, they could select any username without an association with any aspect of their identity. This mode of participation is not always possible in many formal learning systems, which typically require learners to, at the bare minimum, reveal their identity in a class email list. Of the 12 learners who participated in the experiment, only five of them chose a username that included their first and/or last name. It quickly became clear that participants did not always want to be identified. Participants could remain anonymous but still participate in questionnaires, check and compare their scores on a scoreboard, and "open up" about topics that may otherwise be too personal or confidential to share with other learners.

In fact, participants were quite candid in the ReflectCoach forums; they discussed topics that would in many cases be discussed with a close confidant, not a stranger or a classmate. Topics included strategies for sticking to personal goals like losing weight or making more time for projects, struggling with managing workload at their jobs, and admitting failure and needing to revise strategy. This suggests that learners using ReflectCoach felt comfortable discussing their metacognitive abilities across domains and experiences, rather than stay on topics related to the writing course in which this system was introduced to them. While

the open-ended prompts in the discussions invited topics beyond writing and school, such as "Describe a time you failed at something", the option for anonymity could be an additional reason the adult learners discussed topics across domains. In one exchange during a discussion on Planning and Organizing, the learners not only shared some fairly personal information but also compared their experiences like old friends:

> Participant T1: I need 3 of me. Everything seems to carry the same weight and require the same amount of attention. Web dev and the related consulting is time consuming. School almost demands that I shut down the consulting projects in order to give it the proper attention. My nest, they know that I have professional and academic goals, but they want my undivided attention. They deserve it. I get little sleep.

> Participant T7: […] Working on weight loss is my on going issue but I make time for everyone else except for me. I'm working on that but what I've done in the past hasn't been working so I need to try something new.

> Participant T1: Ditto! We need to take time to take care of ourselves. If we don't, what good are we to anyone else. So a correction, I need 4 of me, one that takes care of me.

Furthermore, because the questionnaires and discussion forums are not graded and do not require completion before moving on to the next activity, and because the scores and posts remain in the application indefinitely, learners can "lurk" in

the scoreboards and discussions and still be reflective without actively participating. Research shows lurking is still a strong form of learning for certain personalities and learning styles (Beaudoin, 2002; Gray, 2004). Three from the treatment group were inconsistent about actively participating in quizzes and discussions, but were still lurking in the discussions and found value in doing so:

"I was doing well on all the quizzes, so I didn't really think I needed to continue on those. But it was kind of cool to see what everyone had to say about their jobs and how they organize and plan and stuff, and to see what they said about my posts."

"The discussions were interesting. I didn't always respond to the other people on there like we were supposed to because sometimes I was the first one to say something, and sometimes I just didn't have the time, but I read what they said later when I got the email that someone else posted."

"The scoreboard was a good way to check other people's scores and see how you did in comparison but not feel bad if you didn't score as high."

The concept of privacy isn't mentioned in the adult learning literature, but it can be assumed that adults would appreciate it in online learning experiences because of these three assumptions about adult learners' preferences for learning, discussed in Chapter 1: (1) prior experience, (2) learning orientation (to authentic contexts), and (3) motivation to learn (which tends to be intrinsic for adults, but can be extrinsic as well) (Knowles, Holton, Swanson, 2012). Without privacy in ReflectCoach, adult learners may not have felt as comfortable exploring their prior experiences, personal goals and motivations, or strengths and weaknesses

with metacognition in an authentic, honest way. Brookfield (2013) has noted that adults do indeed appreciate this type of safety from "exposure" to others in learning environments. At the same time, the privacy also affords extrinsic motivation because it allows learners to see each other's scores and comments about metacognition and feel an impetus to compete or compare themselves to their peers in an effort to better themselves.

B. Instant Feedback - Self-scoring questionnaires and peer forums

During the interviews, participants mentioned that feedback and the timeliness of it was key to a meaningful interaction in ReflectCoach and in their online courses overall. The automated, self-scoring questionnaires and their peers' feedback (which would stream in throughout the weeks of the study) were often brought up in comparison to the one week it took for their instructor to give them feedback on their course assignments:

"Yeah, I liked that I could just pop through the questionnaires, get my score, see what everyone was talking about, and add my two cents and move on to the next thing. And sometimes I would get a reply from someone that same night because we were both working at the same time. […] When I wasn't getting feedback from the instructor for, like, more than a week, I sort of lost focus. Plus, I felt like I couldn't move on with homework until I knew if I was on the right track with last week's."

Similarly, the ReflectCoach discussion forums demonstrate that participants were maintaining engagement in the metacognition prompts because the conversation, even if it was asynchronous, appeared to them to be ongoing,

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always open to new ideas and contributions, and, most importantly, personally relevant to them and relatable because it was among a community of peers with shared experiences. The discussion forums received more hits than any of the other pages on the site. One participant stated that the email notifications she received when someone responded to one of her posts, "made me feel like someone else understood and could give me advice, and not just replying because it was for a grade, even if I never met them before". Another participant, mentioned earlier, stated that these notifications that someone responded to them drew their attention back to the conversation: "sometimes I was the first one to say something, and sometimes I just didn't have the time, but I read what they said later when I got the email that someone else posted." The timestamps of users posts on the activity log showed that six participants returned to discussions later the same day; three participants commented on the same topic three weeks after they had initially posted.

Feedback that is instant, from one's peers, and that is relatable and suggests a shared experience (as student, as professional, as family member, or all of the above) tends to be a key engagement factor for adult learners. Plenty of literature on online learning supports this point – feedback, especially when it is sooner rather than later, supports reflective practice and learning (Hootstein, 2002, Mason, 2006, Van den Boom, Paas, F., & van Merriënboer, J, 2007). While not discussed specifically as "instant feedback", these findings also align with the adult learning assumption that suggests adults have a readiness to learn: adults are ready to learn what is most relevant to them at a given time. It also makes sense

due to their motivation to learn. Instant feedback, whether automated or from a peer, provides just-in-time information that the adult learner can analyze, internalize, and act upon as they see fit while they're already engaged in a process of reflection and metacognitive practice.

C. Opportunities for Gaming the System

The questionnaires in ReflectCoach confirmed my initial findings discussed in Chapter 2 about adult learners' metacognitive awareness and ability. The participants received the highest scores on the ReflectCoach questionnaires about "monitoring and tracking." From the interviews, most participants felt that they were good at determining when to change direction or at assessing the results of a strategy. Participants received the lowest scores on the ReflectCoach activities about "managing information and seeking resources". During the interviews, three participants made reference to the need for more information about seeking resources, knowing when to ask for help, and knowing what type of help to look for, so I modified ReflectCoach in Iteration 2 so that learners could read more tips on how to seek resources and managing information.

However, and notably, when I looked at the activity log for these questionnaires, one third of all treatment group participants had a pattern of completing the questionnaires, receiving their score, and then re-taking the questionnaire. I hypothesized that this was an attempt to get a higher score or to see what combination of responses would make them a "Rookie" or an "All Star". In a traditional online course, this would be considered "gaming the system", which adult learners have been wont to do with Intelligent Tutoring Systems

(Fancsali, 2012, Walkington, 2013). However, since this was an ungraded and reflective exercise, I suspected that the learners were genuinely reconsidering the metacognitive awareness and seeking a way to improve or picturing themselves as improving. Upon questioning one of the participants that repeatedly completed a questionnaire, she said, "I just wanted to see what it took to be an All-Star". Another participant said, "I took it over again because I was pretty sure I was good at it [evaluating]. I thought I clicked the wrong button or something and that the score was wrong. But then I realized that I could be better at knowing when it's time to change my strategy. I think that was one of the questions." The role of instant feedback (as well as repeated attempts) plays an important role here, since if the learner had to wait until an instructor scored the questionnaire and only had one attempt, he or she would not be able to "see what it takes" or "realizing I could be better" and consider ways to improve.

4.1.2 Discussion

Together, these findings lead me to believe that the persuasive and social elements of ReflectCoach played an important role in guiding adult learners to adopt metacognition and metacognitive awareness as part of their personal learning "story", or as it is called in psychology, their "narrative identity" (Clark & Rossiter, 2008; Singer, 2004). Narrative identity is important in learning and particularly in metacognitive development for adult learners because adult learners often have years of professional and personal experiences across domains that most traditional-aged undergraduate students do not have (Clark & Rossiter, 2008; Singer, 2004). These experiences and responsibilities can play a significant

role in their learning processes while in college or another formal (or informal) learning environments. In addition, research on returning adult learners at the college level suggests that this population of students learns best through critical reflection on their prior learning and experience at work, home, or in their personal life within an academic context (Brookfield, 1990; Knowles, 2005). ReflectCoach helped adult learners bring their existing knowledge and experiences – their narratives - into a learning context to deconstruct and develop awareness of what they already know and determine how they might advance their understanding (Knowles, 2005). Since metacognition is both personal and introspective, it makes sense that it is approached – from a learning standpoint - as a component of one's narrative identity.

The ReflectCoach questionnaires, scoreboard, and peer forums provided multiple opportunities for peer comparison, coaching, and friendly competition, as well as self-reflection and goal-setting to reach established levels of metacognitive achievement (Rookie, Pro, All-Star), even if these levels were arbitrary. Adult learners who are developing their metacognition with ReflectCoach are engaging in a transformation of their narrative identity so that it incorporates metacognition. The learner who said that she would go back to retake the questionnaires to try to figure out what combination of answers would put her at the "All-Star" level on the scoreboard is a perfect example. She was attempting to figure out how to write this "Metacognition All-Star" identity into her narrative and used ReflectCoach to do just that. The learners were comparing themselves to others, lurking, collaborating to discover a better way, and gaming

the system. Opportunities like these helped learners to get in the habit of thinking

of metacognition as part of their identity, part of how they learn, part of their

lifelong learning story, and ReflectCoach helped them explore this

transformation.

4.2 SUMMARY

The results from the interviews, activity log, and discussion forums helped

me to continue to answer Research 2 and address Research Question 3:

RQ2: What are the important design parameters (elements and features)

for e-learning technologies that support adult learners' metacognitive

development?

RQ3: How do specific design elements and features aid in supporting

adult learners' metacognitive development?

The scoreboards and discussion forums, both of which were informed by adult

learning principles and social and persuasive design in the first iteration of

ReflectCoach, were most frequently visited by the participants and were often

referenced in participant interviews. For the second iteration of ReflectCoach,

adult learners requested more customized reminder emails, comprehensive

questionnaires on each topic (rather than multiple short questionnaires), and

additional opportunities for learning strategies for improving their metacognition.

These features of ReflectCoach demonstrate the aspects of adult learning, social

learning, and persuasive design that support metacognition.

The adult learners also valued features and allowances that weren't closely

considered when designing ReflectCoach but which appear to have contributed to

their metacognitive development. The membership levels of the system allowed for anonymity and lurking, the automated forms allowed for instant feedback, and the opportunity for repeat attempts on the questionnaire allowed for users to "game the system". Comparing these features and elements to what we know about adult learning and about metacognitive development, it is clear that adult learners' are likely to improve their metacognition if the technology supports integration of the concept into the adult learner's narrative identity. These findings contribute to larger questions about adults and e-learning more generally as well, which is discussed in the next chapter along with contributions from the other studies in this dissertation.

CHAPTER 5:

CONCLUSIONS & FUTURE RESEARCH

5.1 CONCLUSIONS

Because metacognition is so important for learning, because adult learners are a large portion of the post-secondary learner population, because the average age of an online learner is 33 years old, and because adults learn differently than children and teenagers, I want to know: "How can we support adult learners' metacognitive development in online learning environments?" This was my motivating question for this research. I first wanted to better understand adult learners' metacognitive ability so that I could determine what support they need. I then designed a support system based on those needs and based on existing research on adult learning and designing for learning. Finally, I conducted an experiment to see if that system supported them and exactly what elements and features were most supportive in their metacognitive development. The studies I completed for this dissertation have brought to the surface several key factors in understanding and supporting adult learners' metacognitive development, such as how to identify their metacognition, how to measure it, how to support it, and questions for future research.

Below are the research questions that I used to answer my motivating question along with a summary of my methods and findings for each question.

RQ1: How can we characterize adult learners in terms of their metacognitive

abilities?

To answer this question, I analyzed a sample of adult learners' learning portfolios for evidence of their metacognition. Then, I used Schraw and Dennison's (1994) Metacognitive Awareness Inventory (MAI) questionnaire to gauge the metacognitive awareness of a cross-section of adult learners who take courses either primarily online or primarily in-person.

Together, these findings revealed that adult learners tend to be stronger in the metacognitive activities of identifying and situating themselves in learning contexts, planning, and monitoring their cognitive processes for learning. They are weaker in integrating their varied learning experiences, managing resources and information, and evaluating themselves and their strategies. To support adult learners in developing their metacognition, it is important to balance attention to all of these metacognitive factors since learners should be supported in leveraging their strengths as well as improving their weaknesses. Providing tips and strategies as well as reflective prompts for learners to consider the ways these established metacognitive factors play a role in their lives is key.

I also analyzed the MAI data for differences between adults who learn primarily online versus in-person to see if their metacognitive strengths and weaknesses are different. There was a significant difference between the two populations. Adult learners who take courses primarily online reported that they more frequently use strategies from the past, understand their strengths and weaknesses, assess comprehension, and assess goals than the adult learners who

learn primarily in-person. The only area where the in-person learners more frequently engaged in metacognitive practices than online learners was in reflecting on the success of completion of a task. However, this finding was limited by asking the participants about the frequency of learning online versus in-person since there are too many factors that may contribute to that frequency and may not give a valid picture of differences between the two (if a difference exists at all). Thus, rather than attempt to conclude that we need to design differently for online learners than in-person learners because they have different metacognitive abilities, I concluded that we need to design for all adult learners' metacognitive development, and make the support system accessible to them no matter whether they learn online or in-person.

RQ2: What are the important design parameters (elements and features) for e-learning technologies that support adult learners' metacognitive development?

Based on the answers I found to the first research question, as well as the research on how to design for adult learners and for learning more broadly, I designed and developed a web-based intervention called ReflectCoach to support adult learners' metacognitive development. I iteratively tested and revised ReflectCoach with a treatment group of adult learners enrolled in an introductory online writing course and compared their metacognitive development (via their MAI scores and learning portfolios) to a control group in the same course who did not interact with ReflectCoach.

There were a total of 24 participants in this study: eight in the first iteration and 16 in the second iteration. After conducting the experiment with the

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treatment group, and analyzing pre-test/post-test MAIs and learners' portfolios for evidence of metacognition for both the control group and the treatment group, the MAI scores of the treatment group improved by 5.61 points compared to the control group who only improved by 2.29 points. The learning portfolio scores were also significantly higher for the treatment group (average score of 2.25 out of 3) than the control group (average score of 1.75 out of 3). Based on these results, it is clear that those who interacted with ReflectCoach were stronger in metacognitive development than those who did not, so I am fairly confident in concluding that ReflectCoach supports metacognitive development.

There were some additional findings from this study that were not part of my research question, but are important to note here. First, the MAI pre/post test alone appeared to improve learners' metacognitive awareness. We see this in the MAI results for the control group. While the treatment group's change from pre- to post- test was significantly higher than the control group's change, the control group still changed for the better. This makes me believe that if educators or adults have no time to do anything else to improve their metacognitive awareness, simply completing the MAI is a good first step to improving. This inventory has been tested in many other contexts, including online environments, so I fully support it as a base-level intervention.

Another issue raised by these results was that of the control group's fairly low metacognition score on their learning portfolios. Since learning portfolios have been established as a means of both developing and assessing metacognition, I expected the learners' scores to be at least at the "meets expectations" level.

Their "does not meet expectations" score suggests that even when learning portfolios are integrated in formal learning situations, like college-level courses, and even when the course is designed with the intention of helping learners develop their metacognition, learners still require support and scaffolding to develop and/or articulate their metacognition. This course was about writing, which involves many metacognitive processes that are covered in ReflectCoach. While the control group may have indeed developed metacognition during the course, they did not provide enough evidence of their metacognitive ability in their learning portfolios. They need better supports and guides in doing this.

Finally, these studies also revealed important information about measuring adult learners' metacognition and improvement in metacognitive awareness. The learning portfolios were obviously a more reliable tool than the MAI for measuring improvement in metacognition because the learning portfolios were rated by trained raters while the MAIs were self-reports completed by the learner. Self-reports can be quite unreliable. However, it is interesting in both cases to see that both measurement instruments revealed similar results: the treatment group improved more than the control group (evident in the MAI) and their metacognition score was higher (evident in the learning portfolio). Furthermore, the control group improved their metacognitive awareness score from pre-test to post-test, which suggests that the self-assessment had some impact on the learners' slight improvement without using ReflectCoach. I recommend that when educators or researchers are assessing metacognition, despite the reputation of self-reports, we consider using both instruments for the benefit of the participants.

RQ3: How do specific design elements and features aid in supporting adult

learners' metacognitive development?

There were several expected and unexpected findings from the interviews and activity logs. Since ReflectCoach was intentionally built with persuasive and social design principles, it was not surprising to find that:

- Learners most frequently visited the scoreboards (36% of total hits for the site) and the discussion forums (42% of total hits for the site), both of which had the strongest presence of both persuasive and social design

- The sports-themed skill levels for metacognitive awareness assigned in the ReflectCoach scoreboard: Rookie, Pro, or All-Star was a familiar and memorable model for participants, which suggests that it is also a valuable persuasive design element in the intervention.

- The scoreboard and sports-themed skill levels created a sense of competition and gave learners a need to improve to meet their peers or their own personal standards.

- ReflectCoach "tips" were more valuable to those who scored lower on the questionnaires in those areas.

- Learners who were strong in the "Knowledge of Cognition" metacognition factors tended to use the scoreboards and reference the achievement levels the most. Learners who were strong in the "Regulation of Cognition" metacognition factors tended to use the discussions and reference peer feedback in addition to the independent

activities like the questionnaires and scoreboards. If we want to

support learners on both types of factors, we need to balance the social

and self-guided features of the system.

While the above were expected patterns, there were also a few unexpected

connections between the data in the activity logs and patterns in the interview

codes. These connections suggested that learners valued the following

ReflectCoach elements: privacy, instant feedback, and opportunities to game the

system to learn best practices for metacognition. I argue that these features, many

of which tie back to the social and persuasive design, also align well with

Knowles's adult learning assumptions and allow adult learners to integrate

metacognitive development into their narrative identity. I argue that this

alignment also led to the learners' improved metacognitive development.

The ReflectCoach questionnaires, scoreboard, and peer forums provided

multiple opportunities for peer comparison, coaching, and friendly competition, as

well as self-reflection and goal-setting to reach established levels of

metacognitive achievement (Rookie, Pro, All-Star), even if these levels were

arbitrary. Adult learners who are developing their metacognition with

ReflectCoach are engaging in a transformation of their narrative identity so that it

incorporates metacognition. I argue that designing for opportunities like these will

help learners to get in the habit of thinking of metacognition as part of their

identity, part of how they learn, part of their lifelong learning story. ReflectCoach

helped them explore this transformation.

5.2 LIMITATIONS

There are four main limitations of this research. First, there was no control for the range of backgrounds and experiences of the learners. Second, there was no control for the amount of time the learners from the control group or the treatment group engaged with the concept of metacognition. Thirdly, there was no examination of the final grade of each learner after the experiment and compare it with their MAI score or their learning portfolio score. Finally, there was no individual investigation of each main ReflectCoach feature to see if each feature would have the same effect as all features combined. Future research into adult learners' metacognition and the systems built to support them could benefit from further exploration in these four areas.

First, since all the learners who partook in this research were enrolled in the introductory-level writing course in a program for adult learners aged 24 and older, there was consistency in their age range and number of years of previous college experience. The mean age of all participants was 37 years old; the fact that the learners were enrolled in the introductory-level writing course suggested they had a similar number of years of college experience. However, a 45-year old married construction worker with kids who took five general education courses at a business college in 1998 may have different metacognitive abilities than a 29-year old single mother who was near completion of her associate's degree at a community college before transferring to this program. Learning more about the demographics of these learners could reveal relevant aspects of their metacognitive history, the role their job or previous coursework played on its

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usefulness in their formal and informal learning, and possibly suggest contexts

and other factors that may predispose a learner to stronger metacognitive ability

or to developing metacognition in a more effective and efficient way. For

example, conducting the ReflectCoach study with adult learners who may not be

in college but are all in a supervisory role at the same bank, and then gathering

data about their gender, age, marital status, family status, and other factors, would

be an interesting follow-up study that may reveal new information about the

metacognitive development of adult learners.

Second, in the ReflectCoach study, we did not control for the amount of

time the learners in the control group and treatment group engaged with the

concept of metacognition, whether through the MAI, the portfolio, the

ReflectCoach study, or some other activity. The control group only completed the

Metacognitive Awareness Inventory before and after the course and completed

the learning portfolio according to the instructions given by the instructor. We did

not track how much time they spent completing either activity. On the other hand,

the treatment group also completed the MAI and the learning portfolio, and while

it was possible to track the learners' amount of time spent in ReflectCoach, we did

not analyze this data nor were we able to compare this data to the control group.

For example, the control group could have read a series of online modules about

metacognition to even out the amount of time that they were spending engaging

with the concept of metacognition with the treatment group learners who were

using the ReflectCoach system.

Thirdly, this research did not compare learners' metacognition scores to

their final grade for the course or their GPA. Other studies have shown that metacognition, GPA, and final course grades are correlated, nor was our goal to show a relationship between success in the course, formal learning success, and metacognitive success, so it was not necessary to replicate those studies again here. Furthermore, the introductory-level writing course in this research is taught on a Pass/Fail grade basis, so the learners' "grade" in the course would not have told us much about their level of achievement anyway. It was important to learn how well they did with regard to metacognitive capacity, and this is why we conducted an analysis of both their MAI and learning portfolios.

Finally, ReflectCoach was designed with a combination of several key features that aligned with social, persuasive, and adult learning principles. The system as a whole was under investigation in the experiment and the correlations among the features and learners' metacognitive development were calculated. However, each feature was not investigated independently to see if its presence or absence would make a difference in learners' metacognitive development. Rather, this study took a system-wide, holistic approach to designing the system and supporting metacognitive development. To look at the success of each feature in supporting metacognitive development, a study that examines learners' interactions and metacognitive development with each feature independently (e.g. discussion forum only, self-scoring questionnaires only) could be conducted.

5.3 IMPLICATIONS & FUTURE RESEARCH

This research indicates that there is room for improvement in adult learners' metacognitive development, so it is important that we continue to

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explore these characteristics and ways to support them. This research is valuable to adult learners so they can direct their own learning, to educators who are working with adult learners, and to designers and developers when designing online learning experiences more broadly for the adult learner population. In a world where metacognition is imperative for success in any context, and where the Internet is quickly becoming the primary space wherein adult learning takes place, educators, trainers, and the e-learning industry must stay cognizant of its adult learner population when designing for their success in learning.

Considering the newfound characteristics of adult learners' metacognition that this research revealed, I propose that we look closer at metacognitive abilities of adult learners in specific contexts (workplace, academic, home, or community; independent or collaborative; novice to expertise, etc.) so that we can further the background knowledge that designers use when designing learning experiences for them. An investigation into professional contexts would be a good first step since most adult learners spend most of their time (or will spend most of their time) learning and achieving in this context. More specifically, we can ask, "How can we apply what we've learned about adult learners' needs for metacognitive support and the means that they may be supported to professional contexts?" We can integrate ReflectCoach alongside workplace training to see whether it supports metacognitive development in the same way. We might also investigate the metacognitive characteristics of adult learners in these professional contexts to see if their workplace environment, their existing training, and/or their demographics have any relationship with their metacognition and performance.

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This information would be particularly helpful if delivered in the form of adult

learner personas. While there are a plethora of personas for adults in particular

domains, fields, trades, and work environments, they do not typically incorporate

metacognitive ability nor do they consider Knowles's adult learning principles.

When designing web applications for adult learners, we should more

closely consider the roles of persuasive and social elements that align with adult

learning principles, including instant feedback, options for anonymity and lurking,

peer-feedback, friendly competition, and gaming the system. Together, these

features and elements afford opportunities for adults to tie their learning to their

narrative identity and have potential for engaging them in a deeper way. If the

adult learner cannot write metacognition or an element of metacognition into their

narrative identity, they will not value it, and so the likelihood of their improving it

decreases. On the other hand, if we can help adult learners assess their own

metacognition, direct themselves into improving it, and share stories to

authentically engage with others in a way that is personally relevant, they are

more likely to improve. The elements and features of ReflectCoach demonstrated

promise in supporting metacognition for adult learners, so it is probable that they

would apply to other learning situations as well. Future research in this area might

involve development and testing of more features that support narrative identity

development in online learning environments.

Furthermore, encouraging adult learners to reflect upon and be more

aware of their metacognitive abilities, as well as showing them ways to improve

upon or think differently about their metacognition and how it impacts their lives,

improves their metacognition and can ultimately play an important role in lifelong learning and success. These findings suggest there is a need for an intentional long-term approach to metacognitive development for adult learners in and beyond the classroom and within various learning communities. We might ask: How can we encourage long-term metacognitive development for adult learners and ensure transfer to new contexts and domains? One way to do this is by exploring approaches to metacognitive development with a focus on learners' reflection, creation, and participation in identity construction and collaborative learning environments. ReflectCoach will continue to be available free-of-charge and accessible to all learners, no matter if they are in an academic or workplace setting, but it is just a baseline approach. It would be exciting to see an integration of ReflectCoach in professional development settings, as part of entry into online workshops and webinars, or as a self-assessment in performance reviews over several years. It would also be exciting to see it adapted as a component of one's online identity in social/professional media such as LinkedIn or Facebook.

Finally, supporting metacognitive development involves behavior modification and reflective practice, and this can be done in a ubiquitous and sustainable way via a web-based application. ReflectCoach is an engaging, sustainable, and accessible application. In Chapter 1, I noted that while there have been educational technologies to support metacognition, they are limited by their scope, affordability, and accessibility and tend to be more instruction-centered than learner- or learning-centered. Existing tools for metacognitive development often require a significant amount of setup time and resources to integrate them

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into existing learning environments. Online courses and webinars, which often do incorporate social opportunities, tend to still be heavy in lecture and "instruction", emphasize grading and assessment, may be fee-based, and require regular instructor intervention. To make up for these gaps, ReflectCoach relies on reflective prompting through auto-scoring forms and social exchange through peer forums. The application developed for this project was also built without funding and continues to run without funding thanks to Wikispaces Education platform and Google Forms. The application appeals to adult learning principles to engage them while remaining low-maintenance and low-stakes so that it is ubiquitous and accessible to all adult learners.

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