5-6-2010

THE USE OF A METACOGNITIVE TOOL IN AN ONLINE SOCIAL SUPPORTIVE LEARNING ENVIRONMENT: AN ACTIVITY THEORY ANALYSIS

Ray Earl Martinez
University of Missouri-St. Louis, remm79@umsl.edu

THE USE OF A METACOGNITIVE TOOL
IN AN ONLINE SOCIAL SUPPORTIVE LEARNING ENVIRONMENT:
AN ACTIVITY THEORY ANALYSIS

by

Ray Earl Martinez
M.S. in Instructional Technology, 2005, Southern Illinois University at Edwardsville
M.P.A. in Public Administration, 1994, University of Illinois at Chicago
B.A. in Speech Communications, 1991, University of Illinois at Urbana

A DISSERTATION

Submitted to the Graduate School of the

UNIVERSITY OF MISSOURI- ST. LOUIS
In partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY
in

EDUCATION
with an emphasis in Teaching and Learning

May, 2010

<u>Advisory Committee</u>

Carl Hoagland, Ph.D.
Chairperson

Wayne Nelson, Ed.D.
Committee Member

Joseph Polman, Ph.D.
Committee Member

Randall Sommers, Ph.D.
Committee Member

Acknowledgments

As I sat writing the very last section of this document, my daughter spilled a cup of hot tea on the table. She immediately knew the gravity of the situation. All four family members sprang into action, lifting the MacBook and accessories out of the way of the scalding, raging, destructive, river of liquid, in a desperate effort to save daddy's dissertation. No one even considered that by this point in the proceedings at least 23 backup copies were stored on various Internet servers and portable media devices around the world and the neighborhood. I convey this story to illustrate why the Acknowledgments section has always been my favorite part of dissertations. The section demands that we always remember that a dissertation is never a solitary endeavor. This study likewise would not be possible without the support of many others.

First, my thanks go to my dissertation committee members. Carl Hoagland guided me through the maze of the doctoral process. He offered long chats on subjects ranging from metacognition and technology to World Cup soccer, and always had perfect timing with kind words when needed most. Joe Polman nurtured my interest in the development of learning environments based on strong cognitive science foundations, and inspired me with his own research and teaching. Wayne Nelson has been part of my journey from the beginning, starting when I thought it would be cool to make multimedia with Macromedia Director; Wayne taught me that same cool multimedia could be used to educate students too and advised me how best to do that. Randy Sommers graciously joined the committee to offer his expertise and insights from his recent work. I also need to thank all of those professors from whom I learned and with whom I worked with during my graduate studies. That saying about a teacher never knowing where their influence stops is certainly true. My inspiring teachers have included Elisha Chambers, Gooyeon Kim, Curt Bonk, Barbara Bichelmeyer, Ted Frick, Charles Reigeluth, Tom Duffy, Ivor

Davies, Tom Schwen, Elizabeth Boling, Adele Meadows, and countless others.

Of course, writing a dissertation is not possible without social support. I want to thank the Uds: Steve, Chris, Greg, Dave, Ken, and Rud; not many people are lucky enough to have such a close knit circle of friends for over twenty years. A very special debt is owed to Steve; the Metacog software would still be a sketch on a napkin without your technical expertise.

My parents have supported me all the way. Mom and Dad gave me everything I needed to succeed as the first college graduate in the family; they had no idea of the number of degrees they would inspire in me. My siblings, Rachel, Randy, Ralph, Rebecca, and Robert have encouraged me constantly, even though they are still bewildered about why someone wants to go to school so long. Becky, I wish you could have seen it. The Rapp family has been extremely understanding over the years, and undoubtedly looks forward to my consistent attendance at future family gatherings.

My daughters Grace and Sylvia need to know that your curiosity and zest for learning are contagious. It affirms my vocation as an educator. Despite what I say in the following chapters, you two are the original researchers who introduced who, what, when, where, and especially why metacognitive questions into my life. (P.S. We are around 54,000 words now.)

And finally, I thank my soul mate, Karen, although I know I can never repay you, even if I had two lifetimes. I remember crazy times, studying until 3 AM, going to work, running to class late, just to start all over again in a few hours. I was mistaken that I was doing all the hard labor until I saw you crying once during the girls' bath time, overwhelmed by that particular day. I've never forgotten that image. Please plan on spending many, many, many days and nights frolicking with me. You are the one who made this possible.

Abstract

This investigation is an exploratory study of the use of a metacognitive software tool in a social supportive learning environment. The tool combined metacognitive knowledge and regulation functionality embedded within the content of an eight week online graduate education course. Twenty-three learners, who were practicing teachers, used the tool. Prior knowledge of metacognition, including responses to the Metacognitive Awareness Inventory (Schraw & Dennison, 1994), was obtained. Prior knowledge of community instructional approaches was also obtained. Learner interviews focused on the mediational aspects of the metacognitive tool and the social supportive learning environment, as well as an evaluation of the tool.

Content analysis, combined with an activity theory framework, was used to analyze data. Findings are organized around three main themes: prior knowledge, the usability of the tool from design and technical perspectives, and the effectiveness of the tool related to its design principles.

The practicing teachers were found to be knowledgeable about metacognition and community; however, this knowledge did not often translate into successful instruction. Learners found the metacognitive tool easy to use, but had difficulty with its design for conversation. They found activity theory disconnections between the tool and other course tools, and found the other tools more successful at creating community. The tool was evaluated as equally useful for metacognitive knowledge and regulation, and more useful for more complex domain content than less complex content. Learners also found the tool useful for modeling the design of metacognitive instruction for their own teaching.

Conclusions are offered for improvements to metacognitive instruction in general and in particular for the use of cognitive tools in a social supportive online learning environment.

Table of Contents

Chapter 1

The topic of this research study is metacognition. Metacognition has been called one of the top 100 most influential topics of cognitive science, as a comprehensive meta-analysis of over 228 instructional variables that influence learning found student metacognition near the top of the list (Wang, Haertel, & Walburg, 1990). A review of instructional approaches for students with learning disabilities found similar results (Swanson, 2001). The National Resource Council (NRC) report on how people learn (Bransford, Brown, & Cocking, 2000) cites the benefit of a metacognitive approach to education as one of its three main findings. The American Psychological Association (APA), in its report for a framework for school redesign and reform (APA, 1997), concluded that metacognition is one of the most important principles for learning. Based on that research, McCombs and Vakili (2005) included metacognition in their own framework for a learner-centered system of instruction. A new journal, *Metacognition and Learning*, was launched in 2006 to address several components of metacognition, including metacognitive awareness, experiences, knowledge, and executive skills. Most recently, three new compendiums of metacognition research have been published (Waters & Schneider, 2010; Hacker, Dunlosky, & Graesser, 2009; Dunlosky, 2009). Metacognition has been a popular research topic for over 35 years; a recent ERIC keyword search for the term returns at least 3,200 studies between 1975 and 2010.

This first chapter provides an overview of various definitions of metacognition. It then highlights different approaches to metacognitive instruction. The lack of consensus to the variety of approaches indicates a need for further research. The purpose and significance of this study are established and the research questions are introduced. Then, in order to situate the reader to the following chapters, a detailed description is given of the researcher-created metacognitive tool, Metacog, used in this study. Finally, given its relative novelty, the analytical framework of activity theory used in the study is explained.

Metacognition and Metacognitive Instruction

Despite its popularity, both researchers and practitioners often disagree on exactly what metacognition is. Even a cursory review of the literature reveals a dizzying array of ideas associated with metacognition. These include knowledge of strategies, tasks, and self; monitoring and regulation; planning and problem representation; reflection and evaluation; and even control over environmental factors such as study space and noise level. The plethora of definitions, components, and subcomponents are detailed in Chapter 2.

Not surprisingly, the various definitions and models of metacognition have also led to different approaches to practically integrate the benefits of metacognition into the design of education. These different approaches are also detailed in Chapter 2. Lin (2001) asserted that metacognitive instruction studies generally concentrated on either a strategy approach or a social (community) approach to instruction, but not both. In strategy training, students are taught metacognitive strategies and then practice them at regular intervals. In the creation of social supportive environments, metacognitive skills, while still explicitly taught, are practiced in the context of the working on domain content with others.

Lin (2001) also asserted that the content taught in metacognitive instruction studies was either domain-specific, or self-as-learner, but not both. Domain-specific content relates to one particular domain, for example, algebra or science. Self-as-learner content relates to helping students understand themselves as learners, for example, their strengths and weaknesses as readers. Lin (2001) advocated combining both approaches (strategy and social) and both areas of content (domain-specific and self-as-learner) to better reflect the reality of metacognition in applied learning environments.

The Present Study: Purpose and Research Questions

Metacognition is important to learning, yet teaching methods for metacognition are not clearly agreed upon. Social supportive learning environments hold great promise for such instruction, yet the design of these environments for this instruction is also not clear. Relative to the study of traditional environments, the study of approaches and tools for teaching metacognition using virtual communities is also fairly recent.

In order to investigate metacognitive instruction in an online community where strategy, community, domain knowledge and self-as-learner knowledge are considered, a focus on the change process in the learners who are part of such an environment is needed. Researchers need to know not only *if* a particular implementation of instructional design works, but as importantly, *how* it works (Briggs, 2008; Fletcher, 1996). Speaking about online courses Henning (2003) states “more than data of performance in the technology is needed to interpret the learners’ social position comprehensively” (p. 304).

The purpose of this study, then, was to describe the experiences of learners during embedded metacognitive instruction in a social supportive learning environment, and the tools and factors that facilitated metacognitive learning in such an environment. This study specifically focused on using a particular tool in a social supportive online graduate course, and the change process related to adult learners’ metacognitive knowledge and regulation in that context.

Given its purpose, three research questions were considered:

1. What were learners' prior knowledge and use of metacognitive skills based on their educational experiences and life experiences?

2. How did a particular metacognitive tool (Metacog), in the context of a socially supportive online learning environment, mediate the actions of learners?

3. How did learners evaluate their experience of learning metacognitive skills in such a context?

Design of the Learning Environment and Metacognitive Tool

In order to study these questions, a cognitive software tool was designed. The tool was named, appropriately enough, Metacog. Learners used Metacog during an online graduate education course, which itself was designed as a social supportive environment. Given their critical importance for this study and their understanding and evaluation by the reader, the social supportive learning environment and Metacog are described in detail in the following pages.

A Social Supportive Learning Environment

Following on the characterization of trust as foundational to community (Kling & Courtright, 2004; Wenger, McDermott, & Snyder, 2002) there was a focus on establishing trust in the online learning environment. This was done using a variety of practical and research-based methods. Practically, learners were required to introduce themselves and find out about each other early in the course. Rules of community etiquette were also posted and learners were encouraged to suggest additions or modifications to these. In addition, learners were introduced to the basic characteristics of collaborative work group dynamics (Forsyth, 1998).

Jarvenpaa and Leidner (1999) describe several other instructor behaviors that facilitate trust in virtual communities, which were also employed in the course by the instructor: communicating enthusiasm, coping with technical uncertainties, predictable communication, and substantial and timely response. The objective of these various approaches was to create a safe environment for the risk taking that helps form trust.

Metacog: A Cognitive Tool for Metacognitive Instruction

The metacognitive tool, Metacog, was a central node in the study. The tool allowed for the application of metacognitive knowledge (defined as knowledge of task, person, and strategy variables) and the practice of metacognitive regulation (defined as planning, monitoring, and evaluation) through answering specific questions individually, then engaging in conversation with other students about those responses in order to reach mutual understanding. Help videos and instructor instructions to use the tool were available for review at any time. Several screenshots of the tool interface are included in Appendix A.

As part of the learning activities associated with the course, learners used the web-based metacognitive tool while completing two kinds of activities, course readings and course assignments. Course readings were academic journal articles taken from the cognitive science literature. Course assignments were associated with the final project for the course, a complete unit plan based on the domain content taught by the learner (all learners were practicing teachers). The readings and assignments are part of the course syllabus in Appendix C.

A learner (Learner A) first used the tool with the course readings, and the focus was on metacognitive knowledge. During or after a reading, Learner A completed a series of questions. The questions themselves embedded metacognitive strategies, but related specifically to the domain content of the course, which was a graduate course on the implications of cognitive science for teaching and learning. For example, learners answered questions about course readings that reflected a particular aspect of person, task, or strategy knowledge. Learner A might answer the question “Using only one sentence, what is the author’s main point in this reading?" as an illustration of the metacognitive learning strategy of summarization. Likewise, a learner might also answer the question, "If you were to implement the author's main suggestion in this reading, how comfortable would you feel doing it and why?" This question served as an example of metacognitive person knowledge, in this case self-efficacy (Bandura, 1986), in a particular topic area. A list of all questions is included in Appendix B.

While answering questions, learners were also shown a definition of the metacognitive strategy, as well as how and when to use it. This explicit declarative, procedural, and conditional knowledge is an important part of metacognitive training (Lin, 2001). Once Learner A had answered the questions, her answers were submitted and stored by the tool.

The next step in the process was for Learner A to read the responses of other learners. The tool, however, allowed learners to view other learners' responses only after they had answered the initial questions individually. This requirement forced learners to compose their own ideas, which promotes monitoring of current understanding (i.e., feeling of knowing), another metacognitive skill (Nelson & Narens, 1990), which in turn also helps focuses on areas for improvement.

Learner A was directed to find an answer given by another learner (Learner B) with which Learner A disagreed. Learner A then contacted Learner B using the tool and engaged Learner B in a one-to-one conversation. Learner B then explained his answer. Both learners continued the conversation to arrive at mutual understanding (whether or not agreement was reached). Each learner then reflected on how (and if) their understanding changed during the duration of the conversation.

The sociocultural perspective of Vygotsky (1978), discussed later in this chapter, would suggest that such learning with others is essential for the development of higher psychological functions, such as metacognition. From a cognitive science approach (e.g., Clement & Nastasi, 1998; Bruer, 1993), the conversations with others offered consideration and reconciliation of different perspectives, which facilitates the development of higher order thinking, such as metacognition.

The choice of one-to-one conversations versus a larger group discussion was made for two reasons. First, learners gained the benefits of collaboration and perspective taking with one person without the additional cognitive load of managing multiple perspectives as well as group dynamics, as cognitive load has been theorized to interfere with metacognitive processing (Veenman, Hout-Wolters, & Afflerbach, 2006). Cognitive tools in general usually attempt to reduce cognitive load (Lajoie, 1993; Oliver & Hannifin, 2000; Van Bruggen, Kirschner & Jochems, 2002; Robertson, Elliot, & Robinson, 2007). Besides reducing cognitive load, the other reason for one-to-one conversations was that trust might be more easily established in dyad relationships than the competing interests of a larger group.

In addition to required one-on-one conversations with other learners, learners also had the ability to view (only) the conversations between other learners. This further allowed for exposure to multiple perspectives, both at the individual level and conversation level. The possibility to evaluate one's standing in relation to the group, i.e., social metacognition (Inaba, 2006), could be a valuable tool to motivate improvement in problem areas.

After using Metacog with course readings to address metacognitive knowledge, the tool was used by learners to address metacognitive regulation, defined as planning, monitoring, and reflection. The use of the tool followed the same collaboration pattern for both metacognitive knowledge and regulation; however, the implementation was slightly different. When the focus was on metacognitive regulation, learners were directed to answer questions related to completing a particular unit plan assignment, instead of a course reading. For example, a learner was asked to describe her plan for working on the unit plan, finding resources, anticipating difficulties, etc. A list of all questions is included in Appendix B.

The design decision to direct metacognitive knowledge practice at the course readings and metacognitive regulation practice at the course assignments was made for two reasons. First, practicing the different components of metacognition in different situations should promote generalization of metacognitive skills (at least within the domain), and guards against inert knowledge. Second, the unit plan assignments were multi-faceted tasks involving coordination of several elements done over a period of time (i.e., they are complex tasks). Since the benefits of using metacognitive skills has been shown to be affected by task complexity (Veenman & Spaans, 2005), this design allowed for metacognitive skills to be used which might not be needed for the less complex tasks associated with the readings.

Activity Theory

In the naturalistic setting of the online social supportive learning environment, a case study approach was used to gather data. Based on the study's focus on the activity of the learners in such a community, an analytical framework called activity theory was used to find and organize patterns in the data. Given its critical importance for this study and its understanding by the reader in evaluating the study, activity theory is detailed in the following pages, rather than waiting until the data analysis section of the methodology chapter of this study.

Sociocultural Theory

No discussion of activity theory can begin without a prior discussion of sociocultural theory and Lev Vygotsky. Vygotsky is arguably the most influential Russian psychologist of the last 100 years. Although his academic career was cut short by tuberculosis at the age of 37, his ambitious goal during his short professional life was to radically change psychology (Kaptelinin and Nardi, 2006). Vygotsky believed that psychology in the early 1900s was trapped at a theoretical impasse (Kaptelinin and Nardi, 2006; Vygotsky, 1978). He argued that the root of the problem was the conception at the time in psychological thought about a separation of the individual from society. While society was seen as influencing the development of an individual’s thinking, the emphasis was always on the inner workings of the individual mind.

Vygotsky’s (1978) radical departure from this position was that society did not merely influence cognition; rather society was mainly responsible for the development of that cognition. All higher psychological processes (e.g., mathematical reasoning, language use, metacognition) beyond the basic cognitive processes that are shared with animals (e.g., memory and perception) were developed as the result of the interplay between an individual’s basic cognition and the society to which the individual belonged (Vygotsky, 1978). From this, Vygotsky posited the first law of genetic development that states that all higher psychological processes first manifested themselves socially at the interpersonal level between people, then were manifested again, internalized at the intrapersonal level, within the individual (Vygotsky, 1978). From this perspective, Vygotsky developed his now well-known concept of the zone of proximal development (ZPD), which is the difference between the level of development of an individual acting alone, and the potential level of development of an individual acting with a more knowledgeable other. The concept of ZPD has often been cited as the theoretical grounds for such instructional methods as scaffolding, fading, and collaboration (Kaptelinin and Nardi, 2006).

Vygotsky further believed that the interplay between society and individual was always mediated by activities involving tool use (Vygotsky, 1978). He described physical technical tools (such as hammers), psychological but physical tools (such as art and maps), and psychological symbolic tools, or signs (such as mathematical formulas and language) (Kaptelinin and Nardi, 2006). Tools originate in society, and as such contain all of the historical, social, and cultural knowledge of a society regarding the process for which the tool is used. But the use of tools can be eventually internalized by individuals to make sense of and act upon the world; the "tools transform natural mental processes into instrumental acts, that is, mental processes mediated by culturally developed means" (Kaptelinin and Nardi, 2006, p. 42). These instrumental acts are the higher psychological functions discussed above. This action in the world results in a cycle of internationalization and externalization. Society shapes individual cognition and individual cognition shapes society. Mind and society cannot analytically be separated.

Vygotsky also believed that the research methods of the time could not adequately capture the relationship of mind and society as mediated by tools (Kaptelinin and Nardi, 2006; Vygotsky, 1978). Traditional experimental techniques measured only the products of development, and also sought to "control for" the sociocultural influence on development. He advocated methods that considered this influence and allowed for observation of change in cognitive processes over time, rather than solely as an end product.

Interestingly, in the introduction to Vygotsky's *Mind in Society* (1978), two of the book's editors, Michael Cole and Sylvia Scribner, explicitly mention (in the Introduction, p. 13) the studies of John Flavell, considered by many the founder of modern metacognition research (discussed in Chapter 2). Flavell advocated the use of how and why research questions, and the use of methodology similar to that advocated by Vygotsky.

Vygotsky's call for a methodological framework to address the needs above significantly influenced the development of activity theory by one of his pupils, Aleksey Leontiev.

Activity Theory

Aleksey Leontiev was a student of Vygotsky. Leontiev, like Vygotsky, believed in the unity of human consciousness and the activity of human beings in the world. The mind was social in nature and therefore any study of the mind should also investigate the interplay between mind and the world (Kaptelinin & Nardi, 2006). While developing a theory of the historical origin of the human psyche (Kaptelinin & Nardi, 2006), Leontiev began using the concept of activity as an analytical tool in his research. At its basic level, activity is understood as a system encompassing a subject acting towards an object of the activity.

Subjects

A subject is the doer of the action, whose perspective forms the focus of the activity. For example, an activity such as a soccer game is interpreted differently depending on whether the subject is a player, a coach, a fan, or a non-fan. For Leontiev, the subject was a living individual organism, and his concentration was on human subjects. Later Engestrom (1987) extended the concept of the subject to include groups as subjects. In the present study, subjects of the activity were the learners in the online course; their characteristics are detailed in later chapters.

Object

The object is what subjects are trying to accomplish in an activity. Objects are of special importance then in activity theory; they are the critical characteristic in defining an activity. For Leontiev (1981), an “objectless” activity is not possible.

The exact meaning of object in an activity theory analysis is often confused. Kaptelinin and Nardi (2006) think that some of this confusion arises because Leontiev provides support for two different meanings of the word *object* in his explication of activity theory; Leontiev uses both the words *predmet* and *objekt*. *Predmet* refers to “the target or content of a thought or action" (Kaptelinin & Nardi, 2006, p. 139; Ozhegov, 1982). This can be considered the *object of the activity*, or as Kaptelinin and Nardi (2006) helpfully suggest, the *objective* of the activity. It is the "why" of an activity.

The other word for object in activity theory, *objekt*, has a narrower meaning. It refers to primarily "material things that exist independently of the mind" (Kaptelinin & Nardi, 2006, p. 139; Ozhegov, 1982). Marken (2006, p. 47) describes the object in this sense as "that which is acted on by the activity system." He suggests thinking of the object element of activity as conceptually similar then to the grammatical object in a sentence diagram – what the subject performed some action upon. He goes on to offer that a helpful prompt to get at this meaning is, "What will change as a result of this activity?"

The different emphases on object in Leontiev's work have resulted in different contemporary uses of activity theory. An approach based on Leontiev's original psychological perspective illustrates the "object as objective" *predmet* perspective. While it does not exclude collective subjects, and it acknowledges that all activity is inherently social, the approach is geared towards the analysis of individual subjects. The overall emphasis is on their understanding of the object.

A different approach, most often associated with the work of Engestrom (1987), to be detailed later in this chapter, focuses on the "object as thing" *objekt* orientation. This focus stems from Engestrom's application of activity theory to organizational management. This approach often is used with collective subjects in applied settings; for example, a group of users testing a new corporate software product. Each individual subject still has an idiosyncratic object (as objective), but the overall emphasis of the analysis is on the object as thing.

Nardi and Kaptelinin (2006) argue that the two approaches, while different, are complementary. The present study combined approaches. While the "object as thing" was a focus on metacognitive knowledge and skills, the "object as objective" was to use the metacognitive tool in a social supportive learning environment for purposes of the course.

Needs and Motives

Regardless of the interpretation of object, in activity theory the subject must be meeting some kind of need by interacting with an object. A need can be physical, such as hunger, or mental, such as success. For Leontiev, when a need is met by an object, this creates a special relationship between the need and object, known as the motive (Kaptelinin & Nardi, 2006). While humans can have needs without objects, once a need has met an object, and a motive has been created, the elements are inseparable.

Later theorists (Dmitry Leontiev, 1993; Hyysalo, 2005; Kaptelinin & Nardi, 2006) rightly argue that Leontiev's concept of object in the *predmet* "object as objective" sense is problematic for at least two major reasons. First, if a need is met by an object and this pairing is accorded the special status of motive, then what is the conceptual difference between an object of activity and a motive? Is the thing that the subject is trying to accomplish the object or the motive, once it has become intertwined with a need? The second problematic aspect of the concept of object is that Leontiev, while acknowledging the possibility, did not adequately account for multiple motives that result in a particular activity being undertaken (Kaptelinin & Nardi, 2006). In his conception, there is a one-to-one correspondence between a need, a motive, and an object. Of course, every day life often reflects competing motives.

Kaptelinin and Nardi (2006) suggest separating the idea of motive from the idea of object of activity. This elegant proposal allows for an acceptable solution to both of the problems associated with Leontiev's concept of object of activity. First, it suggests that while an object and a motive are conceptually similar when there is only one motive, this is not the case when there are two or more motives. When there are two or more motives (now coupled with their underlying needs), then the object of activity that results combines the multiple motives. Secondly, the suggestion of Kaptelinin and Nardi (2006) affords activity theory more analytical power. Activities may be much more explainable when multiple motives are considered for one resulting activity. The authors give the example of a hunter who is hunting dangerous game. His two simultaneous motives are both to stay alive and to get food, so he engages in the object of the activity of chasing his game until it tires and is less dangerous to confront and kill. Without accounting for both motives, his activity is less reasonable from the perspective of an observer.

Tools, Functional Organs, and Metafunctional Competencies

Leontiev follows Vygotsky in highlighting the mediational quality of tools, including language, in activity. Subjects use tools (also often called instruments or artifacts) to address their objects. The tool, as a product of a society, contains the collected wisdom of that society. By its use and internalization, it transforms the individual; society shapes mind. Leontiev (1981) describes the combination of human internal capabilities and external tools as creating functional organs. Functional organs "allow the individual to attain goals that could not be attained otherwise" (Kaptelinin & Nardi, 2006, p. 65).

Kaptelinin (1996) proposes three extensions of the concept of functional organs. First, tool-related competencies include "knowledge about the functionality of a tool, as well as the skills necessary to operate it" (Kaptelinin & Nardi, 2006, p. 64). Second, task-related competencies "include knowledge about the higher-level goals attainable with the use of the tools, and skills of translating these goals into the tool's functionality" (Kaptelinin & Nardi, 2006, p. 65). Finally, Kaptelinin and Nardi (2006) describe metafunctional competencies that:

> ...integrate the functional organs into the system of human activities as a whole. In contrast with tool-related and task-related competencies, metafunctional competencies are not directly related to employing functional organs for reaching goals. Instead, they deal with the coordination of multiple goals that can be attained via one action, with the limitations of the functional organs …and with side effects, maintenance, and troubleshooting. (p. 65)

The similarities between these three competencies (task-related, tool-related, and metafunctional) and several metacognition concepts to be detailed in Chapter 2 are striking. Briefly, metacognitive task knowledge and strategy knowledge (Flavell, 1976) are conveyed in the concepts, as in the distinction between declarative, conditional, and strategic knowledge. In addition, the concept of metafunctional competency alludes to the metacognitive regulatory functions of planning, monitoring, and evaluation.

Division of Labor

Leontiev further expanded upon the influence of society on the mind by stressing the role of the division of labor in society. Biological factors were no longer the primary factors that shaped mind once humans organized into society (Kaptelinin & Nardi, 2006). Society, especially through the division of labor, had the effect of disassociating a person's actions from her ultimate goals. In a famous example by Leontiev, hunters in a society divide into two groups. One group beats the bushes to scare animals out of hiding, while the second group waits nearby to actually kill the animals. The actions of the first group are not directly related to the ultimate goal of killing the animals. But if one takes into account the division of labor between the bush-beaters and animal-killers, the arrangement makes perfect sense from the perspective of society. A division of labor explains the individual's actions, dissociated as they are from the more obvious ultimate goal. In the present study, the division of labor might be thought of the different actions learners had to take in the course in relation to each other, such as engaging in a conversation with another learner after answering the initial questions. Another division of labor might be what the instructor did versus what the learners did.

Engestrom's Activity Theory Triangle

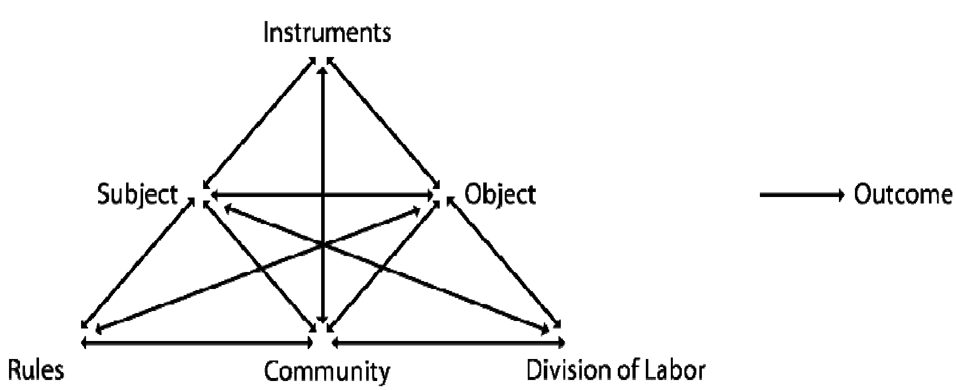
Activity theory is an ambitious analytical framework for describing activity and it contains many components that may not be relevant to all researchers. The ambition of the framework has also sometimes made it difficult for practical use. Since Leontiev's initial conception, others have sought to create tools based on the theory to make it more usable. One highly influential tool is the activity triangle (Engestrom, 1987).

Engestrom (quoted in Kaptelinin & Nardi, 2006) describes his tool as such:

> … object-oriented, collective, and culturally mediated human activity system. Minimum elements of this system include the object, subject, mediating artifacts (signs and tools) [or instruments], rules, community, and division of labor. (p. 99)

Engestrom's triangle is usually presented graphically as in Figure 1.

Figure 1. Engestrom Activity System Triangle



Based on Engestrom's language, the nodes of the activity triangle have come to be called the elements of activity. All of the elements have been previously described in this chapter with the exception of rules, community, and outcome.

Rules guide or constrain the system's actions and interactions (Nelson & Kim, 2001). They determine what subjects can and can't do. For example, in a university education setting, the instructor usually determines the course readings, assignments, and schedule. Students may or may not have the ability to decide on paper topic areas. These formal rules are generally found in the syllabus. A more informal rule may be that an online instructor will not answer a question via email if the question has been answered on a general course discussion board already. In this study, rules were grouped into two major categories. First, there were rules that defined what the learners had to do individually in the class (e.g., assignments). Second, there were rules/constraints that had been built into the functionality of the metacognitive tool (e.g., having to answer a question first before seeing the response of others).

The community is people (individuals or groups) who have the same object (Engestrom, 1999). For example, a research team collaborating on a grant proposal may share the object of being awarded the grant. Another community may be a sub-group of the same researchers tasked with designing the methodology section of the proposal. Engestrom specifically developed the triangle as a solution to both considering groups as subjects, and as an explicit acknowledgement that subjects are always acting within a larger (community) activity system (Kaptelinin & Nardi, 2006). This extension of activity theory is hardly surprising given its sociocultural basis; the triangle has since been used as an analytical tool for both single and group subjects. Marken (2006) suggests that community, in a more formal organizational or corporate setting, also may also be considered as all the stakeholders related to an object. In this study, the formal community was all learners in the class in relation to an individual learner, plus the instructor. At a broader level, any other person or group that affected the object of the activity, e.g., the developer/programmer of Metacog, instructors teaching other classes in which learners were enrolled, university administrators, etc. could have been considered stakeholders in the community.

Finally, the outcome is the goal of the activity. In this sense, the outcome in the activity triangle, positioned to the right of the triangle in Figure 1, is conceptually similar to Leontiev's *predmet*, or "object as objective." (The object in the triangle, meanwhile, positioned as a node of the activity triangle along with subject, rules, tools, community, and division of labor, is more similar to Leontiev's *object* where the focus is on an "object as thing" orientation.) While this exploratory study was not designed to formally test it, the ultimate outcome of using the metacognitive tool would be having learners internalize metacognitive knowledge and skills.

Disconnections

Of special note is that the activity triangle is often used by researchers to discover disconnections (also called contradictions or tensions in the literature) at or between elements of an activity system. For example, a disconnection may exist between the rule element of a system such as the mandated use of a particular reporting hierarchy in a corporation, and the tool (instrument) element of a system, such as the ease of copying multiple people in any email software program. Barab, Barnett, Yamagata-Lynch, Squire, and Keating (2002) used Activity Theory to discover tensions between elements of a university astronomy course using 3-D modeling technology. They found, for example, a tension at the subject element between students being active and engaged learners, as mediated by the new 3-D technology, versus being passive recipients of knowledge.

Engestrom (1987) outlined four possible levels of contradictions in an activity system. (While this study uses the term disconnection throughout, Engestrom uses the term contradiction, so the latter term will be used in this section.) According to Engestrom, a Level 1 Primary Contradiction is when there is a conflict between an element and itself. The two different expectations of students in the astronomy class above would be an example of this. Another example would be two conflicting rules that employees are expected to follow in an organization.

A Level 2 Secondary Contradiction is when two different elements in an activity system conflict with each other. The conflict between the email software and the reporting hierarchy rules is such an example. Another example would be a situation where there is no clear definition of rules about dividing work in a group, creating a conflict between a (lack of the) rule element and the division of labor element.

A Level 3 Tertiary Contradiction involves the entire activity system over time and transition. Engestrom describes this as "a contradiction between the object/motive of the dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity." (p.89) Objects can change faster than the formal activity systems around them, creating a conflict between the old and new ways of doing things. An example might be schools using technology in instruction. With advances in the last 20 years, the expectations of technology-enhanced instruction are rapidly changing. Administrators and educators must adjust their practices to meet these changes.

Finally, a Level 4 Quaternary Contradiction is when whole activity systems conflict with other activity systems, such as the level of international conflicts between two cultures. Examples would include the Cold War in the last century between the Soviet Union and the

United States, or the recent conflicts between Islam and Christianity. On a smaller scale, another example might be the integration of two different company cultures resulting from a merger. Quaternary disruptions involve multiple causes and effects interacting. The uncovering and analysis of all levels of contradictions is one of the strengths of activity theory.

With its focus on activity, activity theory has become a well-developed analytical framework, and is often used in studies of educational technology (although not specifically with metacognitive tools). Murphy and Rodriguez-Manzanares (2008) provide an introductory overview to such uses. In recent years, activity theory has been extended beyond psychology to a variety of fields including human computer interaction (HCI) and computer supported collaborative learning (CSCL), as well as education, communication studies, and ergonomics (Kaptelinin & Nardi, 2006). Given the aim of investigating learner use of a new tool, with probable varying motives, all within a specific sociocultural and historical learning context, activity theory serves as strong foundation for this study.

Significance of the Study

This study contributes to the literature by focusing on the learner’s change process, as well as by situating the study as an investigation of effective instructional methods for metacognitive skills. The findings of this study will have implications for both practice and theory.

Theory

Metacognitive skills are only one aspect of learning, but an important part. It is important for educational researchers to better understand the construct and the instructional methods related to it. While Brown (1987) acknowledges that metacognition is “fraught with some of the most difficult and enduring epistemological problems of psychology” (p. 66), she also believes that "metacognitive-like entities lie at the very roots of the learning process" (p. 66). Should metacognition strategies be taught as embedded within domain instruction, and that domain instruction itself embedded in a social supportive environment? What does such an experience look and feel like to students? Additionally, as education is increasingly delivered through virtual learning environments, there is a need to understand how such environments affect instructional design. What tools facilitate metacognition? This study intends to provide some insight to these questions by illuminating the role of metacognition in student learning.

Practice

This study addresses metacognition and its associated learning methods in an online social supportive learning environment. The beneficiaries of the findings of this study will be students who will gain from improvements in learning environments designed to teach metacognition. More directly, those professionals who create and teach through such environments will benefit from the knowledge of environmental design, tool use, and student factors examined in this study.

Chapter 1 Summary

This chapter has introduced the topic of metacognition. Metacognition has been popular in educational literature for at least 35 years, and is still popular today. Despite this popularity, there are many different conceptions of metacognition. This diversity of opinion, premised on a variety of definitions, has led to a multitude of instructional approaches. This suggests a need to study instructional approaches to metacognition more closely. The purpose of this study is to analyze one particular metacognitive tool in a particular social supportive learning environment.

Likewise, the appropriate analytical framework should be used for such a study. Activity theory was also introduced in this chapter. With its focus on the elements of activity, and its ability to uncover disconnections within that activity, activity theory is well suited for the task. The next chapter will describe the various approaches to metacognition and its teaching in detail.

Chapter 2: Literature Review

Despite its seemingly universal appeal to educators, metacognition has been defined in different ways over the years by researchers. In fact, reviews of metacognition, this one included, generally spend at least some time commenting on the various uses of the term itself.

This chapter begins with an overview of different models and components of metacognition. It then describes the overlap of metacognition with the closely related construct of self-regulated learning. The impact of these definitional issues on the study of metacognition is also discussed related to the measurement of metacognition, including distinguishing between cognition and metacognition, and the debate over the domain dependence or independence of metacognition. An overview of approaches to metacognitive instruction is provided, as well as specific detailed examples of several studies and tools. These instructional approaches include classroom scaffolding, the use of cognitive tools, and virtual communities. Finally, recent literature and tools on metacognitive instruction, available after the development of Metacog (the metacognitive tool used in this study), are discussed.

Metacognition Components and Models

Metacognition was introduced formally to the educational research community by Flavell (1976) who explored the use of mnemonics with children. When some children failed to generalize the strategy after it was taught, Flavell concluded that successful children were not only aware of the usefulness of the mnemonics strategy, but were also monitoring and regulating their own memory processes during its use. Popularly referred to as "thinking about thinking," Flavell (1976) said:

> Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data…

> Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete [problem solving] goal or objective. (p. 232)

Schoenfeld (1992) described this definition as “kitchen-sink” (p. 38) in that it includes a number of categories. Brown (1987) acknowledges that the fuzziness has resulted in “nontrivial problems associated with the current blanket usage of the term” (p. 107). While many definitions and models of metacognition have been offered since (e.g., Borowski, Chan, & Muthukrishna, 2000; Butterfield, Albertson, & Johnston, 1995; Nelson, 1996; Quintana, Zhang, & Krajcik, 2005), the Flavell definition encompasses the two main components of metacognition most often mentioned in the literature: knowledge of one’s own thinking, and regulation of that thinking (Flavell, 1977; Brown, Bransford, Ferrara, & Campione, 1983; Hacker, Dunlosky & Graesser, 1998; McCormick, 2003). Even the simple two-component model of metacognition suggested by this definition, however, is not without disagreement in the literature. Brown (1987) argues that it is regrettable that both knowledge and regulatory components are included in the same model. On the other hand, it is hard to imagine regulating a cognitive process without being knowledgeable about that process; the knowledge component of metacognition seems to be a necessary part of any model of the construct.

Metacognitive Knowledge

The presence of the knowledge component in a model of metacognition, however, does not alleviate disagreements about which subcomponents of knowledge should be included in the model. Flavell and Wellman (1977) originally suggested three knowledge subcomponents: knowledge of task, knowledge of strategy, and knowledge of person.

Knowledge of Task

Tasks are the activities that learners are trying to accomplish. Knowledge of the task affects how learners attempt to solve them. Examples include knowing that the more information given in a question, the easier it should be to solve (Pintrich, Wolters, & Baxter, 2000); knowing that some tasks like remembering the gist of a story are less difficult than other tasks such as remembering a story verbatim (Flavell, 1979); and knowing the basic characteristics of a task such as pair association or sort-recall (Reid & Barkowski, 1987).

Knowledge of Strategy

Strategies help learners achieve tasks. Strategies are "cognitive operations above and beyond the processes that are a natural consequence of carrying out a task, ranging from one such operation to a sequence of interdependent operations" (Pressley, Forrest-Pressley, Elliot-Faust, & Miller; 1985). Knowledge of strategies facilitates cognitive activities used in learning such as "memorizing, thinking, reasoning, problem solving, planning, studying, reading, writing, etc." (Pintrich, Wolters, & Baxter, 2000, p. 46). Using the earlier task examples, a strategy to achieve the pair association task might be the use of interrogative-associative mediators, and a strategy to achieve the sort-recall task might be the use of clustering (Reid and Barkowski, 1987). Other examples include knowing that rehearsal can help in memorization, and elaboration can help in comprehension (Pintrich, Wolters, & Baxter, 2000).

Critically important to the knowledge of strategies is the distinction among declarative, procedural, and conditional knowledge. A large group of metacognition researchers (e.g., Alexander et al., 1991; Paris, Lipson, & Wixson, 1983; Schraw & Moshman, 1995) note this distinction; it is also found in more general studies of cognition (e.g., Bransford, Brown, and Cocking, 2000; Bruer, 1993). Briefly, declarative strategy knowledge is knowledge that a strategy exists. Procedural strategy knowledge is knowledge of how to use the strategy. Conditional strategy knowledge is knowledge of when and why to use a particular strategy.

Knowledge of Person

Flavell's original conception of knowledge of person included beliefs about the self such as knowing that one is better at memory than problem solving tasks (Flavell, 1979). Some authors have suggested, however, that knowledge of person is a non-cognitive affective variable, and while important, should be excluded from the knowledge component of metacognition (e.g., Pintrich, Wolters, & Baxter, 2000; Garcia & Pintrich, 1994).

Most conceptions of metacognition, however, based on a more holistic perspective of learning, continue to include the motivational aspects of the person knowledge subcomponent (Lin, 2001). Lin's (2001) call for the inclusion of self-as-learner knowledge in metacognitive instruction mentioned earlier, reflects this. Person knowledge in models which include it is often interpreted to mean attributional beliefs of learners about personal success or failure in learning (Borowski, Chan, & Muthukrishna, 2000). Borowski, Chan, and Muthukrishna (2000) list common reasons attributed to success or failure, including ability, effort, attitude, fatigue, and luck. Weiner (1984) classifies these attributions according to internal or external locus, stability over time, and controllability by oneself. Different attributions or combinations of attributions ultimately can affect strategy selection and task performance. For example, attribution to personal effort results in persistence when difficulties arise (Nicholls, 1984; Weiner, 1984).

Metacognitive Regulation

The second basic component of all models of metacognition is regulation, also referred to in the literature as control processes (Reed, 2004; Nelson & Naren, 1990). As Flavell (1976) suggested, the component is often divided into two separate but related subcomponents:

monitoring and regulation. The idea is that metacognitively aware learners actively monitor their own learning, and upon discovering something amiss, then seek to repair the misunderstanding. While the separation of monitoring from regulation is theoretically attractive, research has yet to show that the two components are completely separate (Pintrich, Wolters, & Baxter, 2000; Schraw & Denison, 1994). Although learners may frequently recognize issues in their thinking, but then fail to regulate (i.e., repair) those issues, it is more difficult to imagine a learner regulating a cognitive process without first monitoring it. In addition to the general terms monitoring and regulation, similar constructs have also been investigated under such headings as ease of learning (EOL), feeling of knowing (FOK), judgment of learning (JOL), and confidence judgments (Nelson & Naren, 1990). Dunlosky and Metcalfe (2009) offer a recent overview of research on these constructs, classifying them as metacognitive judgments.

In addition, under the component of regulation, some authors include other subcomponents in addition to monitoring and regulation. For example, either problem representation or planning is sometimes included before monitoring. Clements and Nastasi (1991) separate problem representation from planning in their model. Conversely, Quintana, Zhang, & Krajcik (2005) combine the two subcomponents as task understanding and planning in their metacognitive model for online inquiry.

The term reflection is also a subcomponent of metacognitive regulation in some models. For example, Quintana, Zhang, & Krajcik (2005) include reflection as the last step in their metacognition model. Unlike monitoring, which usually occurs during a task, reflection is generally conceptualized as occurring after a task has ended. In a complex task, however, monitoring and reflection might well be viewed as the same activity, but having this temporal distinction.

Metacognition and Self-Regulated Learning

In recent years, there has been much focus on self-regulated learning (SRL). This construct shares many similarities with the idea of metacognition, and the resulting overlap has caused some confusion in both literatures. From a practical perspective, metacognition researchers and metacognitive tool designers are advised to look to the literature of SRL for related ideas.

The biggest overlap between definitions of metacognition and SRL is that both usually include references to regulation (i.e., monitoring and control). Pintrich, Wolters, and Baxter (2000), however, explain that in SRL, learners are not only regulating cognition, but they are also regulating "other factors that can influence learning, such as motivation, volition, effort, and the self-system" (p. 45). In this view, metacognition is a narrower construct than SRL.

When models of metacognition include person variables, however, they can be seen as very similar to models of SRL, and this may be cause for some confusion. Garcia and Pintrich (1994) suggest that regulation of both cognitive factors affecting learning and non-cognitive factors affecting learning are related to the knowledge component of metacognition. Paris and Winograd (1990) believe some confusion might be avoided by reserving the term metacognition specifically for metacognitive knowledge and not for metacognitive regulation.

SRL models may also differ from metacognitive models in the inclusion of learner control over environmental factors. For example, a learner can realize that the level of sound or music in which they are studying is unacceptable, and she can control whether to continue to study there (or alter the volume). Not all SRL models, however, include environmental control.

Winne and Hadwin (1998, 2008) offer perhaps the most complete model of SRL, which includes phases of task definition, goal setting and planning, tactics (learning strategies), and adaptations based on reflection. Each of these phases is influenced by various task (environmental) conditions such as time and resources; each phase is also influenced by person (cognitive) conditions, such as self-as-learner beliefs, motivation, domain knowledge, task knowledge, and strategy knowledge. Each phase, influenced by the different conditions, is metacognitively monitored, and then adjusted (controlled) as warranted, depending on a learner's evaluation of progress towards standards the learner has internally established for the phase.

The model is characterized as "unfolding over four flexibly sequenced phases of recursive cognition … the results of events in any phase can feed into the metacognitive monitoring and metacognitive control of any other phase (Winne and Nesbit, 2009, p. 261)." In this sense, while subordinate to SRL, metacognition underlies and is fundamental to the entire model. Azevedo and Witherspoon (2009) suggest that other popular models of SRL (e.g., Dunlosky, Hertzog, Kennedy & Thiede, 2005; Koriat & Goldsmith, 1996; Nelson & Naren, 1990; Thiede & Dunlosky, 1999) reflect the essential metacognitive components of the Winne and Hadwin (1998, 2008) model.

The variety of models, components, and subcomponents included in different models of metacognition (including overlapping self-regulated learning models) make the study of the construct flexible for a variety of research questions, but also simultaneously often perplex the area of study. A sampling of these issues is explored next.

Issues in the Study of Metacognition

Undoubtedly stemming from the underlying definitional issues, researchers are faced with several related issues in the study of metacognition.

Cognition versus Metacognition

In distinguishing cognition from metacognition, cognition is usually characterized as cognitive activities that are a necessary part of doing a particular task, while metacognition is characterized as cognitive activities, such as memorizing or reasoning, that are “above and beyond” these task-specific cognitive operations (Gredler, 2001; Pressley, Forrest-Pressley, Elliot-Faust, and Miller, 1985). In other words, metacognition is learning strategy use (Waters and Schneider, 2010). Clements and Nastasi (1999) suggest that this strategy use is under conscious control and is analogous to purposeful reflection. It is this reflection, or evaluation, on different strategy options that makes metacognition “meta” in the first place. This is related to conditional knowledge as discussed earlier.

Where exactly cognition ends and metacognition starts, however, is difficult to ascertain when other conceptions of metacognition are suggested beyond conditional strategy use. For example, Reed (2004) summarizes the relationship between his conception of metacognitive skills and cognitive skills used in problem solving. In doing so, both problem representation and planning are listed as cognitive processes, while both strategy selection and monitoring are listed as metacognitive skills. This would conflict with models where problem representation and planning are considered metacognitive skills themselves.

Adding to the confusion between cognition and metacognition, and metacognition in general, Clements and Nastasi (1999) argue that the term metacognition is additionally used to describe the unconscious use of executive processes that oversee cognition, such as in the cognitive models of Nelson and Naren (1990) and Sternberg (1985). Brown (1987), while herself perhaps the biggest proponent of metacognitive instruction found in the literature, nevertheless comments that the idea of a metacognitive executive process poses a homunculus conundrum. That is, if there is an executive process overseeing cognition, what is overseeing the executive process?

Domain Dependence versus Domain Independence

Arguably the holy grail of education is to teach students to become independent, strategic thinkers. From Piaget to Bloom to Bereiter, educational thinkers have in one way or another alluded to this. The goal of education is to teach students to learn how to learn (Sternberg, 2009). It is perhaps no wonder then that metacognition researchers often debate whether metacognition is domain-dependent or domain-independent. If metacognition is domain-independent, then once a student has mastered the skill, the student can use metacognition to learn in any domain.

Perspectives on this issue, of course, depend on the underlying definitions of metacognition used, and are especially relevant to the knowledge component of metacognition. To illustrate, is the knowledge of summarization strategies domain-dependent to reading or domain-independent since such strategies can be used in numerous other domains? What does it mean if a student can summarize readings in biology and English, but not in philosophy? Is summarizing in one domain different from summarizing in another domain? Likewise, are only *some* summarization strategies domain-dependent and some are domain-independent?

Waters and Waters (2010) offer a recent overview of the current state of the debate. They cite earlier studies on expertise (Chi, Glaser, & Farr, 1988; Ericsson & Lehmann, 1996) to make the case that transfer of general skills from one domain to another has been established as limited. For example, expert chemists don’t do particularly well in addressing political science problems. Bruer (1993) makes a similar illustration that a chess grandmaster would not necessarily make a good leader of a country.

Water and Waters (2010) argue however, that more recent literature (Roberts, 2007; Siegler & Alibali, 2005) revisits the domain dependence issue (specifically in the areas of logical reasoning, theory of mind, and number reasoning) and concludes that domain-general processes are essential. It is not an either-or question, but rather a question of integration between domain-general and domain-specific knowledge. Especially important to this study, Waters and Waters, like many other metacognition researchers, suggest that the best way to study and teach metacognition is "within a particular domain, but in a context in which individuals are challenged to use a broad range of general strategic knowledge." (p. 115)

In addition to metacognitive knowledge, metacognitive monitoring and regulation research must also be scrutinized. Pintrol, Walters, and Baxter (2000) state that these control processes are often assumed to be domain-independent, but suggest that since most metacognition studies are done within one domain such as reading, researchers need to explore how such skills transfer across other domains. Similarly, Baker and Cerro (2000) maintain that metacognitive knowledge and control are domain dependent, citing studies on low correlations between metacognitive studies in different domains (e.g., Byrd & Gholson, 1985; Kurdek & Burt, 1981).

Measuring Metacognition

Even assuming that a researcher has sufficiently outlined the subcomponents of metacognition that she will be exploring, the hidden nature of the construct makes measuring it difficult (Wolf, Brush, & Saye, 2003).

Researchers have relied on a variety of student behaviors to operationalize metacognition, including verbal indication of miscomprehension (Markham, 1977) and strategy use based on an awareness of task and personal characteristics (Palinscar & Ransom 1988; Savery, 1998). Researchers have also employed various methodological techniques for measuring metacognition (Gay, 2002; Wolf, Brush, & Saye, 2003). These include think-aloud protocols

(McNamara & Magliano, 2009; Hill, 1995) and journaling activities (Brush & Saye, 2000; Harada, 2001).

The issue is of such magnitude that an entire conference of noted metacognition scholars convened to discuss this; a subsequent publication, *Issues in the Measurement of Metacognition* (Schraw & Impara, 2000), resulted from the conference. Lessons from the conference included that researchers should be explicit about which subcomponents they are including in their models, and that researchers should use a variety of methods in order to establish validity for their measures and the construct as a whole. The issues are far from settled, as one of the original authors recently reiterated many of the same admonitions in a contemporary compendium on metacognition (Schraw, 2009), almost a decade after the conference and subsequent publication.

Teaching Metacognition

As discussed throughout this paper, numerous writers cite the importance of metacognition for learning (e.g., Brown, 1987; Jacobs & Paris, 1987; Gredler, 2001). However, students do not spontaneously develop or use metacognitive skills unless they are explicitly made aware of them (Lin, 2001; McGregor, 1993). This underscores the need for instruction that helps learners to “plan, implement, and evaluate” learning strategies (Palinscar, 1986, p. 123). Many instructional methods for metacognition have been tried to address this need (e.g., Azevedo & Cromley, 2004; Schwartz, Andersen, Hong, Howard, & McGee, 2004; Land & Hannafin 1997; Hill 1995; Osman & Hannafin, 1992; Clements & Nastasi, 1988; Nastasi, Clements, & Battista, 1990).

Lin (2001) claims that given the large number of metacognition studies, a comprehensive review of the literature “would require a book length monograph” (p. 24). Dunlosky & Metcalfe (2009) similarly claim there have literally been hundreds of studies of metacognition. Any attempt at concise review is compounded further by the large variation in metacognition models, and the overlap between metacognition and self-regulated learning.

To remedy this situation, some authors have attempted to create frameworks for classifying studies of metacognitive instruction. For example, as mentioned in Chapter 1, Lin (2001) describes metacognition studies as analyzable along two dimensions. One dimension is the kind of instructional approach taken, either strategy training or the creation of a social supportive environment. In strategy training, students are taught metacognitive strategies and then practice them at regular intervals. In the creation of social supportive environments, metacognitive skills, while still explicitly taught, are practiced in the context of working on domain content with others. The second dimension of Lin's framework is the metacognitive knowledge that is taught, either domain-specific strategies or knowledge of the self-as-learner (i.e., person knowledge).

The Lin (2001) framework is useful to initiate discussion, but the framework proves unworkable for anything more than simple classification purposes. For example, consider a study which takes place in a classroom "community," features an online component, and uses prompting, modeling, and scaffolding within the domain of mathematics to teach knowledge of domain-specific learning strategies, as well as the metacognitive skills of monitoring and regulation! This kind of study is not an exception, but rather similar to a large majority of studies that look at a number of different subcomponents of metacognition in realistic settings. This observation is not a critique of research methods, as Baker and Cerro (2000) suggest these very kinds of studies for evaluating the teaching of metacognition. The example rather underscores the point that metacognition studies do not neatly fall into any one exclusive category. Given the variety of issues with classifying studies, the approach taken here is to describe salient features of particular studies employing various approaches to metacognitive instruction, while being as specific as possible about the included subcomponents.

Early studies of metacognition focused on one-to-one skills tutoring by researchers or whole group training on general metacognitive skills outside of any particular domain (Lin, 2001). Such a de-contextualized approach, however, often results in students with inert knowledge who have learned metacognitive skills, but divorce them from environments in which they could be used (Brown, Collins, & Duguid, 1989). The end result is that the skills are not used when and where they should be (Cavanaugh & Perlmutter, 1982).

Again, Baker and Cerro (2000) citing many authors emphasize the importance of teaching metacognition within the context of domain knowledge. Many such methods have been implemented and studied with successful results (e.g., Cognition and Technology Group at Vanderbilt [CTGV], 1990; Schoenfeld, 1988; Costa, 1984; Brown, Bransford, Ferrara, & Campione, 1983). While such embedded metacognitive instruction has been promising, the most effective instructional method for such an approach is far from decided.

Lin (2001) has called for extending this concept of embedding metacognitive skills within a domain to an even broader context. She suggests that designers could create engaging socially supportive learning environments to better facilitate this process (Lin, 2001). In addition to supporting the acquisition of the traditional components of metacognitive knowledge and regulation, Lin places special emphasis on the affective components of metacognitive person knowledge, which are often part of SRL models. As discussed earlier, not all models of metacognition include such affective components, but Lin argues strongly for their inclusion. She further argues that social supportive learning environments, including virtual online environments, can be especially effective at facilitating this kind of “self-as-learner” knowledge.

Social Supportive Learning Environments

Research has established that learners benefit from social supportive learning environments, usually described as physical or virtual communities (Barab & Duffy, 2000; Bransford, Brown, & Cocking, 2000; Brown & Campione, 1994; Lave, 1993; Wenger, 1998; Wellman & Gulia, 1999). Like metacognition, however, community is not easily defined. While researchers have explored community from a plethora of theoretical perspectives, design criteria, and methodological approaches, conceptualizations of the underlying construct abound. In many cases, the term is applied to any kind of social grouping, from social clubs to work places to classrooms to street gangs to nations (Kling & Courtright, 2004).

Kling and Courtright (2004) summarize the community literature as it relates to their work in an online electronic forum. In doing so, they reference the attempts of Brint (2001), Nolan and Weiss (2002), and Haythornwaite, Kazmer, Robins, and Shoemaker (2000) to define community.

Brint (2001) looked at different kinds of community and found the following common characteristics:

- dense and demanding social ties
- social attachments to and involvements with institutions
- ritual occasions
- small group size
- perceptions of similarities with the physical characteristics, expressive style, way of life, or historical experiences of others
- common beliefs in a moral order, an idea, an institution or a group

Nolan and Weiss (2002) summarizing the work of Ostrom (1990) and Kollock (1998) describe the following characteristics of community:

- group boundaries are clearly defined
- the implementation of rules governing collective goods are well matched to collective needs and conditions
- most individuals affected by the rules can participate in modifying the rules
- the right of community members to define their own rules is respected by external authorities
- a system for monitoring members' behavior exists, undertaken by the community themselves
- a graduated system of sanctions is used
- the community members have easily accessible ways to resolve conflict (p. 295-296).

Haythornwaite, Kazmer, Robins, and Shoemaker (2000) looked at community in an online master's degree program. They suggested that virtual learning communities have traits such as recognition of members and nonmembers, a shared history, a common meeting place, commitments to a common purpose, adoption of normative standards of behavior, and emergence of hierarchy and rules.

While it is obvious that virtual communities share many traits with physical communities, Renninger and Shumar (2002) are quick to reflect that there are very real differences between the two. For example, physical communities are much more defined by spatial and temporal considerations, i.e., being at the same place at the same time. In contrast, connections to virtual community do not have similar boundaries. Participants may be drawn to communities initially by a shared interest, but the individual participant does not have to be present for any particular function, and may more easily observe at a distance without participating.

In looking at several of the preceding examples, Kling and Courtright (2004) conclude that community has many aspects, and not all communities have all the aspects found in the literature. In addition, virtual “communities” are often nothing more then overhyped descriptions of web sites accessible to millions of people over the Internet.

Kling and Courtright (2004) offer that perhaps the common theme among the more convincing claims to community involve the underlying idea of trust. They suggest that trust is important to any community because it allows participants to safely take risks such as sharing information, respecting one another, and keeping some matters confidential. Wenger, McDermott, and Snyder (2002) provide similar examples of making a community safe for “dumb” questions, disagreeing with others including leaders and experts, and openly discussing problems. When trust is present, it forms the foundation for the social and educational benefits of community such as facilitating cooperation and collaboration as a means for learning, even within the tension and conflict that are normal parts of any community. However, “while tension and conflict are normal in community, the notion gets romanticized often with regards to virtual communities and learning communities.” (J. Polman, personal communication, March 18, 2010).

Approaches to Metacognitive Instruction: Extended Examples

As discussed earlier, metacognition studies do not fit into neat categories. While strategy versus community (physical or virtual) approaches are often contrasted theoretically, actual studies can and very frequently do employ both approaches. In addition, software tools are often used in metacognitive instruction. The distinction is one of emphasis within a study. Several extended examples will illustrate various approaches within metacognitive studies.

Strategy Training Within a Classroom Community

White and Fredericksen (1998) used a controlled study with 7^{th}-9^{th} graders to investigate the importance of metacognitive monitoring and reflection. The program was implemented in 12 urban classes by three teachers. They set out to teach students not only physics knowledge, but also, more importantly, the scientific method and how to monitor and reflect on that process. Pretests and posttests measured students' inquiry and physics expertise. Student research projects were also evaluated. The instruction also used a scaffolded software environment within the classroom that included a "reflective-assessment process" (p. 6).

The White and Fredericksen study shares similarities with many metacognitive studies. Specifically students are given a specific metacognitive process model to follow. This process is actually a learning strategy in the metacognitive knowledge sense. In this case, it was a five-step inquiry cycle (Question, Predict, Experiment, Model, and Apply). Likewise, the study makes an argument for creating a social supportive community of learners within the classroom to simulate authentic scientific inquiry. According to the authors:

> According to this [community of practice] postpositivist view, the community is responsible for developing a consensus about what are the important theoretical concepts to consider, how these concepts are lawfully related within a model, and how such models can be used to represent real-world behavior. The community must also assess the results of experiments and observations they have carried out and judge their relevance and implications for the models they are constructing. (p. 8)

The difference between the experimental and control group in the study was the reflective-assessment process, operationalized as prompts to remind the students to remember important aspects of the scientific process, such as being systematic, reasoning carefully, and being inventive. The prompts were to be considered during teacher-led peer and self-assessment.

White and Fredericksen found a positive significant effect on quality of student projects due to the reflective-assessment process, $F(l, 106) = 6.82$, $p = .005$. The effect was particularly noticeable for students who entered the class with lower standardized achievement test scores (ES=1.44). This is consistent with the idea that lower achieving students often benefit more from metacognitive instruction; higher achieving students generally have already internalized these skills (Lin, 2001).

Especially germane to this study are two issues. First, the peer and self-assessment during the reflective-assessment process was teacher-led. This was perhaps designed in this manner given the age of the students (middle school) or the student unfamiliarity with the inquiry process or assessment process. In other metacognition literature (e.g., Brown, Bransford, Ferrara, & Campione, 1983), this kind of teacher modeling of a process is often faded and students eventually (ideally) learn to internalize the metacognitive skill, in this case self-evaluation. White and Fredericksen (1998) do mention scaffolding and fading, however, it is in regards to aspects of their general inquiry model, rather than the experimental intervention of metacognitive monitoring and reflection. Earlier modules, for example, provided students with research questions, middle modules scaffolded the process, and later modules required students to create the research questions themselves. The monitoring and reflection process appear to be teacher-led through all modules.

Second, while White and Fredericksen (1998) make significant mention of a community of practice model (i.e., a social supportive environment), their monitoring and reflection process is actually a process of public evaluation. For example, they provide a page-long sample of the process. An excerpt below from the larger sample, however, captures the process:

> Teacher: OK, what about “being systematic”?
>
> Emily: I think I would give them a 4 because it sort of looked like they skipped some parts of what they were supposed to do.
>
> Teacher: OK, Carla [one of the presenters], how would you evaluate yourself?
>
> Carla: I gave myself a 4 because I was organized in my work most of the time. And, we did all the steps that we were supposed to do for our project. And, we summarized them in our presentation. (p. 27)

While White and Fredericksen (1998) point out that such a public evaluation approximates the peer review process of authentic scientific research, sometimes missing from their process is the voice of the individual or group being evaluated. One would assume at some point a peer would attempt to rebut a negative evaluation, and some kind of discussion would then ensue, as is revealed in the sample above. Consequentially, by not emphasizing the role of peer collaboration during the reflective-assessment process, the authors miss the collaboration that is the essence of a learning community. (The authors also mention another form of peer review during the inquiry cycle, rather than during the reflective-assessment process. This review is actually more collaborative in nature; however, this was not part of the experimental intervention.)

Cognitive Tools for Metacognitive Instruction

It should be noted that White and Fredericksen (1998) prominently mention the use of the software tool created for their instruction. In their study, however, the tool was primarily focused on scaffolding conceptual learning and the scientific process, and the metacognitive skill instruction (as defined by them) itself was accomplished by face-to-face modeling. In many other metacognition studies, the software, often called a cognitive tool, plays a central part in the metacognitive instruction.

Wolf, Brush, & Saye (2003), for example, used three specific “metacognitive strategy scaffolds” to facilitate metacognitive thinking and information problem solving. Working with 18 eighth grade students, the researchers collaborated with a classroom teacher to create a complex assignment, to research and write a news article about the Selma March during the Civil Rights era in the United States in the 1960s.

The first metacognitive tool the children were taught to use was *Big Six*, a “general, non subject-specific, metacognitive scaffold” (p. 1) which consists of the following steps: task definition, information seeking, strategies, location and access, use of information, synthesis, and evaluation. The authors contend that “Palinscar’s (1986) definition of metacognition as the ability to plan, implement, and evaluate strategic approaches to learning and problem solving is supported by the six steps of *Big Six*” (p. 2).

In addition to *Big Six*, the children were taught to use a multimedia database that contained hundreds of artifacts from the Civil Rights era. The database used prompts to guide the children toward information needed for the newspaper articles, such as the people involved, the goals of the people involved, and the causes of this event. The database also had journaling capabilities for supporting reflection on completed work and planning future research activities.

Based on student journals, interviews, surveys, observations, computer logs, and the student newspaper articles themselves, the authors concluded that the tools had several beneficial effects. These benefits included supporting student awareness and monitoring of thinking during complex tasks, providing a common vocabulary to make their thinking explicit to teachers and other students, and providing a generic but powerful process that could be used by students for other learning tasks. The authors also briefly note that student self-efficacy was reported as moderate to high, despite the complexity and novelty of the learning task.

The use of multiple data sources does give some credibility to the validity of the findings of the study regarding the effectiveness of the student use of metacognitive skills. The authors concede, however, that a longer study would be needed to fade the various scaffolds to see if students had actually internalized the metacognitive skills. What would happen when the tools were no longer available? This issue has also been specifically raised regarding prompting in other studies involving metacognitive training with software (Lin, 1998). In addition, while the stated focus of the *Big Six* study is on the *Big Six* process itself, it is unclear which of the metacognitive tools (the *Big Six* process, the database prompts, or the database reflection journaling) accounted for the purported benefits. Would the outcomes have been the same without, for example, the journals for reflection and planning? Metacognitive instruction studies that explore multiple tools and instructional design elements are often open to this question.

An earlier example of a metacognitive-oriented software tool is described by Angeli and Cunningham (1998). The authors employed Bubble Dialogue, an instructional software tool, to provide support for the acquisition of literacy. The qualitative study findings were based primarily on the thematic analysis of student-generated dialog captured by the tool in a population of 50 second through sixth graders. The instructional environment, designed to instantiate the 14 learner-centered psychological principles (American Psychological Association, 1995), used an electronic comic strip interface to facilitate student-student and instructor-student dialog. The tool had two modes. In the creation mode, students were required to work with a partner through a scenario related to some element of literacy, and complete either a “speech bubble” or “think bubble” to keep the dialog continuing towards a resolution. Speech bubbles represented a student’s explicit speech in the virtual conversation, while think bubbles represented their internal thoughts. In the creation mode, students could only move forward in the conversation. The second mode, review mode, allowed students to review completed conversations. In this mode, students could also edit both the existing speech and think bubbles. In addition, the review mode featured a Notes tool, where students could write additional comments, such as commentaries on the scene or the motives of the characters in the conversation.

Specific to metacognition, the creation mode allowed students, through use of the think bubble, to monitor and regulate their thinking internally during a conversation. The aim was that eventually students would internalize this way of thinking in their daily lives. Likewise, in review mode, students could re-visit a scenario, reflect on their ways of thinking in a particular situation, and revise their speech accordingly.

Despite the reported success of the tool in helping students improve their literacy, the authors noted that most students hardly used the metacognitively-oriented think bubble tool. When questioned, the students said they did not really need to think about what they were going to say; the tool seemed redundant with the speech bubble. The researchers noted, however, that this was not the case; in many events the students would pause and then start again before replying. The researchers surmised that students either did not want to take the time to use the speech bubble, or “they did not see the connection between internal and external dialog” (Angeli & Cunningham, 1998, p. 90). The researchers suggested that practice in the use of the tool would have increased its use during the study. Likewise, the other metacognitive tool, the notes tool that offered the opportunity to comment on a transcript of the conversation in review mode, was lightly used. Again the researchers suggested more practice would have resulted in higher use during the study. Cooney (1998) also found high achieving 10th grade English students in a computer-supported collaborative environment reluctant to use transcripts for reflection, preferring to make comments during the actual virtual interaction. Cooney speculated that engagement during the interaction was more cognitively challenging to the students.

Interestingly, in the Bubble Dialogue study, Angeli & Cunningham (1998), also identify four levels of control that could be given by the tool, based on a variety of individual characteristics related to learning. One specific level of control is related to the level of metacognitive skills a student already possesses. If needed, the tool might adapt to focus primarily on metacognitive skill in the instruction. Others have also suggested such an adaptive metacognitive tool (Azevedo, 2004; Mayer, 2005; Inaba, 2006), and learning object researchers interested in metacognition have described some work in this area (Vovides, Sanchez-Alonso, Mitropoulou, & Nickmans, 2006). Unfortunately Angeli and Cunningham did not provide any detail on how such a diagnostic and adaptive system works or might work in the tool.

Virtual Communities and Metacognition

White and Fredericksen (1998) studied a mix of strategy and community approaches, and used software for limited purposes, within a classroom to facilitate metacognition. Wolf, Brush, and Saye (2003) and Angeli and Cunningham (1998) emphasized such cognitive tools in their studies of metacognitive strategy use in classroom instruction. What happens when the classroom becomes virtual? What happens when the software *is* the classroom? What happens when the design of the tool is more than partially responsible for facilitating both strategy and community approaches to metacognition?

Dettori, Gianetti, and Persico (2006) investigated self-regulated learning within a blended, mostly online course, rather than as a classroom software adjunct. The study describes student survey responses on the use of a learning management system, Centricity FirstClass, to facilitate self-regulated learning (SRL) in an educational technology course with 72 Italian pre-service teachers.

The authors rely on the definition of Zimmerman (2000) of self-regulated learning (SRL) as an individual's capacity to control their learning cognitively, motivationally, and behaviorally. As noted earlier, the term SRL is often used interchangeably with the term metacognition, or used as an umbrella term to include traditional metacognition plus affective variables. In this case, the student survey was divided into three main sections: cognitive, emotional and motivational, and social aspects. The cognitive section of the survey was then divided into four "metacognitive" areas: 1) goal orientation (planning), 2) time and environmental management (monitoring), 3) reflection, and 4) self-assessment. The first two and last two were grouped together in the results.

According to the authors, the students highly rated the planning and monitoring flexibility of the system to make some decisions about the content, learning strategies, and time management of the course. It should be noted the actual ratings of questions in this section were 2.94-3.75 on a scale of 1-5 with standard deviations ranging from 0.77-1.55; therefore the distinctions of these ratings as high is dubious. (Additionally, no reliability or validity information is reported.) The authors conclude, however, that while the ratings were high, this flexibility in planning and monitoring was largely the result of the instructional design of the course (e.g., students were allowed to access material at their own pace). The software facilitated the flexibility, but was not the source of it.

The students were more positive about the system and its use in providing for reflection (*M* = 3.62-3.65/5, *SD* = 1.15-1.37). The authors suggest that this is due to the availability of asynchronous discussion boards and their characteristics for reflection, including their written, permanent nature, and their opportunity for exchange of multiple perspectives (Palloff & Pratt, 1999). They acknowledge, however, that the course design also specifically included content areas on the importance of reflection, and this may have influenced the higher ratings.

The students rated the potential for self-assessment with the system as low according to the authors (*M* = 3.11/5 *SD*=1.37, although only one question on this is included in the survey). The authors insightfully suggest, however, that the nature of the course may have again been the issue, rather than the system. The course concentrated on the use of technology in course design, and as such there were no “right” answers. Students who were seeking such clarity from the system would have disappointed.

The next main section of the survey was motivational and emotional aspects of SRL. The authors do not explain the difference between motivation and emotion; however, they do discuss emotion in terms of “self-efficacy and ability to cope with stress and failure” (p. 406). They then discuss the system’s poor online help facilities, as well as some learners’ feelings of anxiety with technology-based learning. The implication is that poorly designed tools might actually inhibit, rather than facilitate, SRL/metacognition.

Finally, the authors discuss the social aspects of SRL facilitated by the system, including “help-seeking, communication ability, effective collaboration, etc.” (p. 408). These aspects of the tool receive the highest ratings (*M*=3.16-4.13, *SD*=1.02-1.40). Regrettably, the authors do not elaborate on the actual tools used for these social aspects; one can only surmise based on the course design description that discussion boards were the only such tool.

The authors conclude that the social aspect was highly rated for two reasons. First, it allowed for the exchange of different perspectives and experiences. Second, a supportive learning community or social presence (Garrison, Anderson, & Archer, 2000) was created that allowed such exchange to safely take place (although there is acknowledgment of some disgruntled students negatively influencing this sense of community). Unfortunately, the authors do not specifically say why or how this social supportive environment formed. They do suggest, however, that an explicit focus on “metacognitive reflection” (p. 410) in the form of an activity that spanned several weeks during the class may have helped. The details of the activity are not given, but it may have led to student claims about gaining the ability to work in groups, to collaborate, and to entertain the perspectives of others.

Recent Metacognitive Instruction Tools and Literature

Recent literature and tools, available after the design of Metacog (the metacognitive tool developed for this study) was conceived, reiterates many of the trends in earlier studies but with important new contributions. For example, Winne and Nesbit (2009) continue the discussion of how cognitive software tools can support self-regulated learning, which includes metacognition in their model. Specifically, they ask:

What data can software gather?

What can software do better than a student?

How can software facilitate metacomprenension?

How can software teach learning tactics and strategies?

How can software help learners benefit from errors?

How can software foster adaptive help-seeking?

How can software motivate learners to self-regulate?

The authors cite several recent tools including gStudy (Nesbit & Winne, 2007); eHelp (Schwonke, Hauser, Nuckles, & Renkl, 2006); guided discovery software (Moreno, 2004); I-Help (Bull, Greer, & McCalla, 2003); and Help Tutor (Aleven, McClaren, Roil, & Koedinger, 2006). The authors suggest that metacognitive tools can allow students to predict scores; tutor students who need help; expose and remediate critical errors; serve as recommendation agents; and aid learners' recollection. Like earlier authors, they also conclude that metacognitive tools should be embedded within other tools rather than developed independently. Rather than making the specific argument that embedding such tools is a better way to teach metacognition, they reason that embedding the tools allow access to learner performance data, which ultimately is needed to facilitate metacognition. In addition, they make the practical point that learners are likely to be more motivated to use tools that directly support their acquisition of domain knowledge, rather than independent tools that provide indirect support.

Azevedo and Witherspoon (2009) make similar recommendations regarding cognitive software tools to facilitate metacognitive knowledge of learning strategies and metacognitive planning and monitoring. They advocate the design and development of authentic computer-based learning environments that allow students to study and learn, while also allowing researchers to gather very detailed process data which will allow researchers to analyze changes that occur during self-regulated and metacognitive learning. In addition to their own efforts, they point to other researcher-created learning environments. (e.g., Biswas, Leelawong, Schwartz, & TAGV, 2005; Witherspoon, Azevedo, Greene, Moos, & Baker, 2007). They specifically suggest that such tools and environments can offer prompts for planning and activating prior knowledge; offer scaffolds to learners to encourage knowledge elaboration, and monitoring of that process; and detect both effective and ineffective learning strategies and to provide feedback as needed.

Finally, Schwartz et al. (2009) describe their recent work with a tool called Betty's Brain. The tool allows for "interactive metacognition" which the authors describe as a form of learning by teaching. Using the tool, learners program software-based teachable agents with the goal of making the agents effective learners. The authors suggest that this form of learning allows students to engage in metacognitive activities such as anticipating difficulties, monitoring, and regulating. Consequently, as learners work with their agents, they begin internalizing metacognitive behaviors themselves. Using a variety of measures, the initial results for use of the agents is promising; however, the authors acknowledge that much work is still to be done before any definitive claims of success can be made for his method of metacognitive instruction.

Chapter 2 Summary

The preceding studies reveal several issues in existing metacognition studies. First, a variety of instructional methods have been used to study metacognition. These include strategy training featuring modeling, physical and virtual learning communities based on trust, and software tools with various levels of scaffolding. Second, the studies reveal that more often than not metacognition studies are not clear about what they are studying. They are not explicit about either the metacognitive subcomponents included in their studies, or about which instructional methods or tools are being introduced to study which subcomponents. Next, while many of the studies report successful results, they are not overly enlightening about *how* and *why* their interventions brought about metacognitive change. For example, the Dettori, Gianetti, and Persico (2006) study speculates about the use of the virtual classroom, especially the discussion board, to generate community, but the details are absent about how this process may have emerged over time, i.e., the contributions and interactions among the tool, the students, the instructor and other factors is not explicit. Recent literature and tools continue earlier trends in the use of cognitive tools and online community environments for metacognitive instruction.

This chapter began with an overview of different definitions and models of metacognition. While it is generally agreed that metacognition is composed of knowledge and regulation components, there are a variety of subcomponents included in different models, such as strategy knowledge, task knowledge, person knowledge, planning, monitoring, and evaluation. Additionally, self-regulated learning models overlap considerably with metacognition models. These definitional factors have created a variety of issues in the study of measurement of metacognition, as well as approaches to metacognitive instruction. These instructional approaches include classroom scaffolding, the use of cognitive tools, and virtual communities.

This study adds to this literature with a focus on a cognitive tool (Metacog) for metacognitive instruction within an online social supportive learning environment. The next chapter outlines the methodology employed in the study.

Chapter 3: Methodology

The purpose of this study was to describe the experiences of learners using a metacognitive tool in a social supportive online learning environment, and the tools and rules that facilitated or inhibited metacognition in such an environment. The study was done to contribute to the improvement of metacognitive instruction using such cognitive tools. This study specifically focused on the change process related to adult learners' metacognitive knowledge and regulation in an online graduate course.

Given the purposes of this study and the focus on the activity of learners in a social supportive learning community, three research questions were considered:

1. What were learners' prior knowledge and use of metacognitive skills based on their educational experiences and life experiences?
2. How did a particular metacognitive tool (Metacog), in the context of a socially supportive online learning environment, mediate the actions of learners?
3. How did learners evaluate their experience of learning metacognitive skills in such a context?

In this chapter the research methodology for the study is detailed. First, ontological and epistemological justifications are made for the study. Following from this, the appropriateness of the qualitative case study method used for this study is discussed. Then the context of the study is reviewed. This includes a description of the researcher's relationship to the setting and its influence on the study. Next, the sampling and data collection methods employed in this study are discussed, as well as how threats to validity associated with these methods were dealt with in the study. After that, the content analysis process that was used for data analysis is explained, with special attention to how the mediator nodes of activity theory and the concept of disconnections (contradictions) were a significant part of this analysis. Finally, following Berg

(2005), the evolving process of the data analysis is detailed. The hope is that this detail can serve future researchers using activity theory to analyze qualitative data derived from the study of metacognitive tools.

Ontological and Epistemological Justification

Mason (2002) argues all researchers should explore their own ontological and epistemological perspectives as a foundation for their research.

Ontology is one's belief about "the very nature and essence of things in the social world" (Mason, 2002, p. 14). Mason's examples of ontological properties include such diverse perspectives as people, objects, social processes, rules, morality, chaos, markets, and cultures. The ontological properties most associated with this study were learners and the metacognitive tool they used and its associated rules, within a motive-oriented activity.

Epistemology is concerned with "what we regard as knowledge or evidence of things in the social world" (Mason, 2002, p. 14). Understanding the meaning that learners gave to their use of the metacognitive tool in the online social supportive environment was best accomplished using their own words. Such a perspective leads to ideas on the appropriateness of different data collection methods, such as the applicability of data derived from personal interviews. In this case, verbal language and written text were used extensively for data collection; these methods will be described later in this chapter.

Qualitative Research

This study was qualitative in nature. Qualitative research is used for several purposes required by the research questions. First the study was exploratory (Marshall & Rossman, 1999). The metacognitive tool, Metacog, had never been used before in any applied learning environment. This was the tool's debut, so to speak. The study also sought to be explanatory

(Marshall & Rossman, 1995); although the tool was investigated in one particular setting; the findings and conclusions can then be incorporated by other researchers doing similar studies. The study was descriptive (Marshall & Rossman, 1999); the background of learners is detailed, as is their use of the tool's functionalities. The focus of the study was on the process (Krathwohl, 1998) of that use. The context and setting were important (Marshall & Rossman, 1999), especially as this was an initial exploratory study. While the literature provided a basis for the design of the tool, one never can be sure how a tool will actually be used in an applied setting. Finally, the focus of the study was on the meaning of a phenomenon from the perspective of the participants' experience (Marshall & Rossman, 1999). This perspective was critical, given the focus on process, and that the tool was being introduced for the first time.

Case Study

Yin (2006) describes the strength of the case study method as "its ability to examine, in-depth, a 'case' within its 'real-life' context" (p. 111). He goes on to say that, "The case study method is best applied when research addresses descriptive or explanatory questions and aims to produce a firsthand understanding of people and events" (p. 112).

In this study, the context of the research is an authentic ("real life") online learning environment. As mentioned above, the research questions address both description and explanation. Descriptively, the questions focus on what specifically happens when learners participate in a particular kind of social supportive online learning environment using particular tools. Likewise, as explanatory research, the questions address how and why the specific design features of the learning environment and tools, together with learner and sociocultural factors, affect learners' metacognitive development in this context. The observations of the learners themselves were used to produce firsthand understanding.

The Context

Setting

The setting for this study was an online graduate course titled, "Instruction, Learning, and Assessment" offered at a medium-sized Midwestern public university. The course was a requirement for the Master of Education degree in the elementary, secondary, and special education programs. In addition, the course was also listed as a required course in the educational technology concentration of the same programs. This was the first offering of an online version of the course. It was offered over the summer of 2008 as an eight week course meeting entirely online using the university's online learning platform, Blackboard, which is described next.

Online Learning Platform

The university uses the Blackboard Learning System as its e-learning platform. The platform provides a number of components to allow for fully online courses, as well as to enhance classroom courses. These components include WYSIWYG content authoring, discussion boards, assessments, surveys, and gradebooks. Blackboard also supports learning objects, chat, blogs, portfolios, and learning communities (Blackboard, 2008).

Learners

Twenty-two adult learners (18 female, 4 male) were enrolled in the class. The learners were all graduate students attending school part-time, taking evening or online courses. All of the learners were practicing K-12 teachers, except one who taught adult GED classes. The learners resided and taught in the state where the university is located, or the adjoining state. The learners had an average of about four years of teaching experience, although the range of experience varied (M= 3.85, SD=2.60).

Description of the Course

The course syllabus, included in Appendix C, describes the course “Instruction, Learning, and Assessment” as:

> This course uses learning as the basis for the design of classroom instruction. By applying learning theories, teachers can improve their own unit development, lesson plans, assessment strategies, and the use of technology for effective teaching. This course will deal with the impact of cognitive educational research on the subject content and what is known about how people learn. Teachers will learn to critically evaluate and improve their own educational practices, design principled and appropriate assessments based on their instructional goals, and to assess their own professional development.

The two main texts for the course were *How People Learn* (Bransford, Brown, & Cocking, 2000) and *Understanding by Design* (Wiggins & McTighe, 1998), along with several other readings from the cognitive science and sociocultural literature. The syllabus and course design had been used, only slightly modified by different instructors, in the classroom version of the course for several years. The online version of the course kept the same readings and activities, as well as their sequencing, intact from earlier classroom versions. Given the online context, the online course relied extensively on electronic communication tools, including discussion boards and email.

Description of Researcher Relationship

The researcher also served as the instructor for the course. While this relationship had the potential for conflict between attending to instructional requirements of the course and the research requirements of the study, this potential was alleviated by both the online delivery format of the course, and by the research design created to minimize this conflict.

Relative to the online format, this allowed the researcher to communicate asynchronously with learners and to have all communications recorded electronically. At no time did the researcher/instructor have to make a choice between research activities such as writing memos, and instructional activities, such as providing learner feedback.

The research design of the course also minimized any possible conflict between research activities and instructional activities. First, theoretically, the design was qualitative and employed activity theory; there was no positivist concern for instructor effects. Second, more practically, the main metacognitive tool used in the study was incorporated into the existing design of the class. Taking the form of a web-based aid for understanding, the tool was meant to be a part of the normal structure of the class from the beginning, rather than just a tool for research data collection. Third, as the class content domain was educational psychology, the metacognitive strategies discussed as part of the tool were a supplement to the formal syllabus, rather than something outside of the domain. For example, the learners used *How People Learn* (Bransford, Brown, & Cocking, 2000) as a textbook in the course; the text features specific content on the topic of metacognition. Finally, formal learner interviews regarding tool use were conducted shortly after the course was completed and grades had been formally submitted to the university, in order to avoid any appearance of coercion in the research process. In sum, the researcher also serving as the course instructor was not problematic to this study.

Data Collection Methods

Case study researchers often use several collection strategies to gather data to address their research questions (Marshall & Rossman, 1995). This study followed in this tradition.

One criterion for evaluating qualitative research is informational adequacy. In other words, “Does the research design maximize the possibility that the researcher will be able to respond to the questions thoroughly and thoughtfully? Will the strategy elicit the sought after information?" (Marshall & Rossman, 1995, p. 42). The focus of this study was to describe the experiences of subjects using a metacognitive tool in an online social, supportive learning environment. To gather data that explicitly revealed learner experience, the study design used four main data sources: reflective self-reports, student artifacts, semi-structured interviews, and a standardized metacognitive instrument. System-generated data was also used to supplement data from the four main sources.

Self-reports

Given that metacognition is inherently a cognitive construct that occurs "in the head" of participants, self-reporting has a long history in the study of metacognition (Gay, 2002). There are, however, legitimate concerns about the reliability of this self-reporting. For example, some learners may not have the skills necessary to articulate their cognitive processes; this could be especially problematic in a study designed to explore the personal meaning associated with the process of metacognition. Taken as one source of information among others, however, self-reports were a valuable source of data and appropriate to this study. In this study, self-reports were specifically represented by initial discussion questions answered by learners, and by an evaluation of the metacognitive tool completed by the learners during the last week of the course.

Artifacts

Artifacts are things people have created (Anderson-Levitt, 2006). As such, artifacts convey meaning that participants give to their surroundings. Researchers can study this meaning by examining these artifacts; this characteristic makes artifacts an appropriate instrument for data collection. In this study, artifacts were specifically represented by the activities that learners completed using the metacognitive tool.

Semi-structured Qualitative Interviews

Interviews are an obvious way to make thinking explicit (Anderson-Levitt, 2006). In a semi-structured interview, interviewers begin with a list of focused questions or topics and then allow participants to answer freely. Follow-up probes may be used to elicit additional information, return to previous topics, or to explore interesting topics that arise during the interview process. For this study, the ability of interviews to elicit private meaning from participants, more than other techniques, made it especially appropriate for data collection. In this study, semi-structured qualitative interviews were specifically represented by the interviews conducted with a sample of students after the course has ended. The interview questions were based on the Activity Checklist (Kaptelinin, Nardi, & Macauley, 1999) and the Activity Interview (Duignan, Noble, & Biddle, 2006), both described later in this chapter. The interview questions used in this study are available in Appendix D.

Standardized Metacognitive Instrument

Standardized instruments are generally associated with quantitative research studies and are often used as the basis for generalizing findings. The standardized instrument used in this study, the Metacognitive Awareness Inventory (Schraw & Dennison, 1994), was developed as such an instrument. This 52-item Likert-scored instrument was developed to measure adults' metacognitive awareness, defined as the two traditional components of metacognition, knowledge of cognition and regulation of cognition. Schraw and Dennison report a reliability of .90 in their own studies of the instrument.

In this study, however, given its qualitative nature, the use of non-random sampling, and the sample size, the standardized instrument serves another purpose. The instrument served as another source of data about learners' prior knowledge and use of metacognition at the beginning of the study.

System-generated Data

The Blackboard online education platform provided by the university provided a variety of tracking features. Likewise, the Metacog tool provided limited tracking functionality. This system data was used to triangulate other data sources. For example, system data confirmed whether learners had or had not accessed a particular discussion board or Metacog activity.

Table 1 provides the relationship of the data sources to the research questions in this study.

Table 1

Relationships of Research Questions to Data Sources

Research Question	Data Sources
What were learners' prior knowledge and use of metacognitive skills based on their educational experiences and life experiences?	Self-reports at beginning of course Standardized metacognitive instrument Semi-structured qualitative interviews after course
How did the metacognitive tools, in the context of a socially supportive learning environment, mediate the actions of the learners?	Artifacts System-generated data Tool evaluations during the last of the course Semi-structured qualitative interviews after course

How did the students regulate and evaluate their experiences of learning metacognitive skills?	Tool evaluations during the last of the course Semi-structured qualitative interviews after course

Data Collection Procedures

The online course was offered over the eight-week 2008 summer semester session. Data collection took place during and immediately after the course. Table 2 illustrates the data collection procedures. A detailed description of each data collection component follows the table.

Table 2

Data Collection Procedures

Step #	Data Collection Component
1	Learners reply to a discussion question on their background, teaching experience, life experience, and academic experience
2	Learners reply to question on their prior knowledge and use of metacognition
3	Learners reply to question on their prior knowledge and use of community and collaboration strategies in their teaching
4	Learners complete standardized metacognitive instrument
5	Learners are introduced to the metacognitive tool and use tool with a course reading and for planning course final project
6	Learners use the metacognitive tool with a second course reading and for monitoring course final project
7	Learners complete online evaluation of metacognitive tool

8	Sample of learners participate in semi-structured interviews

Data Collection Step 1: Demographic Information

During the first week of the online class, the learners answered a course discussion question titled "Introductory Activity" that asked for a variety of demographic background information. The activity is shown in Figure 2.

Figure 2. Course Introductory Activity

Introductory Activity

Welcome to the course! I hope you will approach every part of this course as a tool to help you improve your understanding of teaching and learning. One important tool for teaching and learning is collaboration, which in turn can lead to a valuable sense of community.

With that in mind, I'd like to start out by asking you to let me and your classmates know about yourself and your background. Please post answers to the following questions to the discussion board:

1. Who are you? Tell us a little about your background prior to this class, i.e. where are you in your masters or doctoral program? What has been your favorite class so far and why? Why are you taking this EDPSY/TCHED 6030 course?
2. If you teach, what grade, and subject, and where, and how long? Why do you like or dislike teaching? (If you don't currently teach, tell us about what you do too!)
3. Job interview question: What is your major professional goal in the next five years?
4. Which topic or goal of the course listed on the syllabus is most appealing to you and why? Which topic or goal is least appealing and why?
5. How comfortable are you with using technology for teaching and learning? Please provide some examples if possible.
6. Keeping in mind the idea of mutual respect, tell us something you think is unique or interesting about yourself.

Before you answer, I want to emphasize again that besides the academic aspects of this course, which are the main reason you are here, I would like to create an open, safe, and sharing learning community where we are learning as much from each other as we are from the official texts and readings. If you ever have any questions or concerns, contact me as soon as possible.

So, let's get started – I'll go first! Click the "Introductory Activity" link above to enter the discussion board.

Data Collection Step 2: Prior Knowledge and Use of Metacognition

During the first week of class, learners responded individually via email to a question on their prior knowledge and use of metacognition. The exact question was:

> The term "metacognition" will appear in some of the readings for this class. What does it mean to you? Do you know it, have it, or use it personally or in the classroom? If it means nothing to you right now, that is a perfectly acceptable answer! But if you have

heard of it all, please let me know what you think. I am looking for your current understanding of the term right now.

The learners responded to this question *before* reading about metacognition in the course textbook, *How People Learn* (Bransford, Brown, & Cocking, 2000).

Data Collection Step 3: Prior Knowledge and Use of Community and Collaboration

Given the importance of a social supportive learning environment in this study, learners were asked to individually email a response to a question about their prior of community and collaboration in their own classrooms. The activity is shown in Figure 3.

Figure 3. Perspectives on Community and Collaboration Activity

Initial Perspectives on Community and Collaboration
As you have probably discovered in your other courses, collaboration is often mentioned as an important part of learning. We'll be collaborating quite a bit in this course. We'll have a couple readings on the subject as well. Likewise, community is also mentioned as important for learning, and ideally comes out of collaboration.

Intuitively it makes sense. After all, we are always interacting with each other, and the experiences and knowledge of others are a valuable source of information. Although we may not always agree on everything, the different perspectives that come from collaboration are helpful to see what others are thinking, which in turn shapes our own thinking.

But the benefits of collaboration and community, however, don't just "happen" by simply talking to each other. The chance that the benefits occur can be increased through the design of our learning environment. In particular, we want to create an environment that fosters the shared values of mutual respect, openness, and safety. I hope we can begin to create such an environment and such a community of learners over the duration of this course.

In order to do this, it is important to understand what you believe about all of this right now. Do you use collaboration and community in your classrooms? Does it help learning? Have you had positive or negative experiences? What is you opinion?

Data Collection Step 4: Standardized Metacognition Instrument

During the first week of class, learners completed an online version of the standardized metacognition survey, the Metacognitive Awareness Survey (Schraw and Dennison, 1994).

Data Collection Step 5: Use of the Tool with Course Reading #1 and Metacognitive Planning

During the fifth week of the course, the learners were introduced to the metacognitive tool, Metacog, and then asked to use the tool with two assignments. First, they used Metacog with one of the course readings, "Beyond Bloom's Taxonomy: Rethinking Knowledge for the Knowledge Age" (Bereiter & Scardamalia, 1998). They also used it with that week's assignment related to the planning of the class final project, a unit plan in the subject matter they taught, based on the cognitive science principles taught in the class. (Originally, the tool was planned to be used from the first week of class for several readings, as well as an assignment related to evaluating their unit plan; however, technical issues with its development resulted in the delay in its implementation until the fifth week of the course.)

Data Collection Step 6: Use of the Tool with Course Reading #2 and Metacognitive Monitoring

During the sixth week of the course, the learners were asked to use the tool with a second course reading, "Problem-based Learning: An Instructional Model and its Constructivist Framework" (Duffy & Savery, 1994). Learners were also asked to use the tool as they monitored their progress in completing the class final project. Learners were encouraged to use the seventh week of the course to complete all Metacog activities.

Data Collection Step 7: Evaluation of the Metacognitive Tool

During the final week of the course, learners completed an online researcher-created evaluation of the metacognitive tool. The evaluation questions are included in Appendix E.

Data Collection Step 8: Semi-structured Interviews

The online evaluation form had a question asking for volunteers to participate in a follow-up interview. Within 10 days after the course had ended and course grades had been submitted, a sample of six learners were interviewed regarding their use of the metacognitive tool. The interviews were conducted either at the university's main campus, or at a location convenient to the interviewee. The interviewees were audio recorded.

The interviews addressed the learners' experience with the metacognitive tool in the context of the entire course activity system. The interview questions were based on two interview tools developed for use in activity theory studies, the Activity Checklist (Kaptelinin, Nardi, and Macauley, 1999), and the Activity Interview (Duignan, Noble, and Biddle, 2006). The interview questions used in this study are available in Appendix D.

Kaptelinin, Nardi, and Macauley (1999) devised the checklist specifically for use in the field of interaction design for creating tools (usually software) for complex tasks. The checklist begins with a preamble outlining its overall use and then is divided into two main versions. A design version is intended for tool designers during the design process (before the tool has been developed or implemented). An evaluation version is intended for evaluators after the tool has been implemented with a particular group of users. Both versions are very similar, and the temporal distinction of pre-implementation design versus post-implementation evaluation seems to be the major difference.

Both versions are divided into the same four major categories: means/ends, environment, learning/cognition/articulation, and development. While these categories do not match the specific nodes in the activity triangle (Engestrom, 1987), the categories cover the same information important in any activity theory analysis. For example, the means/end category is concerned with goals; the environment section is concerned with rules, tools, and division of labor; the learning section is concerned with activities and strategies for achieving them, including self-regulation and distributing the activity between the subject and the tool; and the development section is concerned with all elements as they are situated in a historical context, as well as how they happen over time (the change process). The categories each contain several areas such as the above examples for consideration by the designer or evaluator. In addition, Kaptelinin, Nardi, and Macauley (1999) include a list of suggested questions that are applicable for design and evaluation researchers.

Duignan, Noble, and Biddle (2006), however, considered the Activity Checklist difficult to administer in real world settings. Specifically, they found that there was much repetition in the elements, and that the example questions were not as useful as they wanted for their own work. In response, they created the Activity Interview. Their interview purports to make the original checklist more usable for data collection by presenting the essential components of the checklist as questions ready to be asked of study participants. The questionnaire also condenses several of the original checklist components.

Sampling Strategy

The decision on which class to use for the study resulted in a convenience sample. Given practical considerations, it was a matter of feasibility. Likewise, at the end of the class, the six learners in the smaller sample who agreed to the in-depth interviews were volunteers. As such, there was no attempt to find a certain kind of course or class, or to include certain types of learners in the course. The purpose of the study and its qualitative nature, however, demonstrates that the convenience samples pose no threat to validity of the study. While this study may provide some evidence for the applicability or non-applicability of the metacognitive tool for different types of students, the tool employed in the study made no initial claims to being applicable to any one type of student. Nevertheless, sampling strategies should be evaluated for their use in any study.

Miles and Huberman (1994) suggest that sampling strategies can be evaluated using six different criteria: relevance to conceptual framework, potential to generate rich information, analytic generalizability, potential to generate believable explanations, ethics, and feasibility. Despite the use of convenience sampling, this study attempts to meet these criteria.

Relevance to Conceptual Framework

The class represented initially the full spectrum of perspectives that comprised and influenced the activity system. During the post-class interviews, this variety was also preserved. The interviewees included not only more than one case, but also interviewees with differing amounts of experience and age, different genders, and different grade levels and subject matter domains.

Potential to Generate Rich Information

Rich information is abundant and detailed. Overall, this requirement was met by using a variety of data sources as well as several learners. The Metacog questions and answers and the collaboration on several readings and assignments generated a large amount of data. In addition, the qualitative semi-structured interviews in particular were a rich source of information, with their open-ended nature and follow-up probing by the interviewer. The large majority of the data collection involved the learners' own words permanently captured through the various systems and processes used in the study.

Analytic Generalizability

Unlike quantitative studies, the goal of qualitative sampling strategies is not statistical generalization; however analytic generalization is desired based on "how selected cases fit with general constructs" (Curtis, Gesler, Smith, & Washburn, 2000, p. 1002). Given the convenience sample and exploratory nature of the research, the conclusions from this study attempt to answer the question "Of what is this a case?" (Berg, 2004). Of course, the findings of this study will need to be analyzed along with other studies to suggest any generalizability.

Potential to Generate Believable Explanations

While this criterion is perhaps the least descriptive of Mile and Huberman's criteria (Curtis, Gesler, Smith, & Washburn, 2000), it nevertheless addresses the validity and reliability of qualitative research. In this study, participants were actual students who needed to complete the course for very practical purposes – usually as a required course in their graduate degree curriculum. As such, they were credible as sources of data for how an online metacognitive tool is used by learners in an online academic learning environment.

Ethics

In this study, all ethical considerations required by the university were followed and validated by the university's Institutional Review Board process.

Feasibility

This criterion is most applicable in terms of the number of participants in the study as a whole and the number of follow-up interviews at the conclusion of the study. The data collection resulted in discussion question, Metacog, and evaluation data from 22 learners, as well as six in-depth follow-up interviews. The time needed to interview, transcribe, and code data from all sources was significant, even with the use of the NVIVO qualitative research software.

These criteria, taken together, are ideals, and in practice, researchers often have to find a balance among them (Curtis, Gesler, Smith, & Washburn, 2000). This study is no exception. For example, the potential to generate rich data may be limited by the number of interviewees interviewed. As such this is a clear compromise between Miles and Huberman's (1994) second criteria of potential for rich data and sixth criteria of feasibility.

Data Analysis

In qualitative studies, data analysis is about finding patterns. The researcher is interested in making sense of data from both an insiders' and outsiders' perspective (Anderson-Levitt, 2006). While the data sources that were used in this study, primarily self-reports and interviews, provided a rich and abundant source of raw material, a researcher must decide on a unit of analysis, a level of analysis, and an analytical technique capable of finding such patterns. This study used a thematic content analysis technique focused on activity as understood within the framework of activity theory.

Unit of Analysis

The unit of analysis in activity theory is the activity (Murphy & Rodriguez-Manzanares, 2008). As such, the data analysis looked at the relationships among the subjects (learners), object of the activity (using the metacognitive tool in a social supportive learning environment), the tools involved (primarily the metacognitive tool), and the associated rules.

While the activity and especially its disconnections were the primary unit of analysis, a perspective for analysis is still required for a researcher. As such, the perspective of the individual learner was used.

Level of Analysis

The data for this study either originated as text, or for the interviews, were reduced to text through transcription. Berg (2004) identifies several elements from the literature that can be counted in analysis of content of this type. For this study, *theme* was used as the unit to be counted. Berg (2004) says "In its simplest form, a theme is a simple sentence" (p. 273). For this study, a theme was comprised of one or more sentences which addressed a single topic. Initially, the themes were generated by the data. Eventually, the themes were re-examined with an eye towards disconnections between nodes of the activity structure (e.g., subject-tool-object). This is discussed in-depth in the following sections.

Content Analysis Technique

When data are reduced to text, a content analysis technique is required to explore the underlying patterns. While many nuances exist among such content analysis techniques, Berg (2004) lays out a generic set of activities that are useful. The following six steps based on Berg's list served as a guide to analyze the data in this study:

1. Data are collected and made into text.

2. Codes are identified and applied to the transcripts of the data.

3. Codes are transformed into larger categories.

4. Content from all sources are sorted into the categories from the previous step.

5. Patterns are identified among the categories.

6. Generalizations are established considering previous research and theory.

Of course, all models and guidelines are just that. The real work of data analysis is muddier in its implementation. These issues are detailed in the next section.

Data Analysis Using Content Analysis within an Activity Theory Framework

Berg (2004) urges researchers to use the methodology section of a research report not only to describe the traditional components of this section (i.e. type of research, data collection techniques, etc.), but also to provide some information about challenges faced in implementing the methodology. This allows other researchers to understand the complexities of any research project, and to assist them in their own research. In a qualitative study, this also adds to the trustworthiness of the study through dependability and confirmability of the methodology. The experience of using activity theory combined with content analysis provides one example of this.

Activity theory has been used in a variety of ways for educational technology research (Murphy & Rodriguez-Manzanares, 2008). The flexibility of the framework is both its strength and a limitation. On one hand, a researcher can mold activity theory to fit his research questions. On the other hand, the researcher is constantly reminding himself that the framework has certain minimal requirements that cannot be ignored. For example, there must be a sense of what the elements of activity are for the particular activity system being studied.

Initial Coding

Berg (2004) says while content analysis can be inductive or deductive, the resulting grounded theory can be more valid when starting from an inductive perspective. The learner self-reports about prior knowledge of metacognition and collaboration were coded inductively in this way using the content analysis process detailed above.

The six in-depth interviews were coded next and a decision was made to use a similar inductive approach. While activity theory and its elements and concept of disconnections provided ready made initial “analytic categories” (Berg, 2004), using these categories this early in the process risked ignoring important data that might not fit neatly into an activity theory framework. The inductive content analysis of the interviews resulted in the creation of 77 thematic codes (Appendix F).

Once the initial inductive codes had been created, they were applied in the coding of the Metacog evaluations. The evaluations had been completed online by learners using a survey tool called Survey Share (http://www.surveyshare.com), during the last week of class. The evaluation contained 13 substantive questions. Responses by 21 learners resulted in 273 additional pieces of data.

Naming the Elements

At this point in the analysis, activity theory was formally incorporated. Early in this process, initial decisions were needed about what formally constituted the different elements of the activity. Table 3 reflects these early decisions.

Table 3

Elements of Activity in the Metacog Activity Structure

Element of Activity	Examples in Metacog Activity System
Subject	Learners enrolled in the course
Object	Using the metacognitive tool in a social supportive learning environment
Rules	Two major categories were what the learners had to do individually in the class (e.g., assignments), and the rules/constraints that had been built into the functionality of the metacognitive tool (e.g., having to answer a question first before seeing the response of others)
Tools	Primarily the Metacog software; also the course learning management system (Blackboard) and its associated functionality, e.g., discussion board; and the course readings and assignments
Division of Labor	The rules defining what the learners were supposed to

	do during the class in relation to each other
Community	All of the learners in the class in relation to an individual learner, plus the instructor, and any other person or group that affected the object of the activity, e.g., the developer/programmer of Metacog, instructors teaching other classes in which students were enrolled, university administrators, etc.
Outcome	Internalizing metacognitive knowledge and skills

Formally assigning the thematically coded data to specific activity theory elements proved challenging at times. This is discussed in the next section regarding the community element and the activity theory mediators of rules, tools, and division of labor.

This process also brought up the vagueness in the activity literature between the object of the activity and the outcome. As discussed in Chapter 1, the exact meaning of the object of activity has been analyzed and debated extensively with the distinction between *predmet* and *objekt*. The same attention is sorely lacking in any distinction between object and outcome. Usually, if object is defined as objective in an activity theory analysis, then object and outcome are conceptually the same.

In this study, there is a distinction between the immediate object/objective and the longer term outcome. The eventual outcome of using the Metacog tool would hopefully be that the learners improved their metacognitive skills by internalizing the tool. Given that this was the first exposure of Metacog to a group of learners, the focus was on the use of the tool; the present study was not designed to formally evaluate whether internalization occurred. Arguably then, the outcome of the present study might better be described as something like a useful experience with the metacognitive tool.

Coding for Disconnections

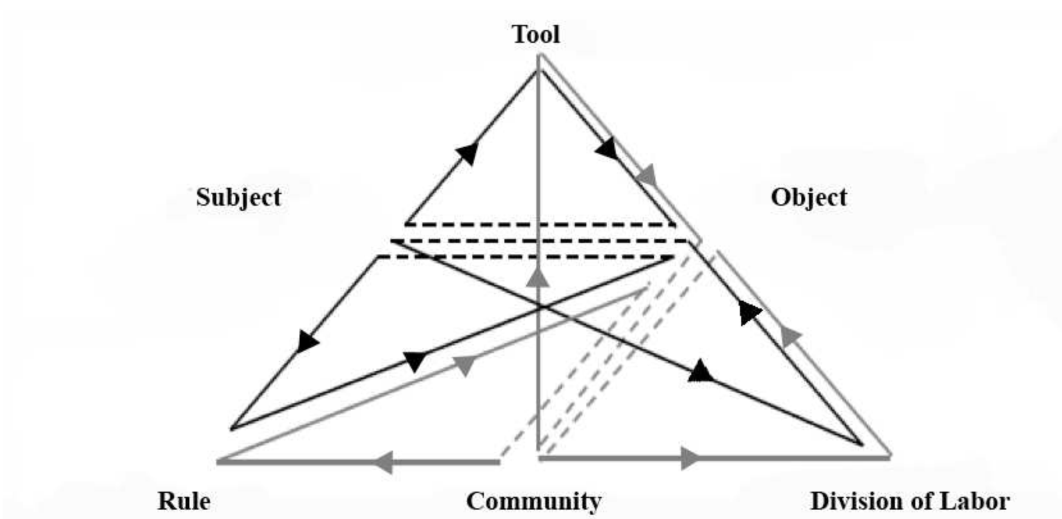
After deciding on which kinds of data belonged to which activity theory element, the next round of coding involved identifying disconnections. For example, some learners thought that there was too much of an overlap between Metacog and the Blackboard discussion board. In the earlier content analysis, this had been coded as *relationship between Metacog and discussion board*. It was re-coded as a tool-tool disconnection. After coding approximately half the evaluations, ten different combinations of such disconnections had been derived. This included disconnections for tool-tool, tool-rule, and subject-rule.

This coding approach, however, created two uncomfortable issues. First, focusing on disconnections ignored those areas where learners had used the tool as designed, and areas where the tool had been favorably evaluated. For example, many learners had discussed how they would begin incorporating different strategies for metacognitive instruction in their own classrooms inspired by Metacog. Both disconnections as well as areas that are working well would be important in fully evaluating the use of the tool, for future re-designs and future research studies. To resolve this, a “no disconnections” theme was added to the analysis. Berg (2004) suggests this approach even when the categories from the content analysis are derived from an existing framework, such as activity theory in this case. Adding themes as needed further validates that the resulting conclusions were grounded in the data.

The second issue with identifying disconnections in this manner was that the data didn’t always fit neatly into one disconnection category or the other. For example, some learners had said they didn’t want to use the Metacog tool for planning since they already planned extensively. Was this a subject-object disconnection or a subject-tool disconnection? The solution to this issue was to return to the literature. While many activity theory analyses speak generically of disconnections of all kinds, Mwanza (2001) elucidates a practical process for using activity theory with her conception of sub-activity triangles.

Sub-activity triangles are formed by concentrating on the rules, tools, and division of labor elements of the larger traditional activity triangle (Engestrom, 1987). According to Mwanza (2001), these three elements are the primary mediators in activity theory between the other elements. By combining the three mediators with the remaining elements of the triangle, six sub-activity triangles are created: subject-rule-object, subject-tool-object, subject-division of labor-object, community-rule-object, community-tool-object, community-division of labor-object. (Noticeably, Mwanza barely mentions the element of outcome and focuses on object instead.) The sub-activity triangles are often depicted in a diagram similar to Figure 4.

Figure 4. Sub-Activity Triangles



Using these sub-activity triangles, as well as continuing to use the no disconnections category, several more of the Metacog evaluations were coded.

Dialectics of the Individual and the Social

While coding evaluations using the Mwanza (2001) sub-activity triangles, there was still substantial overlap in characterizing some disconnections. Primarily the overlap involved subjects (individual learners) versus community (the class as a whole), and rules (in the case of individual learners) and division of labor (in the case of the community). For example, several learners commented that it was difficult to engage in conversations in Metacog because fellow learners did not reply in a timely manner. This was initially considered a subject-division of labor-object disconnection because of the requirement for each learner to respond to posts, i.e. the labor was divided in this way. It could have easily been coded as a community-division of labor-object disconnection, however, since the community members were making the posts and the disconnection was created by the division of labor not being followed, i.e. by community members not making posts individually, the community as a whole suffered. In addition, whether each person making posts was actually a rule or a division of labor was also arguable.

This tension is symptomatic of what Kaptelinin and Nardi (2006, p.189) call the tension to “deal with the dialectics of the individual and the social” in activity theory. Is activity theory ultimately a psychological theory that is at odds with a larger sociocultural theory because of its focus on the individual subject? The challenge is to adequately incorporate sociality into activity theory. As Kaptelinin and Nardi explain, approaches to this problem have favored two extremes. One approach is to assume that sociality is built into an activity system. For example, the act of a subject using a tool towards an object is inherently social. Kaptelinin and Nardi claim this is the approach taken by activity theory reformers such as Radzikhovsky (1983), and related sociocultural theories such as Wertsch’s (1998) mediated action; the other approach, most popularly advocated by Engestrom, which culminates in the activity triangle, is to embed individual activity within collective activities. This is why the there is a separate community element in the activity triangle.

Despite this fundamental tension in approaches to activity theory, Kaptelinin and Nardi (2006) conclude that both approaches are valuable and complementary, rather than mutually exclusive. The analysis in this study took a similar approach; the main activity triangle, combined with sub-activity triangles, continued to be used for their practicality in generating disconnections. This study, however, eventually limited those disconnections to the perspective of individual learners and used only the subject-rule-object and subject-tool-object sub-activity triangles. In this sense, the study sided with the activity theory approach that all activity is inherently initially social.

It can be appreciated, however, that a different activity theory analysis might focus differently. For example, had the focus been on how university administrators made decisions about metacognitive tool use, based on student evaluations, activity theory's ability to incorporate community perspectives and formal divisions of labor would have been extremely useful.

Final Alterations to the Coding Scheme

One final discussion about the use of activity theory elements and disconnections, as it relates to the evaluation of educational technology tools, was highlighted by this study. The distinction between rules and tools is not absolute. In this study, an attempt was made to use the rules element when discussing the constraints imposed upon the subjects, either by the instructor (e.g., how Metacog was to be used for assignments), or the technical constraints imposed by the Metacog tool itself (e.g., having to answer a question before seeing the response of others).

Likewise, the tool element was used when describing the different tools as a whole (e.g., Metacog versus the course discussion board versus articles that were read in the course). In practice, the distinctions are somewhat artificial when discussing the individual functionalities of the Metacog tool, i.e. at what point does the constraint programmed into a tool become a rule? The important point, perhaps, is that disconnections are regular parts of activity systems and provide the opportunity to improve the system.

After all of these transformations, a final grounded coding scheme was developed that adequately allowed the coding of the data using activity theory as an analytical framework to highlight disconnections. The two sub-activity triangles, subject-tool-object and subject-rule-object, incorporated the earlier grounded codes as disconnections where applicable. For example, there was an initial grounded code for *choosing a conversation partner* which was a requirement for using Metacog. This became an example a subject-rule-object disconnection because many learners used their own criteria for choosing a conversation partner rather than the instructor criteria. As appropriate, the no disconnection category was used to keep attention focused on those parts of Metacog which were used as designed or used in innovative ways that had not been suggested by the design.

After the coding scheme was finalized, all of the data from the evaluations and in-depth interviews was re-coded using it.

Also, when analyzing the results, for the purpose of suggesting magnitude, attention was paid to not double counting similar comments that were made by the same learner in both an evaluation and a follow-up interview.

Trustworthiness of the Study

Goetz and LeCompte (1982) urge that, "regardless of the discipline or the methods used for data collection and analysis, all scientific ways of knowing strive for authentic results" (p. 31). Likewise, Marshall and Rossman (1995) stress that, "Every systematic inquiry into the human condition must address these issues" (p. 143). Lincoln & Guba (1985) call the answers to such questions of validity the "truth value" (p. 290) of the study. They suggest four constructs to address the traditional quantitative research concerns of validity and reliability within a qualitative study: credibility, transferability, dependability, and confirmability.

Credibility

Marshall and Rossman (1995) refer to credibility as the "manner to ensure that the subject was accurately identified and described" (p.143). In this study, credibility was strengthened by an in-depth description of the participants, the learning environment, and the setting. The comprehensive descriptions ensured that within the reality of this particularly defined study, the results are valid.

Transferability

Transferability is similar to the quantitative concept of external validity, or generalizability. In other words, can the findings of this context be transferred to another context? This study can in no way claim quantitative generalizability, however, three methods were used to suggest transferability of the study. First, while the sample of participants is not a statistical sample, the sample does represent a variety of typical adult students taking an online course. Such a variety provides other researchers with multiple options for judging the relevancy of the study to other contexts (Marshall and Rossman, 1995). Second, the study is thoroughly grounded in activity theory. Researchers working from the same theoretical model can judge the study's applicability within this model. Third, the use of more than one participant and more than one source of data were used to triangulate findings as appropriate. The multiple sources of data can assist in corroborating findings, which in turn strengthens claims to generalizability.

Dependability

Dependability is a qualitative attempt to address the quantitative concept of reliability. In quantitative studies, this is the ability for other researchers to replicate a study. Marshall and Rossman (1995) argue that such replication is problematic under qualitative assumptions of a reality that is always changing and being constructed within the minds of individuals. Indeed, many quantitative studies allude to this with findings that suggest "implementation issues" may lead to different results in future studies; as such this qualitative study acknowledges that exact replication is not possible. With this acknowledgment, however, researchers can strive to document their methodology as precisely as possible for other researchers. This was accomplished in this study by keeping thorough records of all data, procedures, notes and decisions.

Confirmability

Confirmability, as the term implies, is the ability of the findings of the study to be confirmed by another; the concern is that the subjectivity of the author will negatively influence the research (Marshall and Rossman, 1995). While qualitative research demands that the researcher become intimately acquainted with the setting in order to understand the constructed meaning of participants, there is nevertheless the need to avoid incorrect interpretation or bias in interpretation. In this study, confirmability was assured by having all data collection recorded mechanically or digitally. Interviews were recorded on audiotape, and artifacts and self-reports were in digital format. This insures that the original data is available for analysis and re-analysis should the need arise.

Limitations

As with most qualitative studies, the most obvious limitation of this study is the inability to generalize in a quantitative sense. There were fewer than 30 participants from a convenience sample in the class and fewer than 10 participants in the smaller interview samples; the participants in no way comprised a random statistical sample. Likewise, the case study nature of the research did not allow for a control group or any kind of experimental design. While analytic generalizations from the findings are possible, statistical generalizations are not warranted.

Second, the length of the study was only eight weeks with most students using the tool for only 3-4 weeks, for metacognitive knowledge, and the planning and monitoring components of metacognitive regulation. (The learners had also been scheduled to spend at least one week after answering the monitoring questions, during which they would answer metacognitive reflection/evaluation questions about their unit plans as well. Since Metacog was implemented later in the semester than originally intended, these questions were not answered.) While the findings in Chapter 4 suggest that learners felt comfortable using and evaluating the tool during this short study, it still might be the case that the limited exposure time might have affected their ability to make meaning and critically evaluate their experience.

Additionally, the course content and audience that was the result of the convenience sample – graduate students who were practicing teachers discussing the implications of cognitive science for teaching and learning – cannot be overlooked. Graduate level students who are practicing teachers provided their own unique perspective on the tool. Activity theory was ideal in this sense for analysis to recognize how this use of the tool created its own unique activity structure. This happily resulted in findings related to teachers and metacognition beyond the original conception of the study. The specific user characteristics, however, should be kept in mind in interpreting conclusions.

Finally, a limitation of the study might be in the coupling of activity theory as an analytical framework and an online education course as a context. In this combination, most of the data for analysis were in written form. The richness of face-to-face interaction, which is a valuable source of observational data, was absent. This might have affected the willingness of learners to reveal some of their backgrounds and intentions, both important for an activity theory analysis. The course design attempted to incorporate techniques to build trust in the online course community (described in Chapter 1) to alleviate this.

Finally, the semi-structured interviews (which were done face-to-face), were retrospective at the end of the eight week semester, given constraints of access to the research context. This retroactive nature may have not allowed important in-the-moment understandings of the learners to be captured, or some learners may have simply forgotten some details. With such limitations, the study was designed to maximize the amount of information that could be gathered using the available means.

Chapter 3 Summary

In this chapter the research methodology for the study was detailed. First, ontological and epistemological justifications were made for the study. Following from this, the appropriateness of the qualitative case study method used for this study was discussed. The context of the study was also reviewed. The sampling and data collection methods employed in this study were discussed. The content analysis process used for data analysis was also explained, with special attention to how the mediator nodes of activity theory and the concept of disconnections were a significant part of this analysis. This detail can serve future researchers using activity theory to study metacognitive tools. The next chapter presents the findings which resulted from this methodology.

Chapter 4: Findings

"Rachel" Uses Metacog

Rachel is not a big fan of technology. Her fellow teachers kid her that when she touches a computer, it breaks. She thinks she might have a big piece of metal stuck in her body that interacts with her computer negatively, or something like that. Still, she thinks she has become pretty good with Power Point and Excel over her three years of teaching. She also is very comfortable with teaching her third graders to create webquests in her classes. She's glad she taking an online class and thinks the Metacog tool is easy to learn

After reading the course article assigned for that week, Rachel reads one of the metacognitive knowledge questions in Metacog, and has to think about what the question is really asking. She then goes back and re-reads the article, and paraphrases it in her own words. This is similar to how she works with the course discussion board. Rachel already self-questions herself when reading, maybe even so much so that she ventures into self-doubt. She thinks she concentrates on the main idea and supporting details. But she doesn't think about every question that Metacog asks. So that's an improvement over her usual process.

After posting her initial answer, Rachel scrolls down and looks at the answers of others. She picks one who has conflicting ideas, or maybe someone who might be able to answer remaining questions she still has about this article. She just hopes someone, anyone, responds.

When she checks back later, someone has responded and she finds the information useful. Just knowing that two people read the same article and have different interpretations is helpful; even if she disagrees with her fellow student. She doesn't have a lot of time to really engage in too much debate, but if her post made someone else think about their answer, that was a degree *of success. If they changed their mind, it was even better. If she changed her mind, that was the best.*

"Ralph" Uses Metacog

Ralph is open-minded towards technology because he knows it is important for his high school literature students to know. But that doesn't mean he is comfortable with computers at all. Although he absolutely loves teaching and has been doing it forever, he thinks he is kind of a technology idiot. Before this summer online class, he hardly knew how to do email attachments. The class really taught him a lot. And the Metacog tool is not hard at all. It's pretty easy, actually. You click on a little colored bar and it gives you your questions.

Ralph likes to sit down and answer all of the Metacog metacognitive regulation questions in one sitting. After he answers, he decides to start a discussion with someone who has an interesting answer or maybe one like his.

There are some answers that are like, "I'm not sure, I don't know," even though the instructor told students not to respond this way. Ralph doesn't go near those. Obviously those really do no good because there's no depth. What's to discuss? Although it seems like very few discussions are getting started because of the timing of the initial responses and follow-up exchanges.

But just seeing where others are with their unit plans, and having a little bit of discussion, helps Ralph better understand what he needs to be doing. It really helps him think more deeply about the unit plan, and why he is doing what he was doing. He guesses that's the whole reason for the Metacog tool. You start getting in a pattern of what those questions are. Wow, that's pretty cool, because students should be thinking about those kinds of questions. As *an educator, Ralph thinks he could do something like this for his students. This could be a great educational tool.*

The brief vignettes above, based on post-course interviews, provide a glimpse of the productive as well as typical activities of learners in this study. This study examined a social support online learning environment for teaching metacognitive knowledge and skills through the use of a researcher-created cognitive tool known as Metacog. This chapter provides the detailed findings from this study, organized by the three research questions introduced in Chapter 1. Using activity theory terminology, the chapter first gives a thorough description of the subjects who were the learners in the course, their prior knowledge and skills related to metacognition, and their prior knowledge and skills related to community and collaboration as an instructional strategy (i.e., social supportive learning environments) . The chapter then examines how the tool mediated the learners' required activity with it, i.e., how the subjects used the tool to meet their object(ive). Finally, the chapter reports how learners evaluated their use of the tool, including its strengths and weaknesses. For the second and third research questions, the concept of disconnections found in activity theory is used to further frame the findings. Following Berg's (2004) recommendation for reporting in qualitative research studies, this chapter attempts to limit itself to reporting data findings. While this is not always possible, the majority of interpretations of these findings are found in Chapter 5 as conclusions.

Prior Knowledge and Use of Metacognition

The first research question posed in this study asked "What were learners' prior knowledge and use of metacognitive skills based on their educational experiences and life experiences?" To answer this research question, demographic information about the learners, as well as their prior knowledge and use of metacognition, is reported. Since the concept of a social supportive learning environment was important to this study, this section also includes findings on learner prior knowledge and use of collaboration and community.

Learner Demographic Data

All of the learners in the class were practicing teachers who were attending graduate school part-time, taking evening or online courses. One learner was between jobs at the time of the study, and one was leaving her job to attend graduate school full-time at another institution. Twenty-three learners began the online course; one withdrew from the course after the first two weeks for an unknown reason. The other twenty-two learners completed the course. During the first week of the course, learners provided background demographic information about themselves, presented in Table 4, by answering a discussion board question.

Table 4

Learner Demographic Information

Gender	
Female	18
Male	4
Grade Level Taught [a]	
Pre-K	1
Grades K-5	10
Grades 6-8	4
Grades 9-12	8
Adult	1

Years of Teaching Experience (n= 20)	
M	3.85
SD	2.60
Primary Subject Taught	
Elementary and Middle Curriculum	9
Special Education	4
English/Literature	3
Foreign Language (Spanish, German)	2
Science	1
Math	1
Music	1
Adult GED	1
Graduate Program Enrollment [b]	
Elementary Education	8
Secondary Education	5
Special Education	3
Education	2
Educational Technology	1
Literacy	1
Curriculum and Instruction	1

Comfortable with Technology for Learning	
Yes	15
No	7
Prior Online Courses [c]	
Yes	6
No	4

Note. Not all learners responded to all questions asked.

[a] Two learners taught K-8 and were counted in both categories.

[b] One learner indicated her graduate program as “Elementary/Secondary Education” and was counted in both categories.

[c] Most learners did not answer this question.

Prior Knowledge and Use of Metacognition

During the first week of the course, prior to the assignment of the first course readings (which included information about metacognition), learners were asked to reply via email about their prior knowledge of metacognition. If they were familiar with metacognition, they were asked about their use of metacognitive strategies, both personally and in their teaching. Nineteen learners replied to this question.

Twenty-six percent (26%), or five, of the learners responded that they had no prior knowledge of metacognition. Upon follow up questioning, however, some of these learners noted that they had actually heard the term before (often several times), but they were not sure of the exact meaning. Their confusion over the meaning of the term was attributed to varying definitions, or because no specific behaviors were stressed when they had heard the term, usually during their undergraduate education. An illustrative response came from a practicing fifth grade teacher with three years of teaching experience: "Yes, I have heard the term 'metacognition' in my undergraduate studies. I must say that I don't remember much about it except that it had to do with thinking and learning."

Seventy-four percent (74%), or fourteen, of the learners reported prior knowledge of metacognition. Half of these quoted the familiar characterization of metacognition as "thinking about thinking" or "cognition about cognition" (Flavell, Miller, and Miller, 2002). Specific responses included a wide range of prior knowledge about both the knowledge and regulation components of metacognition.

Prior Knowledge of Metacognitive Knowledge

Learners mentioned a variety of knowledge subcomponents of metacognition, consistent with the literature. Table 5 reports the subcomponents mentioned.

Table 5

Prior Knowledge of Metacognitive Knowledge by Subcomponent (N=11)

Metacognition Knowledge Subcomponent	No. of Mentions
Knowledge of one's abilities and limitations	5
Knowledge of one's own cognitive processes	3
Knowledge of factors that influence one's own thinking	1
Knowledge of other people	1
Knowledge of learning strategies	1

A notable exception from the responses, based on its prominence in the literature, is that there is no mention of knowledge of task. This might be because knowledge of task may have been intertwined with responses that mentioned knowledge of one's own abilities and limitations with a task. One learner said, "To me, metacognition means to evaluate what I already know about a certain topic, subject, etc." A learner may have knowledge, for example, that a task exists, e.g., that computer programming involves writing a code structure called a loop, while knowing that she does not possess detailed knowledge about how to do the task. The latter knowledge is definitely metacognitive in nature. While there is a clear conceptual difference between knowledge of a task and knowledge of ability in a domain, it may be the case that the two are usually mentioned simultaneously.

Knowledge of one's abilities and limitations. The majority of learners referred to metacognition as knowledge of one's abilities and limitations. This is consistent with the metacognition literature, and this subcomponent of metacognitive knowledge has been widely researched (e.g., Mayer, 2004; Maki & McGuire, 2002; Schooler et al., 2004). These studies usually compare a learner's metacognitive self-assessment in a domain before or after learning to their actual performance. The studies may relate variability on this ability to factors such as age and experience. For example, college students often overestimate their comprehension of written text (McNamara & Shapiro, 2005).

Knowledge of one's own cognitive processes. Three learners defined metacognition knowledge of one's own cognitive processes. A female elementary special education teacher with two years of experience said metacognition is "…what a person knows about his or her own learning, cognitive process..." A female secondary special education teacher with two years of experience similarly noted that metacognition is "…what individuals know about…their cognitive processes." A male K-8 music teacher with two years of teaching experience used the term awareness: "My definition of metacognition is being aware of how one thinks." All of these characterizations are consistent with those found in the literature.

Knowledge of factors that influence one's own thinking. One learner referred to metacognition as "knowledge of factors that influence your own thinking." Although the learner did not elaborate on particular factors, the response is consistent with the metacognitive notion of knowledge of self. It is also congruent with the self-regulated learning (SRL) notion of knowledge of external factors that influence one's learning (e.g., the noise level in a room).

Knowledge of other people. One respondent included the idea of knowledge of other people when describing her prior knowledge of metacognition. Although the early research on metacognition arguably concentrated on cognition "in the head of an individual" learner, Flavell (1977) himself early on noted the idea of social metacognition as an awareness of other people. With the trend in research interests in social cultural perspectives on learning in the last twenty-five years, the study of metacognition in a social setting (including this study) has also reflected this interest (Waters & Schneider, 2010).

Knowledge of learning strategies. One learner referred to metacognition as "the knowledge of strategies for remembering and learning." This is consistent with one of the main themes of this study: metacognition as knowledge of learning strategies. The mention of strategies for remembering is also consistent with a long line of literature on metamemory, or how people think about their memory (Matlin, 2009).

Metacognitive Awareness Inventory: Metacognitive Knowledge

In addition to responding to the email question about prior knowledge and use of metacognition, learners were asked to complete an online version of the Metacognitive Awareness Inventory (MAI). The inventory is divided into metacognitive knowledge and metacognitive regulation components. Each component is further subdivided by several subcomponents. For the metacognitive knowledge (knowledge of cognition) component, the subcomponents are declarative knowledge, procedural knowledge, and conditional knowledge. Learners are asked to rate their agreement with several statements related to the subcomponents. The inventory uses a 1 – 5 Likert scale, with 5 representing “Strongly Agree.” Table 6 presents the results on the metacognitive knowledge subcomponents.

Table 6

Metacognitive Awareness Inventory Results of Metacognitive Knowledge Subcomponents (N=22)

Knowledge subcomponent	*M*	*SD*
Declarative knowledge	4.00	0.38
Procedural knowledge	3.99	0.56
Conditional knowledge	3.95	0.38

The results confirmed the theme from the qualitative responses regarding prior knowledge of metacognition: respondents had a large amount of prior metacognitive knowledge.

Prior Knowledge of Metacognitive Regulation

In describing their prior knowledge and use of metacognition, learners mentioned several subcomponents of metacognitive regulation consistent with the literature, including problem, problem representation, planning, monitoring, and control.

Monitoring. More respondents mentioned the monitoring component of metacognitive regulation than any other subcomponent. Respondents indicated that metacognition was about monitoring one’s thinking, and especially one’s learning and comprehension. The monitoring and regulation of understanding, or metacomprehension, has been a popular theme in the metacognition literature.

Reflection. Four learners mentioned described prior knowledge of metacognitive regulation as some kind of reflective process during or after their learning. Words like *control, regulation, reflection*, and *evaluation* were used in these responses. As discussed earlier, there is conceptual murkiness in the literature regarding the distinction between monitoring one's thoughts and actions against some kind of standard, and the temporal point where a learner decides that the standard is or is not being met and what to do next. This possibly explains the variety of terms used by learners.

Planning. Two learners mentioned planning in their prior knowledge of metacognition. Planning can be considered a necessary prerequisite step to monitoring and regulating one's progress.

Problem representation. One learner mentioned a kind of problem representation as part of their prior knowledge of metacognitive regulation by saying that, "I can evaluate what needs to be done." Some models of metacognition include problem representation as part of the planning subcomponent of metacognitive regulation.

Metacognitive Awareness Inventory: Metacognitive Regulation

Learners also completed the metacognitive regulation portion of the Metacognitive Awareness Inventory (MAI). The inventory divides metacognitive regulation into the subcomponents of planning, strategy, monitor, debug, and evaluate. (This is yet another example of the variety of metacognition models.) Learners are asked to rate their agreement with several statements related to the subcomponents. The inventory uses a 1 – 5 Likert scale, with 5 representing "Strongly Agree." Table 7 presents the results on the metacognitive regulation subcomponents.

Table 7

Metacognitive Awareness Inventory Results of Metacognitive Regulation Subcomponenst (N=22)

Regulation subcomponent	*M*	*SD*
Planning	3.77	0.51
Strategy	3.88	0.40
Monitor	3.92	0.47
Debug	4.22	0.35
Evaluate	3.77	0.44

Similar to the metacognitive knowledge portion of the inventory, the results confirmed the theme from the qualitative responses regarding prior use of metacognition: learners reported a large amount of prior metacognitive regulation**.**

Use of Metacognitive Strategies in the Classroom

The cognitive tool used in this study, Metacog, was not designed to be used specifically with practicing teachers. When the opportunity became available to use the tool with such an audience, however, the decision was made to ask the learners how they used metacognitive strategies (prior to using Metacog) as part of their teaching, if they had.

Approximately one-third of the learners (35%) reported they had tried at least one instructional tactic to teach students metacognitive skills. These tactics included having their students plan for future work, monitor current work, and reflect on past work. Table 8 suggests the different components of metacognition represented by the learner responses as well as provides examples given by the learners.

Table 8

Prior Use of Instructional Tactics to Teach Metacognitive Skills by Metacognitive Component

Component (No. of mentions)	Examples
Metacognitive knowledge (4)	
Learning strategies (3)	Ask high school students probing questions to explain why they think the way they do about a topic using support from the text.
	Model what good readers do.
Knowledge of self (1)	Teach students their strengths and weaknesses and how to use their strengths to overcome their weaknesses.
Metacognitive regulation (7)	
Planning (2)	Planning for upcoming work.
	Planning goals for improvement.
Monitoring (1)	Have students create progress reports.
Reflection (4)	Have students predict performance before a test, and why they feel this way, then reflect on performance after the test (and tell the teacher if they studied).
	Have students reflect on how a lesson changed their thinking "about the content, their other classes, or the external world."
General (1)	"Have taught some tools needed to build metacognition."

The number of mentions in each category suggests that teachers focus metacognitive instruction on metacognitive regulation (especially reflection), rather than metacognitive knowledge (learning strategies). Given the earlier responses to prior knowledge about metacognition, this is congruent with the finding that most learners did not mention use of learning strategies there either. It could be that the learners/teachers might not consider strategy use to be a form of metacognition. Three of the four teachers who mentioned learning strategy use in their classroom as an example of metacognition were reading and/or special education teachers, both domains where the construct of metacognition has been widely researched and promoted.

While it is clear that the learners/teachers who used Metacog were experienced in metacognitive knowledge and regulation, as evidenced by the qualitative responses and the MAI quantitative results, this was not unanimous. An alternative explanation for most teachers not mentioning strategy use in their use of instructional tactics for metacognition could be that teachers do not know strategies to teach. One learner expressed this sentiment exactly:

> I struggle to do this on a regular basis. I am not absolutely sure of my ability to help students use metacognition and I feel like I lack the knowledge of various teaching strategies that can [be] used in order to do so.

Learners were not asked to evaluate their own use of the instructional tactics they used for teaching metacognition. Some, however, included such information in their response. One teacher thought metacognitive techniques did not work for some subject matter he taught that required a right or wrong answer. The example he gave was identifying the structure of iambic pentameter in poetry. This same teacher also lamented how metacognitive techniques were hard to teach to students who were "routinized" by prior schooling to not question their own thinking and to always accept the teacher's answers.

Another teacher described an initial attempt to introduce a planning and reflection process into her classroom. She said the process had gone poorly because there was no time in the class's busy schedule to actually create goals which could later be reflected upon. There was also no time for students to pick from their own work to reflect upon so the teacher would pick the work to expedite the process. She felt that she needed more time and tools to implement the planning and reflection process properly.

Finally, one teacher described her attempt to have students track their own progress as part of a lesson. She found the process "too disjointed" to do on a regular basis. These unsolicited evaluations indicated that teacher instructional tactics to introduce metacognitive strategies into their classroom were less than successful. The main obstacles to these implementations are time, tools and support, teacher knowledge and teacher attitude.

Attitude and Use Towards Social Supportive Learning Environments

Given the important of the use of Metacog in a social context for this study, during the first week of class learners responded to a course discussion question describing their attitudes and use towards collaboration and community in their own classrooms. No distinction was made between the terms collaboration and community, nor was the term social supportive learning environment used in the question prompt. Twenty learners replied to the discussion question.

All of the learners who replied (100%) indicated that they currently used some form of collaboration or community approaches in their teaching. Further, all of the learners (100%) indicated a positive attitude towards the use of collaboration and community in the classroom.

Learners were also asked to explain why they used collaboration and community strategies in the classroom as part of their teaching repertoires. Table 9 organizes the learner rationales.

Table 9

Rationales for Using Collaborative and Community Approaches to Instruction in the Classroom

Rationale (No. of Mentions)	Examples
Influences achievement (14)	Students learn from each other (11)
	Leads to better work (2)
	Students learn more
Influences individual learning processes and motivation (6)	Creates a sense of pride (2)
	Allows analysis and reflection
	Builds problem solving skills
	Leads to greater effort
	Leads to better paying attention
Influences environment (4)	Creates an environment conducive to learning (2)
	Safe environment increased risk-taking
	Safety of community allows focus on academics
Useful for particular learning situations (3)	Good for students with learning disabilities
	Useful for difficult material
	Specifically influences development of life skills
Preferred method teaching (1)	Aligns with favored instructional philosophy

The most frequent reason cited for using collaboration and community in the classroom was the effect on achievement. Most learners mentioned that collaboration led to an increase in learning because students were able to learn from each other in some way. For example, one learner remarked that, “I think it a wonderful way for students to gather, analyze, and reflect on concepts with their peers which improves student achievement.”

Many learners continued the focus on how collaboration influenced individual learning processes. These included cognitive processes such as attention, problem solving, and analysis. Collaboration was also felt to influence motivational processes such as individual student effort and pride in work. One learner’s comment was representative when she said that, “I find that students pay more attention in general and try harder when they feel like a member of a learning community.”

Finally, some learners focused on how collaboration influenced not the individual student, but rather the learning environment as a whole. In particular, the learners mentioned that collaboration could create a safe environment which would lead to increased risk-taking. This aligns with one of the design principles incorporated into Metacog.

Metacognitive Tool Mediation on the Object of Activity

Activity theory posits that tools and their accompanying rules will mediate the relationship between a subject and its object. The second research question posed by this study was, “How did a particular metacognitive tool (Metacog), in the context of a socially supportive online learning environment, mediate the actions of learners?” In other words, how did learners use the Metacog tool, and how did the tool contribute or constrain them in facilitating metacognitive knowledge and metacognitive skills? This section describes the findings related to eleven (11) processes or features of Metacog used by learners. The findings are loosely organized temporally in the order that learners encountered them: answering initial questions followed by having conversations with peers.

Answering initial metacognitive questions

1. The process for answering questions
2. The number of questions
3. Time to complete the questions
4. Suggested length of initial responses
5. Visual indicators of the metacognitive strategy associated with each question
6. Having to answer a discussion question before seeing the response of others

Having conversations with peers

7. Choosing a conversation partner
8. Checking for conversation responses
9. Responding to a Conversation Partner
10. Waiting for a conversation to continue
11. Ending a conversation

Answering Initial Questions in Metacog

Process for Answering Metacog Questions

Metacog was designed so that learners were required to answer several questions about the course readings and assignments, each of which related to a particular metacognitive strategy. Questions related to metacognitive knowledge were operationalized as questions about the course readings, with each question modeling a particular learning strategy from the literature. Questions related to metacognitive regulation were operationalized as questions about the capstone project in the course, a complete unit plan, with each question modeling a particular component of metacognitive regulation – planning, monitoring, or evaluation. A complete list of the questions is available in Appendix B.

Most learners chose to answer all of the Metacog questions at the same time, shortly after reading that week's article or the weekly assignment related to the unit plan. (The unit plan assignment was spread over four weeks.) Table 10 illustrates comments about the process learners used to answer the Metacog questions.

Table 10

How Learners Chose to Answer the Metacog Questions

Process	No. of Mentions	
Answered all questions at once soon after reading/assignment	12	
Wanted the material to be fresh or to avoid forgetting		11
This process forced by technical issues		1
Did not answer all questions at once	5	
Answered a few questions at a time and then came back later		3
Waited after reading/assignment and then answered all questions		2

The majority who answered all questions at one time found it easier to answer the questions while the material was still relatively recent, although one learner did so because of technical issues at home required her coming to campus to complete the Metacog assignments and she did not want to make return trips. Those who did not complete the questions all at once either completed a few at a time or took a break between the assignment/reading and answering questions in Metacog, usually in order to reflect on the material, or to go back into the material before answering a particular question.

One learner specifically pointed out a subject-rule-object disconnection between her working style when answering the questions and the rule to later engage in conversations with other learners in Metacog:

> I do not think that I used the Metacog tool effectively in the area of starting discussions. To be quite honest I found it most beneficial when I allowed some time between the completion of a task and my completion of the Metacog because it allowed for a separation from the task that provided additional insight; however this was not the most conducive way to interact in conversations so in that regard I guess I did not use the tool as effectively.

Number of Questions

Metacog featured 15 questions related to metacognitive knowledge (i.e. learning strategies), as well as 13 questions on metacognitive regulation. The regulation questions were divided between eight questions on planning and five questions on monitoring. During the first week learners used Metacog, they answered the 15 knowledge questions and the eight planning questions for a total of 23 questions in the first week. In the second week, they answered the 15 knowledge questions and the five monitoring questions for a total of 20 questions in the second week. (The learners had been scheduled to spend at least one week after answering the monitoring questions during which they would answer evaluation questions as well, but since Metacog was implemented later in the semester than originally intended, these evaluation questions were not answered, to avoid too much work during the last week of the course in which final unit plans were due.) Table 11 details the comments about the number of questions.

Table 11

Learner Comments on Number of Questions to be Answered in Metacog

Process	No. of Mentions	
Too many questions	8	
A lot in addition to the other responsibilities in the class		7
Questions cluttered interface; harder to start conversations		1
Wanted more questions on unit planning	3	
A lot of questions but all served a purpose	1	

Learners who commented were nearly unanimous in thinking that there were too many questions to answer, usually because of the other assignments in the class. The feeling was not unanimous, however, and there is some indication that learners would have appreciated the number of questions per metacognitive component to be more evenly distributed, rather than the bulk of the questions each week devoted to metacognitive knowledge. This is not surprising, given that the unit plan to which the metacognitive regulation questions related counted for 25% of the course grade.

Amount of Time to Answer Questions

During the follow-up interviews, a few (four) learners made unsolicited comments on the amount of time it took them to go through and initially answer the Metacog questions. The comments ranged from “about 30 minutes” to “a long time” in length. Two learners used the course discussion board in Blackboard as their basis for comparison, with one indicating Metacog took less time than the discussion board, and one saying it took same amount of time. While the comments were few and not specific enough to reveal a pattern, these comments do foreshadow the tool-tool disconnections between Metacog and Blackboard. This disconnection is detailed later in this chapter.

Suggested Length of Initial Responses

The instructor instructions in Metacog specifically asked learners to limit their responses to 1-3 sentences, although the tool did not have any technical constraints to prevent this. Two parameters determined the suggested length. First, one stated purpose of the tool was to have learners focus on the important components of their readings and unit plans. Second, there was a purposeful effort to limit the amount of coursework added by the use of Metacog in the class. A small number of learners (four) commented on the suggested length. A representative comment about the length of responses was made by one learner:

> It was ok, that's hard for me sometimes cuz I am wordy so, I mean but some people that was very good for them because they aren't as wordy so they were probably thrilled with that so, I don't know, it depends.

These learners all agreed the suggested limit appealed to some and did not appeal to others, depending on writing style. They were also unanimous in saying that each of them personally always wrote more than the suggested minimum of sentences, a fact triangulated by a review of their initial answers in Metacog.

Metacognitive Strategy Visual Indicator

Each of the questions answered in Metacog corresponded to a particular metacognitive strategy or component. While learners were answering each question, they could see a visual pullout box which contained declarative, procedural, and conditional knowledge, along with examples, about the strategy. An example of the box for the strategy of summarization is shown in Appendix A.

In-depth follow-up interviews with six learners specifically addressed if they had seen these visual indicators and their reactions to them. The learners were split. Three had noticed them and found them useful. One learner who found the visual indicator useful commented, “I looked at it every time…To get, to think, oh what do I want to put in this answer and then, how am I going to get that in one sentence.” Another learner who found it useful similarly commented, “It was kind of a guide of how I answered the questions or that’s the way I seen it, was that what it’s supposed to be?”

The other three learners had noticed the visual indicators but had not paid too much attention. One of the learners, when asked if he gave any attention to the visual indicators replied, “No, I hardly pay [*sic*] any heed to it at all.” Likewise, another learner who did not find the visual indicators helpful commented: “Yeah, I saw it but I didn’t pay any attention to it. I just went ahead and answered the question.”

As numerous educational psychologists have discovered (e.g., Matlin, 2009; Willingham, 2009), attention is a prerequisite for learning. This critical visual indicator in the Metacog interface needs to be re-designed to make it more obvious to learners.

Having to Answer a Discussion Question before Seeing the Response of Others

When initially answering the questions in Metacog, a learner could not see the responses of other learners until after she submitted her own response. At this point, she could see the responses of all other learners.

A little over half of the comments about this rule (15 out of 28) indicated no disconnection between subjects, the rule, and the overall object of the activity. Learners concentrated on two main themes about the functionality. First, they suggested that the requirement made them think harder or more about a response before making it, and this was an effective design (8 comments). Second, they similarly suggested that the design was effective because it prevented them from being influenced by the thoughts of others, or even copying from others, before they had thought through what the question was really asking (6 comments). One response went so far as to say this functionality resulted in a sense of self-pride when seeing her answers compared favorably to others after being forced to answer on her own first.

One learner indicated she already used a similar process to answer regular discussion board questions this way, so this was nothing new. In Metacog, however, the technical design required answering first. In the discussion board, the learner had the choice to read other responses before replying if she desired.

Disconnections around this functionality fell into two major categories, both being Level 2 subject-rule-object disconnections. First, some learners/subjects felt anxious that their answers would be wrong or incorrect compared to others (8 comments). Second, some felt that the Metacog tool was valuable precisely because it allowed for the sharing of ideas among learners, and this sharing was not as effective with the rule that learners had to answer first before seeing what others were thinking (4 comments).

Two other disconnections were mentioned. One learner highlighted a Level 2 subject-tool-object disconnection in that the specific weekly assignments were not listed in Metacog. Both the Metacog assignment and week together (e.g., Savery and Duffy article, Week 7) were listed only in the Blackboard learning management system portion of the online course. In Metacog, learners had to rely on the week label only (e.g., Week 7) and match that to the Blackboard information for the assignment. Since a learner could not see others' answers until she answered, there was no way to use others' responses as cues for the correct assignment, at least until one question had been answered.

The final disconnection regarding this functionality indicates a disconnection between the researcher's object(ive) for the tool and at least one subject's understanding of the object(ive). The subject/learner commented that the tool was a good way for the instructor to "determine if the students have really read the articles and understood what the articles were saying." While this certainly could be a use for Metacog, the focus for the tool was on learners developing their own metacognitive skills through the use of the tool in a socially supportive environment. The tool was not planned to be used for the instructor to check for individual learner comprehension, especially since learners were using the tool either prior to, or concurrently with, the online course discussion tool. That is, there was no expectation that the learners using Metacog would read an article once and have all the "right" answers; in fact most of the Metacog questions did not have "right" answers.

Having Conversations with Peers in Metacog

Once learners had answered the initial questions in Metacog, they were required to start a conversation with other learners with the intent of engaging in academic debate about one of the answers given by the other learner. The processes for doing this included:

1. Choosing a conversation partner
2. Checking for conversation responses
3. Responding to a conversation partner
4. Waiting for a conversation to continue
5. Ending a conversation

The following section details the findings related to these processes associated with the conversation functionality in Metacog.

Choosing a Conversation Partner

After learners responded to an initial metacognitive set of questions in Metacog, they could see the responses of fellow learners to the same questions. They were instructed to start a conversation with someone about any response with which they disagreed. The intent was for the conversation to increase the possibility of perspective change based on some kind of cognitive dissonance with other's ways of thinking.

This rule produced the most subject-rule-objects disconnections associated with Metacog. In fact, of the 42 comments received, only seven indicated that they had actually chosen someone with whom they disagreed. Table 12 details the variety of responses. In addition, one learner said he rarely chose a conversation partner in Metacog, as he preferred the interaction in the course discussion board in Blackboard instead. This is despite the understanding that the Metacog exercises had not been intended to be optional. Similarly, another learner said she at times just replied to discussions started with her by someone else, rather than starting her own discussions.

Table 12

Criteria Used to Choose a Conversation Partner

Criterion	No. of Mentions
Perceived characteristic of the post content	27
Interesting/intriguing, wanted more information	10
Disagreed with	7
Agreed with	4
Good or in-depth	3
Something I could relate to or think logically about	2

Had an opinion about		1
Perceived characteristic of the person who posted	13	
Someone who had a misunderstanding		3
Anyone who would probably reply		3
Someone with common interests, e.g., same content area		2
Someone more knowledgeable		2
Last person who posted		2
Someone who was known to think similarly		1

The two main criteria used by learners for choosing a conversation partner were either a characteristic of the content of the post, or a characteristic of the person who made the post. There were more than twice as many comments indicating a criterion associated with the content rather than the person making the post.

For those who used a characteristic of the post content when deciding on a conversation partner, the majority (10) indicated that they responded to a post which they found interesting or intriguing. Four learners, however, indicated they chose someone who agreed with them, despite this being exactly opposite of the instructor instructions to choose a response with which they disagreed.

Checking for Conversation Responses

Once learners had started a conversation, they needed to come back to the Metacog tool at a later time to check to see if their selected conversation partner had replied. The Metacog evaluations revealed that most learners reported checking for responses frequently or periodically, as illustrated in Table 13.

Table 13

How Often Learners Checked for Responses to Conversations

Frequency of checking for responses	No. of Mentions
Checked frequently (more than once a day)	7
Periodically (at least twice a week)	5
Forgot to check sometimes	1
Did not check for responses (too busy with other course activities)	1

For those who reported checking most often, a frequent subject-rule-tool disconnection emerged. All of these learners noticed that there were few responses to their conversations. Their reactions to this information, however, were quite different. Some reported checking more frequently after this so they would not miss any responses. On the other hand, some started checking less frequently once the expectation of receiving quick responses was not met. This suggests some kind of interaction effect based on individual learner/subject characteristics, and further, that a tool cannot take a one size fits all approach to design.

Responding to a Conversation Partner

Once a conversation partner had responded, a conversation had been started, and the learner who had started the conversation needed to respond back to continue the conversation.

The follow-up interviews revealed two learners reported not replying back quickly in a conversation; if fact, they did not reply back at all. The other learners in the follow-up interviews felt as if they replied adequately and within a reasonable time frame in the conversation. Table 14 illustrates the range of comments.

Table 14

Responding to a Conversation

Time frame for response	No. of mentions	
Responded back quickly	5	
Did not respond (but did read responses)	2	
Too busy with other class activities		1
Felt like did not understand Metacog		1

The initial Metacog evaluations, which were completed prior to and by a larger group of learners than the follow-up interviews, showed a much different pattern, with many comments throughout the evaluations about the long delay between starting a conversation and getting a reply. The effects of this delay are detailed in the next section of this chapter, and can arguably be viewed as the biggest subject-rule-object disconnection reported in Metacog, as it significantly affected the very object of the activity, i.e. facilitating metacognition through a social supportive learning environment.

Effects of Waiting for a Conversation to Continue

Due to the asynchronous design of Metacog (and the online course), after learners responded to the initial questions and began conversations with other learners by responding to their responses, they had to wait for their conversation partners to reply in order to continue the conversation. The time delay of between 1-6 days between their initial conversation-starting response and follow-up responses from conversation partners proved to be a major subject-rule-tool disconnection and impediment to sustaining conversation. Table 15 illustrates the comments related to effects of this delay.

Table 15

Effects of Delay between Initial Conversation-Starting Post and Partner Follow-up Post

Effect	No. of mentions
Feelings of frustration or helplessness	4
Few conversations got started	1
Hard to do final reflection	1
Hard to respond because forgot what reading was about	1
Couldn't focus on making progress	1

Comments focused on the psychological and course assignment effects of the delay. Several learners were frustrated at being somewhat powerless over the situation, while an equal number of comments remarked that it made completing such requirements as conversation responses and the final reflection more difficult, or in some cases prevented them from happening altogether.

Ending a Conversation

After learners engaged with a partner in a conversation, they were asked to end the conversation by clicking a close discussion check box. Once checked, learners were prompted to post a final reflection about the conversation in which they had been engaged. Upon submission of the reflection post (which was only visible to the instructor, not to the learner after submission or to the other learner in the conversation), a star icon appeared which was designed to visually indicate that the conversation was closed and the requirements for the conversation had been met. Table 16 displays themes relating to this process, including activity disconnections between the designed process and the actual process.

Table 16.

Learner Comments on Process of Ending Conversations

Comment		No. of mentions
Process worked as designed	2	
Closed conversation icon was helpful		2
Process did not work as designed	8	
Never made it to the point of closing a conversation		2
Delayed closing conversation because confused over when closed conversation icon would appear		2
Closed conversations earlier because didn't want points taken off for no reflection		1
Some conversations were closed without a final reply to conversation partner; lack of closure		1
Copied final reply to partner and sent exact same thing to instructor as reflection		1
Did not realize conversations were only dyads		1

Specifically related to closing the conversation, two learners found the visual star icon helpful for indicating when the conversation had ended and they had completed the assignment requirements for that conversation.

For two other learners, however, there was some confusion about when exactly the closed conversation icon would appear. Both learners thought it would appear automatically after they had made the suggested minimum number of posts in the conversation. The design actually required one of the two learners in the conversation to close the conversation for the star icon to appear. This confusion resulted in delays before closing the conversation and making the final reflection.

Two learners stated that they never actually made it to the point of closing a conversation. In one case, the learner did not close the conversation because no one responded to her initial posts, so there was no way to have a conversation, much less end it and do a reflection. In the other case, the learner was behind schedule in making posts to Metacog. By the time he posted, other learners had moved on to the next week's Metacog assignment. In one case, the learner was actually involved in a conversation, but neither she nor her conversation partner ever closed the conversation.

Several other less serious subject-rule-object disconnections were also reported. These included closing the conversation early before the assignment deadline (which was usually Saturday at midnight after a week of using Metacog) in order to submit the final reflection in time; conversation partners closing conversations without any kind of acknowledgement of closure; learners using the same exact response as the final response to a conversation partner for the reflection; and learners not realizing that the conversations only consisted of two learners (dyads), rather than several learners which was the case for the Blackboard discussion groups in the course. These disconnections did not affect conversations being completed, but likely had an effect on the quality of the conversations.

Learner Evaluation of the Metacognitive Tool

The third research question in this study was, "How did learners evaluate their experience of learning metacognitive skills in such a context?" The context was that learners used a cognitive tool for metacognition, Metacog, in an online social support learning environment, as part of an online course titled "Instruction, Learning, and Assessment."

At the end of the course 21 of the learners completed an open-ended online evaluation form consisting of 15 researcher-created questions about their use of Metacog (available in Appendix E). Subsequently, six learners volunteered to participate in in-depth follow-up interviews framed by the Activity Checklist (Kaptelinin, Nardi, and Macauley, 1999) and the Activity Interview (Duignan, Noble, and Biddle, 2006). The interview questions are included in Appendix D. These responses form the basis for the findings related to the third research question in this study.

Findings are organized around two main themes: learner evaluations of the usability of the Metacog tool, both from design and technical perspectives; and learner evaluation of the effectiveness of Metacog related to its design principles. Specifically, findings are reported for:

Tool Usability

- Access to Metacog
- Technical functionality
- Resources
- Clarity of terminology
- Question design
- Conversation design
- Metacog and Other Course Tools

Tool Effectiveness

- Learner role in using Metacog
- Metacognition and task complexity

Metacognitive tool use for metacognitive knowledge versus regulation

Metacognitive tool use for metacognitive regulation – Planning versus monitoring

Perspective change

Creation of community and Metacog

Attitude towards the tool over time

Future classroom practices inspired by Metacog

Overall reaction to Metacog

Learners also were asked if they felt they had enough time to learn and evaluate Metacog, as they were introduced to it rather quickly during one week of the online course, and then only used it at most for three weeks. If they did not know how to use the tool for whatever reason, they would presumably also not be able to offer valid evaluations of it, and this could weaken the validity of subsequent findings.

First, follow-up interviewees were asked to comment on the amount of ease or difficulty, and amount of time needed to learn to use the Metacog program. One learner who also had issues in using the Blackboard discussion board commented that it took her awhile to learn to use Metacog. Otherwise, learners were unanimous that the tool was not hard to learn after being exposed to it the first time. A representative comment included:

> I don't think so, it was pretty easy to figure out after you told us what to do to get started on it and I didn't really need the help links on the side after I figured out the one. Or how to get started with it.

Second, follow-up interviewees were asked if they felt they had enough time with Metacog to adequately evaluate it. While the learners acknowledged that more time with any tool would be valuable for evaluation, they were also unanimous that they could make accurate evaluations of the tool based on their use of it during the 2-3 weeks of the online summer course.

> Learner: It was okay. You know, I mean, I think I was pretty fascinated with the tool and I would have liked to use it longer to evaluate it maybe, yeah I probably would have liked to have a little bit more experience with it. You know, but I think if I'm not mistaken, we've seen pretty much all there it is.
>
> Interviewer: Right.
>
> Learner: I mean, if that's all it is, then yeah I can evaluate it just fine.

Tool Usability

Access to Metacog

Learners in the follow-up interviews were unanimous that Metacog's web-based design made it easy to physically access it.

> Interviewer: As far as having access to the tools that you were able to use…
>
> Learner: No, everything was fine, it went perfect.

One learner reported that she lived in a rural area and only had a dial-up Internet connection. This was a subject-tool-object disconnection in that Metacog was neither designed for nor tested with a dialup Internet connection. In this case, however, the learner was coming to campus frequently for a classroom-based course, so she was able to access Metacog and complete assignments through the campus network.

Technical Functionality

Over the course of the summer semester, some technical issues did arise in Metacog. All of these were resolved in a manner that allowed the learners to continue with the Metacog assignments, but they had varying degrees of effect on the overall evaluation of Metacog. Table

17 illustrates the reported technical issues.

Table 17

Technical Functionality Issues with Metacog

Technical issue	No. of mentions
When responding, ended up at top of section or different section	4
Did not work well with dialup	2
Responses were not posted to one question set	1
Did not work well with Safari on Mac	1
Had technical issues (general comment)	1

The most frequent technical issue reported was that at times when a learner would click the submit link after answering a question, the answer would be submitted, but the cursor would jump to the top of the section of questions (or a totally different section one learner claimed). This bug was never corrected given the short amount of time that the learners had Metacog, but it was resolved by counseling learners to try a different browser, e.g., using Firefox if they had Internet Explorer, and vice versa. This makeshift solution worked in each case.

Metacog was not tested for dial-up Internet use. As mentioned above, one learner resolved the issue by coming to campus for Metacog work. The other learner with this issue found that she had to watch the higher bandwidth Metacog help videos by coming to campus (which she was also doing anyway for another class). Her home dial-up connection (although slow of course) sufficed for the mostly text-based Metacog interface for answering questions and having conversations.

Related to technical functionality issues, learners had been asked about their comfort level towards technology in learning during the first week of class. Approximately two-thirds had said they were comfortable, while the other third expressed some apprehension or ambivalence, as illustrated by this learner comment:

> I like to be very open minded toward technology simply because that's the way we're going, especially being in education when I have kids who probably, who know more about a computer then I ever will because they're brought up with it. So I feel like, as an educator I need to really try and catch up. The only negative attitude toward technology I have is when I feel caught up technology moves three times faster then it took me to catch up and I'm just like this is never going to happen. So in a way I'm a bit cynical about it because of that but I do understand that, as an educator I really need to start getting more adapted to it, so.

In hindsight, a better (or additional) question to ask the learners would have been about their own personal computer efficacy. The assumption at the time, however, was that learners in an online class would have a baseline level of technology knowledge. While the technical functionality issues reported with Metacog were definitely issues with the programming of the tool, resolving those issues with learners (e.g., having them download and use a different browser) proved to be time consuming for the researcher/instructor based on some learners' lack of computer efficacy.

Availability and Quality of Resources

Although Metacog was designed to be as intuitive as possible, the tool included resources to assist learners in its use. These included the Metacog assignment instructions and a series of screencast videos (created with the Jing software tool) detailing the use of each section of Metacog. In addition, a discussion board was created for Metacog questions when it was introduced. Finally, based on discussion board and email questions, a Frequently Asked

Questions (FAQ) document was compiled and posted to the Blackboard site after the first week of using Metacog.

The Metacog evaluations specifically asked learners about the help (videos) and the instructor's instructions on the Metacog assignments. Learners who replied were almost unanimous (16 of 17) that the videos had been helpful to them in learning to use the tool. The other learner indicated she did not watch the videos at all. Likewise, 13 of 14 learners who commented on the instructor's instructions found them helpful, although one learner thought they needed more clarification. Finally, all the follow-up interviewees indicated that they felt comfortable and knowledgeable about how to get more help if needed. They all said they would have felt comfortable sending an email to the instructor. In fact, many did while using Metacog.

Clarity of Terminology

Follow up interviewees were unanimous (6 of 6) that the Metacog tool contained no misleading or unclear terminology in the instructions, the Metacog questions, or the interface as a whole. One learner astutely pointed out, however, that by the time in the semester that the class started using Metacog, they were well versed in the terminology of metacognition and cognitive science. First, they had discussed metacognition at a general level at the beginning of the class when asked about their prior knowledge and use. Second, a couple of the course readings prior to the start of using Metacog referenced metacognition, and these readings were discussed on the Blackboard discussion board. In particular, the *How People Learn* textbook used in the class focused on the benefits of metacognitively-oriented instruction. If Metacog were to be used in other settings and with other audiences not related to cognitive science, the clarity of the terminology of the interface would have to be re-visited.

Question Design

In Metacog, learners had to answer questions related to the content of their course readings or their developing unit plans. The number of questions in a question set ranged from 15 – 23 per week. The questions were generic in nature and the same questions were asked each week (e.g., "What is the author saying? In one sentence, summarize the most important position of the author.") The questions are available in Appendix B. Learner comments about the questions are illustrated in Table 18.

Table 18

Question Design Comments

Comment	No. of mentions	
Using the same questions each week	7	
Became redundant		6
Let you know what to expect		1
Quality of questions within a question set	9	
Some were not applicable/too generic/not useful		5
Were repetitive/redundant		2
Were not repetitive		1
Helped focus on important elements		1

Two themes are apparent about the metacognitive questions that were posed in Metacog. First, most learners did not appreciate having to answer the same set of questions each week. It is true that the metacognitive knowledge/learning strategies questions related to the course readings were the same each week. The questions related to metacognitive regulation did in fact change at least once, however, when the focus shifted from planning the unit plans to monitoring their progress. This change appears to not have been significant enough for most learners.

Second, most learners found that the generic nature of the questions made some questions not applicable to every reading or unit plan assignment. This was especially true when a reading contained many different ideas, which might be the case for example, with the Metacog question "What are the pros and what are the cons if I implemented this? If I implemented this, who would benefit? Who would be harmed?" The intent was that learners would use their one sentence summary from the earlier Metacog question to answer this one. Many learners, however, did not know which specific idea of a reading to address.

Conversation Design

In addition to answering questions, the second main activity learners did in Metacog was to engage in conversations with fellow learners. The design of this conversation functionality in Metacog elicited numerous comments, which revealed specific subject-tool-object disconnections. The comments grouped into three main themes, illustrated in the table below.

Table 19

Conversation Design Suggestions for Improvement

Suggestion	No. of mentions	
Improve the activity structure of conversations	12	
Be more explicit about conversation deadlines		5
Better integration of Metacog with other course activities		4
Be more explicit about the debate aspect of conversations		3
Improve the usability of conversations	18	
Confusion on how and where to start a conversation		3

Notification of when conversation response has been made		3
Indicator of minimum conversation requirements being met		3
Conversation functionality hard to use – general comments		2
Wanted “Who’s Online” functionality		2
Better indicator than conversation is open for response		1
Hard to read the responses of others		1
Limit response options to only that week’s assignment		1
Make sure technology works across all platforms		1
More personalization and customization options		1
Inability to edit a response after it is posted		1
Fundamentally change the activity structure of conversations	4	
Would prefer concept map approach for debate		1
Would prefer a different activity than answering questions		1
Change dyads to small groups		1
Make conversations real time using chat		1

While many of the comments are similar to those expressed about learner use of Metacog in an earlier section of this chapter, the comments were all expressed as ideas for improving the tool. The large number of comments suggests, as noted earlier, that the conversation design functionality of Metacog should be re-examined for future audiences who use the tool; the suggestions above would useful for designers of other cognitive tools for metacognition as well. The number of ideas also suggests a high learner interest level in improving the tool. This is discussed more in the Conclusions chapter and may be related to their positions as practicing teachers.

The ideas grouped into three main themes. A small group of comments (4) related to fundamentally altering how the tool works. A much bigger group of comments (12) suggested making changes to the conversation design without altering its fundamental nature. For example, learners wanted more explicit deadlines for posting responses (which in turn presumably would have increased the level of interactions in the conversations).

Finally, the largest group of comments (18) related to the usability of the conversation design. There were a large range of ideas here, but the most frequently expressed were for the tool to have better indicators of learner progress once a conversation had started, and for improved ease of use in starting a conversation. The former comment was a recurring theme in learner evaluations. The latter comments about ease of use in starting conversations deserves more investigation, as it somewhat contradicts other evaluation comments about Metacog being easy to use, the instructions being clear, and the resources being helpful.

Metacog and Other Course Tools

Metacog was only one tool used in the course. The course design employed other tools including the Blackboard learning management system. Blackboard itself can be thought of as a combination of separate tools, the most prominent of which was the course discussion board. Each week, 2-3 discussion leaders in the course posted and then facilitated a discussion question. In addition, the instructor posted and facilitated a discussion question for the class. Learners were required to initially respond to the 3-4 questions, and also to respond to at least one other learner post for each question. This resulted in a minimum of 6-8 discussion posts per learner per week.

A few (3) learners commented that the discussion requirements, coupled with the Metacog requirements resulted in a lot of work for learners in the course. The larger issue for most learners regarding Metacog and the discussion board, however, was the perception that the two tools overlapped. This tool-tool disconnection is illustrated in Table 20.

Table 20

Learner Perceptions of Use of Both Metacog and Blackboard Discussion Boards

Category	No. of mentions
Metacog overlapped with the discussion board	14
Would have liked Metacog earlier in semester	6
Metacog did not overlap with the discussion board	4
Metacog, coupled with discussion board, created a lot of work	3

For the majority of learners who felt that the tools overlapped, the main reason cited was that since discussions/conversations were taking place on the same readings in both tools (at least for the metacognitive knowledge part of the Metacog assignment), there was a redundancy in many of the topics being addressed. Further, as one learner pointed out, since the discussion board was started before Metacog, and at the beginning of the semester, it became the more familiar tool and took priority over Metacog postings. In follow up interviews, several (six) learners echoed these comments all stating that they would have liked to have had Metacog earlier in the semester:

> I saw where it fit in, and that's why I was really excited about it, because I was like we could be doing this from the very beginning, I would have been much more in depth in the readings. The readings, some were difficult some were, the *Understanding by Design* one was fine, no problem with that one. But some of the ones by Vygotsky I was like whoa, that's pretty heavy stuff. But when, we would have applied all the readings to that

> Metacog tool I probably would have been a lot more understanding of everything as we went along, you know?

On the other hand, the minority of learners who felt that Metacog was something different from the discussion board provided two reasons for its uniqueness. First, Metacog's forced constraint of answering the metacognitive question *before* being able to see the responses of others was seen in a positive light. This echoes the findings discussed earlier related specifically to this functionality:

> [The Blackboard discussion board] didn't have those capabilities to post those questions the same way as we did on Metacog. You understand? So like we couldn't have solved the questions first and then answered them, that wouldn't have happened with [Blackboard].

In addition, another learner remarked that the Metacog metacognitive questions were more "probing" than the discussion board questions posed during the first part of the semester.

> I wasn't really expecting to be asked such probing questions about the course readings - we spent the first few weeks doing without Metacog so I'd honestly kind of spoiled myself.

Of course, the difficulty level of the questions is not an inherent feature of either a Blackboard discussion group or Metacog, but the finding does provide the learner's rationale for seeing the two tools as separate.

Tool Effectiveness

As a qualitative, exploratory, case study, this research study cannot provide more definitive control group comparisons about Metacog's effectiveness. Still, the findings do allude to the potential effectiveness of the Metacog tool and its various design features based on the metacognition literature. In this section, themes related to learner evaluation of these specific features and Metacog as a whole are presented in the following areas:

Learner role in using Metacog

Metacognition and task complexity

Metacognitive tool use for metacognitive knowledge versus regulation

Metacognitive tool use for metacognitive regulation – Planning versus monitoring

Perspective change

Creation of community and Metacog

Attitude towards the tool over time

Benefits of the tool over time

Future classroom practices inspired by Metacog

Overall reaction to Metacog

Learner Role in Using Metacog

One of the defining features of activity theory as an analytical framework is a focus on a subject within an activity system. Subjects have motives, which determine the kinds of interactions that occur with mediators such as rules and tools. Follow up interviewees were asked to define their role as they understood it in using Metacog, in order to better frame their other evaluative comments.

Learners largely defined their main roles in Metacog, as intended by the design, as that of reflection and collaboration about metacognitive learning strategies. Other comments, however, mentioned reflection and collaboration only about the course readings and assignments without any mention of metacognitive strategies. For example, one learner thought Metacog was about assessment.

> I guess my role was basically to learn it, it was enhancing or making sure that I learned the material that was presented or that I had a full understanding of what I read or the activities that we had to complete.

The lack of focus on metacognition as a role represents a fundamental disconnection with the object of using Metacog. Specific to this learner, Metacog was also never intended to be an assessment tool.

As discussed later in these findings, however, an important idea in activity theory is that of development over time. Learners may change their initial thoughts about an activity over time. This is reflected in one learner comment.

> My role I just thought as a student it was and I was, actually when I answered a question I just felt like that, I just felt like that it was of a student, that I was answering and then I didn't really get what it was until after like probably the second week into it, how it was helping me.

The learner went on to describe how she realized that she was implicitly applying the metacognitive questions to her other course readings by the end of class.

Metacognition and Task Complexity

One function of the metacognitive knowledge assignments in Metacog was to explore the idea of metacognitive knowledge being more valuable for learners as a function of task complexity (Veenman & Spaans, 2005). Learners used Metacog with two cognitive science readings: "Problem-based Learning: An Instructional Model and its Constructivist Framework" (Duffy & Savery, 1994) and "Beyond Bloom's Taxonomy: Rethinking Knowledge for the Knowledge Age." (Bereiter & Scardamalia, 1998). Based on discussions with other instructors with experience teaching the course (and validated by learner comments), the latter reading was characterized as more difficult for learners due to both the novelty and theoretical nature of its concepts. By contrast, the Duffy and Savery article, despite its title, was characterized as practical and application-oriented for practicing teachers. Table 21 illustrates learner ideas about the usefulness of the metacogntive tool for each article.

Table 21

Metacognitive Tool Usefulness as a Function of Task Complexity

Comment	No. of Mentions
Tool was more useful for complex article	7
Tool was equally useful for both articles	3
Metacog was more useful for less complex article	2
Metacog was not useful for either article	1

The learners who found Metacog more useful for the more complex article (as well as those who found the tool equally useful for both articles) cited both the functionalities for reflection and collaboration in Metacog:

> It helped me realize whether I understood or not. Like the Bereiter article, I think it was, I really was confused about that so reflecting on what I didn't understand was helpful and that discussion was helpful because someone helped me understand a little bit better about it.

Two learners stated that they found Metacog more useful for the less complex article. Further analysis revealed that they preferred using Metacog with the less complex article *because* the article was less complex and they therefore understood it better initially, rather than because Metacog helped them understand it better.

Metacognitive Tool Use for Metacognitive Knowledge Versus Regulation

Learners overwhelmingly agreed that Metacog was useful for both metacognitive knowledge and metacognitive regulation; however, they were split about which metacognition component benefited most from Metacog. Table 22 illustrates the magnitude of each perception.

Table 22

Metacog's Usefulness for Metacognitive Knowledge Versus Metacognitive Regulation

Comment	No. of mentions
Metacog was useful for metacognitive knowledge	10
Metacog was useful for metacognitive regulation	8
Metacog was not useful for metacognitive regulation	3
Metacog was not useful for metacognitive knowledge	2

For those learners who found Metacog more useful for metacognitive knowledge (i.e. questions about course readings which embedded metacognitive learning strategies), the majority mentioned the ability to reflect and have conversations with others as the reasons for their choice. In addition, one learner found the Metacog instruction to limit responses to 1-3 sentences useful for focusing her thoughts and responses.

Similarly, for those learners who found Metacog more useful for metacognitive regulation (i.e. the planning and monitoring of the unit plan), one of main reasons was the ability to have conversations with others and learn from them. Two other reasons were also mentioned. First, Metacog was useful to track progress on a project, either against goals and standards, or against the progress of others. Second, Metacog was useful for application since it allowed for the practical application of the course material to teachers' everyday experience. This last point, of course, was a function of the design of the unit plan activity used with the regulation aspect of Metacog, rather than Metacog itself.

Although there were many fewer learners who did not find Metacog useful, the reasons reflect fundamental subject-tool-object disconnections alluded to in other comments. These learners could not or did not want to use a metacognitive tool. One learner did not want to make explicit her planning and monitoring responses to others because she preferred to complete projects entirely and then reflect afterwards. Two learners felt that Metacog was an intrusion on their already established metacognitive knowledge and regulation practices.

> I unit plan in my own way - I think we all do as established teachers - and answering the questions was more of a bother than a help.

Yuen (2009) has explored the interplay between collaborative learning (such as that envisioned by the Metacog design) and learner's personal theories of knowledge and learning. Yuen argues that advancing the latter can advance the benefits of the former. Activity theory would clearly argue that exploring a subject's "personal epistemology" - as well as more mundane established work practices - might be beneficial for the design of future metacognitive tools.

Finally, in one case a learner did not find Metacog useful for metacognitive regulation simply because he was not ready (due ironically to poor planning on his part) to respond to planning questions during the week the Metacog tool was used for this.

Metacognitive Tool Use for Metacognitive Regulation: Planning Versus Monitoring

Learners also distinguished between using Metacog for two different types of metacognitive regulation, planning and monitoring. (Metacog was scheduled to be used for a third type of metacognitive regulation, evaluating, but this was not implemented due to time constraints in the summer semester.) Table 23 illustrates the magnitude of each perception.

Table 23

Tool Usefulness for Metacognitive Regulation - Planning Versus Monitoring

Comment	No. of mentions
The tool was useful for metacognitive planning	10
The tool was useful for metacognitive monitoring	8
The tool was not useful for metacognitive planning	4
The tool was not useful for metacognitive monitoring	2

The reasons for these findings mirror the earlier reasons about using Metacog for metacognitive knowledge versus regulation. Whether for planning or monitoring, learners appreciated the ability to reflect on their unit plans as they worked, track progress against standards or others, and exchange ideas and perspectives with others. Likewise, those who did not find Metacog useful for either planning or monitoring mentioned they were either not at the point of the unit plan to use Metacog when it was assigned, or already used a similar process and found Metacog repetitive or intrusive to that established process.

Perspective Change

Metacog asked learners to have conversations with fellow learners based on responses with which they disagreed. As noted earlier, many learners either did not choose conversation partners based on a disagreement, or once they chose a conversation partner, a true conversation did not develop. The findings relating to perception change resulting from Metacog use reflect these prior conditions. 15 of 20 comments related no real perspective change on a particular issue after using Metacog, with many reasons attributed to the prior conditions. Table 24 illustrates the comments related to perspective change.

Table 24

Metacog and Perspective Change

Comment	No. of mentions	
Metacog did not result in perspective change	15	
Did not debate in conversations		6
No/few initial posts and/or responses		5
No perspective change (no reason given)		4
Metacog did raise the possibility of perspective change	5	

For those who thought Metacog presented the possibility for perspective change, most said Metacog allowed them to better consider the views of others, even if their perspective did not change as a result in the end.

Creation of Community and Metacog

Most learners felt that a community was created in the online class. Out of 19 learners who commented, 17 thought that community was created, while only two did not. Table 25 details the specific course elements mentioned as contributing to the development of community.

Table 25

Course Elements Mentioned As Creating Community in the Online Class

Element	No. of mentions
Discussion boards	9
Instructor guidelines and facilitation	5
Respectful tone of interaction / safe and trusting environment	3

Constructive and substantive feedback from fellow learners	2
Learner prior knowledge of community expectations	2
Community-building course activities early in semester	2
Metacog	1

The discussion boards were referenced repeatedly as the largest contributor to the creation of community. Several overlapping design elements of the course, however, were also mentioned frequently. For example, the instructor guidelines about community at the beginning and during the class were mentioned several times. These guidelines included offering constructive feedback in a respectful tone. Any of these overlapping design elements could have occurred in the discussion boards and elsewhere in the online learning environment (e.g., other parts of Blackboard, email, Metacog, etc.).

Learner prior knowledge was also mentioned. The class was composed almost entirely of practicing teachers either experienced in using community as a learning strategy, or at least familiar with the idea, as evidenced by their self-reports on the topic at the beginning of the course.

Finally, instructional activities that occurred early in the course were mentioned. Specifically, the learners answered a “Who Am I?” discussion question the first week of the course, in which they shared biographical information. In addition, in the third week of the course, they completed a fairly intense small group activity involving the Jasper Woodbury video “Rescue at Boone’s Crossing” as part of a lesson on cooperative and constructivist learning.

Metacog was only mentioned once explicitly in the evaluations as contributing to the creation of community in the course. Follow-up interviewees were asked how Metacog contributed or did not contribute. The bulk of the comments (4) indicated that Metacog contributed to community by facilitating peer-to-peer interaction in a safe environment. On the other hand, the lack of participation in the tool was the main reason that Metacog did not contribute to creating community.

Two learners specifically indicated a tool-tool disconnection, commenting that they thought the discussion board created community because it had been introduced earlier in the semester when learners were getting to know each other. Had Metacog been started earlier in the semester, it might have played a similar role. One learner went on to speculate that because it was introduced later in the semester, it disrupted the pattern that had been established in the class.

> I think when you start getting into a routine of the class, you start understanding, a lot of that comes with the understanding of the material you know, I saw about late June where we were going when we started reading *Understanding by Design* and some of the readings, and I was like okay now I know where he's going with this. Then when Metacog got thrown in, I see the pattern, but it was still was kind of an intrusion in a way, if that makes any sense.

Finally, one comment indicated another possible reason for Metacog not contributing to creating community (as well as being another tool-tool disconnection): Learners were identified differently in the interfaces of Blackboard and Metacog. This created some confusion over the identity of fellow learners.

> It's so hard to construct mental images and identities for other students when you've never met them and have to piece together information attached to various and sundry usernames and different contexts.

In Blackboard, learners were identified according to their names that were on record with the university's learner information system. In Metacog, learners were identified with their university username, and could change this if they wanted when logging in to the system the first time. The result was that some learners changed the usernames and some did not so that in some cases they were identified in the same way in Blackboard and in some cases they were not.

Attitude Towards the Tool Over Time

An important concept in activity theory is the idea of development. In order words, things change over time. In fact, Leontiev's Level 3 disconnections are defined by an older version of an activity conflicting with a newer version of an activity. Both the Activity Checklist (Kaptelinin, Nardi, and Macauley, 1999) and the Activity Interview (Duignan, Noble, and Biddle, 2006) include questions for interviewees to comment on this development. As such, in the follow-up interviews, learners who had used Metacog were asked to describe how their attitude towards Metacog changed from the beginning of the time it was used until the end. Four of the six follow-up interviewees reported that their attitude towards the tool became more positive the more they used it.

The other two interviewees thought that their attitude stayed the same (1) or "stayed the same, or decreased a little bit." These two learners nonetheless found some value in the tool.

> Probably stayed the same, or decreased a little bit because after awhile I got to do this again, a few more questions, you know. But like I said it depends on your attitude… Because really thinking about it more deeply the unit plan just, when I put more thought into the unit plan itself now I think I made some changes because of the Metacog tool, made some alterations to where I was going with it because of the things I was asked to consider.

Future Classroom Practices Inspired by the Tool

While one goal of Metacog had always been to improve metacognitive instruction in general, it was not designed specifically for teachers, nor meant to inspire their classroom practices. Once the teacher audience began using Metacog, however, it became obvious from the comments that many of the teachers were thinking about how to better teach metacognition, inspired by their work with Metacog. Table 26 illustrates a variety of potential applications of lessons from Metacog, as well as those comments where the learners found no potential use of Metacog for their instruction.

Table 26

Classroom Practices Inspired by Metacog

Practice	No. of mentions	
Metacog-inspired practices	31	
Incorporate the specific Metacog questions		8
Peer interaction		5
Reflection		5
Incorporate more metacognitive instruction (in general)		5
Want to try in a variety of different domains		3
Skill application		2
Teacher rubric for designing metacogntive activities		1
Assessment		1
No Inspiration from Metacog	4	
No relevance to students		3
Already incorporate metacognition extensively		1

A very large majority of learner comments (31 of 35) indicated that Metacog had inspired them to incorporate or increase metacognitive activities into their current instruction. Some comments were very general indicating that the tool made the learners/teachers aware of adding metacognition to their instruction. Similarly, there were some general comments about adding "reflection" to instruction.

Most comments, however, were very specific. In particular, the largest amount of comments mentioned using the Metacog questions directly in the classroom for metacognitive knowledge and regulation; learners thought the questions themselves were effective prompts outside of the tool and activity structure of Metacog. In addition, a few learners/teachers specifically commented on how questions used in Metacog might be used in a variety of domains, suggesting some domain generality of the questions.

In addition, the idea using of more peer interaction was mentioned several times, despite Metacog's own design and implementation issues with conversations/collaboration.

> I enjoyed the opened forum nature of the Metacog tool and such is a lesson that I learned from Metacog in that this is the way that it should be done in schools…and such are lessons that I will use in my own teaching e.g., open forums where students can express their ideas, use their prior knowledge, and apply their own background to the task that we have at hand. I believe this way optimizes learning.

One possible subject-tool-object disconnection was noted when a learner/teacher remarked, "I would definitely use the question-answer format to assess students' understanding of readings in class." Metacog was never designed for assessment purposes. More accurately, this is a disconnection between the object(ive) of the learner/teacher and the object(ive) of the Metacog tool designer/researcher.

For those few comments that indicated no relevant applications of Metacog lessons for instructional practice, it appeared that there was a misinterpretation of the intent of the interview question. The comments were more related to the actual Metacog tool itself, not metacognitive instruction in general. Chiazzese et al. (2006) noted a similar situation with interviewees misinterpreting evaluation questions related to a metacognitive tool. For example, one learner/teacher who had a variety of technical issues with the Metacog and assumed her students would have the same experience. Likewise, one learner/teacher who taught special education thought the interface would be difficult for her middle school students.

Overall Reaction to Metacog

The Metacog evaluations as well as the follow-up interviews attempted to gauge learners' overall reaction to using Metacog. Given the open-ended nature of the question prompt, the responses varied considerably, with some learners concentrating on functional and assignment-related aspects of the tool, and other evaluations being closer to the object of the activity – using Metacog in a social supportive learning environment to facilitate metacognition. Table 27 displays the range of comments categorized as expressing the usefulness of the tool to the learners.

Table 27

Overall Reactions to Using Metacog

Category	No. of mentions
Reasons that Metacog was useful	
Reflection aided comprehension	11
Useful for learning from the perspectives of others	8

Useful overall (general comments)	7
Allowed applying lessons to everyday practice	2
Planning component was helpful	2
Helped with computer literacy/efficacy	2
Reasons that Metacog was not useful	
Tool created too much work for the class	5
Already use metacognition	2
Technical issues	2
Lack of responses in conversation	1
Too much practice, not enough theory	1

The majority of these findings mirror previous findings in this chapter; however, it is useful to report these separately, as this was an opportunity for learners to comment on any aspect of the tool without any specific prompt. In this regard, the positive comments far outweighed the negative comments.

Chapter 4 Summary

This chapter reported the findings from this study related to each research question. Learners' prior knowledge and skills with metacognition as well as community were reported. How learners used the metacognitive tool in an applied setting was also reported in 11 areas of the tools related to answering questions and having conversations. Finally, learner evaluation of the tool was reported related to the tool's usability and effectiveness in 16 areas. In the next chapters, these findings are reviewed in the context of cognitive tool use and recommendations for improvement and future research are made.

Chapter 5: Conclusions and Recommendations

This study employed activity theory to study tool use in the authentic learning environment of an online graduate course. The conclusions drawn from the study therefore emphasize findings about the Metacog tool in particular, as well as metacogntive tool use in online education in general. The conclusions also emphasize findings about rules relating to the use of the Metacog tool in the online course. As activity theory suggests, these tools and rules cannot be separated from the subjects involved in the activity - practicing teachers who were learners in an education graduate program. Likewise, the object of the activity — using a metacognitive tool in a social supportive online learning environment — colors each conclusion.

This chapter discusses conclusions in light of relevant literature. Conclusions are presented regarding the use of Metacog as a cognitive tool, and future research is suggested as appropriate. The conclusions also present design suggestions for future social supportive metacogntive learning environments. After this, several broader conclusions are considered regarding metacognition education for teachers, and the viability of the construct of metacognition itself. Finally, this chapter concludes with a summary of the chapter as well as the study itself.

Metacog as a Cognitive Tool

Tools are major mediators of human activity in activity theory. Cognitive science researchers describe cognitive tools as tools designed to mediate learning. Pea (1985) writes that:

> Cognitive technologies are tools that may be provided by any medium and that help learners transcend the limitations of their minds, such as memory, thinking, or problem solving limitations.

Metacog is a cognitive tool designed to use computer technology to facilitate learner limitations to metacognitive thinking.

Cognitive tools can be physical hardware tools such as calculators or computers. They can also be digital software programs on the hardware. The software can be an existing software package used in a learning situation, such as using a web browser to search for information. The software tool can also be specifically developed as a cognitive tool (Robertson, Elliot, & Robinson, 2007). Metacog falls into this latter category.

Robertson, Elliot, and Robinson (2007) offer several guidelines for using such cognitive tools in their instruction. These guidelines serve as a useful framing tool for summarizing the multitude of individual findings about Metacog.

A Variety of Tools for a Variety of Cognitive Processes

Robertson, Elliot, and Robinson (2007) suggest that a variety of tools can be necessary to support various cognitive processes. They go on to say that the same tool may support various functions.

This suggestion for cognitive tools in general is perhaps more true for metacognitive tools in particular, given the multiple components of the metacognition construct. Metacog, like most metacognitive software tools, is not one tool. It is a collection of small tools, as separate functionalities, marshaled together in the service of the object of the activity in this study, i.e., using such a tool in a social supportive online learning environment. At a functional level, Metacog had sections for answering questions, responding to others, engaging in a conversation, and closing and reflecting on that conversation. Each of these areas had associated designed rules and constraints that themselves created more “tools.”

These different tools were meant to address different cognitive processes, in particular metacognitive knowledge versus metacognitive regulation, with the latter further broken down into separate planning, monitoring, and evaluation sections. Offsetting cognitive load, to be discussed in depth later in this chapter, was also a cognitive process targeted by the tool overall.

Liu et al. (2004) similarly explicated a matching of tools (i.e., tool functionality) and specific cognitive processes in a cognitive tool named *Alien Rescue.* The tool featured functionalities including note taking, storing images, viewing expert videos, gathering data, and submitting solutions. The tools/functionalities took the forms of realistic items such as databases, notebooks, and rooms. For example, the control room featured raw data that students needed to interpret in order to use in developing solutions. These functionalities were matched to the cognitive processes of understanding a problem; identifying, gathering, and organizing important information; integrating information; and evaluating process and outcome. The researchers concluded that some tools were used across cognitive processes while others were used primarily for certain cognitive processes. The control room tool mentioned above, for example, was used primarily for integrating information.

The Metacog findings likewise suggest that different tools can be useful for different cognitive processes. Learners found the questions especially helpful for metacognitive knowledge, while finding the conversations helpful for metacognitive planning and monitoring.

Tools can also be useful across cognitive processes. Liu et al. (2004) found that *Alien Rescue* tools that supported cognitive load were useful for all of the cognitive processes they examined. Likewise in Metacog, the tool/rule that required answering questions before viewing the responses of others was found to be useful for metacognitive knowledge and regulation. It did not matter whether the learners were planning, monitoring, or using different learning strategies (even when they expressed preferences for one of these). The exception, of course, was for the small number of learners (who were practicing teachers) who felt they already used these metacognitive strategies, e.g., teachers who used their own idiosyncratic planning processes prior to using Metacog. They did not like using the tool at all.

In addition to being useful for different metacognitive processes, Metacog seemed to be especially useful for complex tasks (Veenman & Spaans, 2005). Several learners commented that the tool was more useful for the task of understanding the more difficult abstract reading than the less difficult reading used in the course.

Finally, outside of Metacog, there were other tools used in the class, most notably the discussion board, which affected and was affected by the collection of tools termed Metacog. As discussed in the previous section, several learners suggested that the discussion board and Metacog competed for their limited attention. While Metacog was designed to target metacognitive processes in the context of the domain knowledge, the discussion board was aimed at only understanding domain knowledge; there was no effort to address metacognitive processes in its use. Using both tools together, however, created conflicts for learners.

In summary, different cognitive tools can support different cognitive processes. The same tool may also support various cognitive processes. In addition, a variety of tools may be necessary or even unavoidable in a course. The important conclusion is that care must be taken to avoid or manage tool-tool disconnections. Whether different tools create a conflict by targeting the same cognitive processes, or the same tool causes a conflict among different cognitive processes, the end result may require a tool or activity structure re-design. Future research on metacognitive tools might explore the interactions among different cognitive tools in an activity structure, in order to provide designers with strategies to enhance effectiveness and to minimize disconnections. Particular to the use of Metacog, the individual tools could be tested separately as separate tools for each metacognitive process. A more immediately promising test, however, would be to use Metacog without the discussion board in a course and analyze learner comments for such an activity structure.

Meaningful Engagement

Robertson, Elliot, and Robinson (2007) suggest that cognitive tools can motivate and engage learners through meaningful problem solving. This can happen through realistic learning and feedback within learning environments.

One welcome conclusion from the Metacog findings was that for the most part, learners reported that their attitudes towards the tool, and the perceived benefits of it, increased or at least stayed the same as they continued to use it. This was despite the tool being a prototype and by no means being the kind of authentic tool usually envisioned as a cognitive tool, such as BGuile (Reiser et al., 2001), Thinker Tools (White, 1993), Jasper Woodbury (Cognition and Technology Group at Vanderbilt [CTGV], 1990) or Alien Rescue (Liu et al., 2004) .

Still, learners were engaged and motivated by the use of Metacog. For example, even though some learners found issues with the metacognitive questions, the majority of learners found them to be meaningful once they understood their purpose. Likewise, while the conversation design had several weaknesses, learners agreed that it had potential for useful discussions given its underlying authenticity, i.e., the learners (who were practicing teachers) do discuss with each other the kinds of instructional concepts and applications raised by the course readings and assignments. These types of discussions were not foreign to them and Metacog was a means to do what they normally did within a realistic environment. Finally, while the conversation design ultimately inhibited the frequency of responses, the learners recognized how the conversations could provide valuable feedback to them. In fact, the feedback element was one of the most positively commented upon features of Metacog. This was especially true when learners were planning their unit plans. The feedback from other learners allowed them to monitor their own progress as well as to compare evolving designs against their peers. While the above subject-tool-object disconnections were noted, the authenticity and realism of the tool as useful was rarely questioned.

These Metacog findings suggest that metacognitive tools have to be authentic in their "epistemic interface" rather than in less relevant characteristics (Roschelle, 1996; Wenger, 1987). While high-end virtual social worlds and simulations of classrooms may be authentic and thus motivating and engaging in their own right, it seems the fidelity of metacognitive tools such as Metacog do not have to reach this level, at least for this particular audience. Practically, this also bodes well for researchers and designers of such tools who want or need to create tools without extensive technical development knowledge or financial resources.

Managing Cognitive Work

Robertson, Elliot, and Robinson (2007), in their overview of cognitive tools conclude that cognitive tools should help learners manage their cognitive work, and not increase it. Indeed, this is one of the stated functions of technology-based cognitive tools in education - sharing or offsetting the cognitive load of students (Lajoie, 1993). For example, Oliver and Hannafin (2000) used a cognitive tool to handle a variety of functions such as note taking, information search, and information presentation so that students could concentrate on higher order problem solving. Likewise, Van Bruggen, Kirschner and Jochems (2002) suggested that the external representation of student arguments could lighten cognitive load.

In Metacog, the tool was ostensibly designed with this idea in mind. By using the questions as a scaffold for employing metacognitive strategies, learners could concentrate on course work such as their unit plan progress and recognizing upcoming obstacles. They were able to concentrate on instructional design decisions that utilized the content (i.e., cognitive science principles) that they were learning.

Given the reliance on the Metacog questions to perform this cognitive offset function, the findings regarding the number of questions and the time to complete answering the questions suggest that Metacog did not completely succeed in this area. A number of learners found the number of questions excessive and the time to complete them onerous. Rather than offset cognitive load, Metacog may have increased it for some learners.

It may be the case, however, that the same Metacog functionality would have been more useful for offsetting cognitive load – but by using fewer questions. If learners are spending significant amounts of time answering questions, the implication is that an offset in cognitive load is not occurring. A future research area for the use of Metacog or similar metacognitive tools in an applied setting would be to more extensively investigate the relationship between amount of use (i.e., the number of questions and the time required to complete them) and the goal of offsetting cognitive load.

A Need for Scaffolding

Given that learners may not be familiar with new tools, Robertson, Elliot, and Robinson (2007), suggest that scaffolding may be needed for students to use them effectively. Instructional designers, researchers, and teachers employing cognitive tools must decide upon the degree of scaffolding they want to include so that students can use a tool effectively. Too much and students will not engage in the tough work of learning; not enough and students may never even have a chance to attempt the kind of learning for which the tool was designed. Further, scaffolding decisions have to be made for all elements of a cognitive tool, not just for instructional elements. How much is obvious in a tool and needs no scaffolding, and conversely, what is not obvious and requires (at least initially) assistance from the tool or from the instructor?

Metacog exceeded expectations about the ease of initially using the tool. Learners thought that the interface was clear and easily understood. They answered the questions related to readings and assignments without any difficulty using the assistance provided in the tool. They were nearly unanimous that the terminology used within Metacog was clear, the resources provided were helpful, and that they knew where to find additional help if needed. In addition, where provided, the explicit rules about using Metacog were clear and easily understandable.

In addition, learners were clearly informed about the intended use and nature of Metacog in the class and their role in the activity. Their comments indicate that they understood it was a tool that was being tested, it was metacognitive in nature, and that metacognition is an important element of learning. Yet while learners may have been informed about the metacognitive nature of the tool, the explanation provided may not have been enough. For example, several learners commented negatively about having to answer the same set of questions each week, even though the design rationale about the usefulness of their generality had been made known to them.

It appears that these learners were not arguing about whether repeating the same questions is a good design or not. Rather, they did not understand the metacognitive purpose of the questions and Metacog as a whole. McMahon & Luca (2007) found similar student comments in evaluating their metacognitive teamwork tracking tool. While students rated the tool favorably overall, they rated several metacognitive design elements poorly. The authors concluded that the students understood the tool primarily as a teamwork tracking device and had not fully understood its metacognitive features.

Several other examples in Metacog demonstrate the desire for more scaffolding in the form of explicitness. Learners wanted better defined deadlines about when to post and when to respond. They wanted the tool to better help them determine when a conversation had been successfully completed. They wanted a more direct connection between the questions they answered and underlying learning strategies.

Oliver and Hannafin (2000) emphasize that procedural understanding of a tool is necessary in order for it to be used effectively for higher level use. The use of important functions of metacognitive tools should be scaffolded for students to insure that they can use the tool adequately before the tool is expected to be used for higher order thinking. Future research should explore the nature, timing, and degree of this procedural scaffolding. While critically important, it must be designed to be efficiently mastered by students so that more important learning can be accomplished.

How Students Use Cognitive Tools

Robertson, Elliot, and Robinson (2007) conclude that cognitive tools are still relatively new, and many unanswered questions remain about their use and how students actually manipulate them. This study explored how learners use a metacognitive tool in a realistic setting. The design of the tool was informed by the literature on the design of previous metacognitive tools. Students will use tools, however, in ways slightly or even totally differently than imagined by designers. The learners using Metacog reacted in many unique ways.

Question Specificity

As noted earlier, some learners wanted to use the tool primarily to answer specific questions about specific readings. They suggested the questions be less general and generic. Chiazzese et al. (2006) noted similar subject-tool disconnections with Web@Edu, an interactive web browser that provided students with metacognitive questions (similar to Metacog) when they clicked on a hyperlink. For example, students were prompted with questions such as:

- Why have I clicked on this link?
- What information do I expect to find?
- Why have I selected this link rather than the others on the page?
- Have I found the information I expected on this page?
- What has interested me most on this page?

The generic nature of the questions meant that some questions were not relevant to some of the links and pages the students were viewing, leaving them “irritated and confused.” The authors do not describe or provide the amount or nature of the information they gave users about the metacognitive focus of Web@Edu.

Changing the design of Metacog and other metacognitive tools which use generic prompting questions is a suggestion worth investigating if t could be done without fundamentally altering the metacognitive nature of the tools. It is also likely that this would alleviate the charge of a few learners that Metacog was busy work; they would react more favorably to such content-specific questions. Changing the design in this way would require adding a teacher or administrator module that allowed the questions to be customized, rather than using the generic questions. Chiazzese et al. (2006) reached the same conclusion and recommended that future versions of their tool include such a module.

On the other hand, making the metacognitive questions more applicable to each reading or assignment is not something to be done lightly. The questions were specifically designed to be generic in nature. In fact, even the generic versions of the questions may have still been too specific. Less coherent prompts can improve student learning by requiring the students to process material at a deeper level (Waters & Waters, 2010; McNamara, 2001; McNamara, Kintsch, Songer, & Kintsch, 1996; Mannes & Kintsch, 1987). On this particular issue, the solution may be less explicitness. Future research on metacognitive tools using prompting questions should explore the level of specificity of those prompts.

Process for Answering Metacog Questions

Users displayed a variety of processes for working through the initial questions in Metacog. Some learners worked through all of the questions immediately after a reading; some learners answered a few questions at a time; and some learners returned to Metacog only after a length of time went by after reading the articles used in the course.

This variety suggests at least one area for further investigation. Some learner work habits may not be amenable to the design of the tool. A long line of research supports the idea that students are more accurate in making metacognitive judgments of learning – the delayed-JOL effect -- after some time has passed, as opposed to immediately after learning (Nelson & Dunlosky, 1991; Connor et al., 1997; Schneider, 1998; Kennedy, Carney, & Peters, 2003). Similarly, Willingham (2009) suggests that students can more accurately judge their learning after some time has passed because the content is no longer residing in their working memory. The delay insures either the content is in long-term memory or it is not; in either case, students can better judge whether they know it or not. Learners who immediately replied to Metacog questions after finishing a part of an article or their unit plan might have been answering some of the questions based on content that was being recalled from working memory. If this is the case, learners using Metacog immediately after their readings or unit plans may not have been able to adequately judge their learning, which could subsequently affect the ability to allocate study time and resources.

Of course, changing this aspect of the Metacog design could realistically only be done through more explicit information about JOL and study habits (another example of informed training), rather than a technical implementation. It seems unfeasible to try to delay when learners can answer questions after doing their readings. Learners will read and complete assignments at their own pace relative to deadlines.

Suggested Length of Initial Responses

The Metacog instructions suggested that learners limit their initial responses to 1-3 sentences in order to focus on the main metacognitive strategy raised by the question. Many learners did not adhere to the length suggestion, and their answers tended to be longer than necessary, which in turn contribute to some assertions that there were too many questions to be completed in Metacog, and the tool added too much work to the class.

While other metacognitive tools that require student responses to questions have not addressed this issue of response writing length, the writing process itself has a long history in the metacognitive literature. Harris, Santagelo and Graham (2010) offer a comprehensive review of metacognition and writing. The authors conclude that good writers differ substantially from bad writers and some of this difference is attributable to metacognition in two ways. First, good writers have more metacognitive knowledge than poor writers. They know more about writing, its purpose, and more writing strategies. They are able to discuss what good writing is. In Metacog, it could be that some users did not have as much metacognitive writing knowledge as others and did not understand that brevity can be a quality of good writing. Without this knowledge, they felt that they had to write more, rather than less.

Harris, Santagelo and Graham (2010) also discuss the importance of metacognitive regulation to writing. They offer that most models of good writing include a self-regulatory component (e.g., Graham, 2006; Scardamalia & Bereiter, 1986). Good writers plan, monitor, and reflect on their audience and topic more than poor writers. Afflerbach and Cho (2010) suggest that skilled writing *is* metacognition. In Metacog, a lack of metacognitive writing regulation could have ironically led to learners to benefit less from the metacognitive tool. Any solution to this issue should avoid this result in the future.

The functionality to enforce response length could be implemented easily by limiting the number of characters allowed in a text field. In addition, the length could be variable by question if it was determined that some questions did demand longer responses. If the tool were expanded to include a teacher or administrator module, as suggested earlier, then this variable length would be under the control of a specific designer depending on specific content being used with Metacog.

Choosing a Conversation Partner

Most users of Metacog did not seek out someone with whom they could debate. The majority of users attributed this to the lack of responses from others (i.e., it is difficult to debate without an ongoing conversation). This is unquestionably something to be re-designed in future versions of the tool.

Many users, however, did not seek out debate initially (before receiving or not receiving responses). Or they received responses and still chose not to debate. These learners suggested that simple communication was more important than debate, that they did not really know how to debate, or that some responses were not debatable. These very different reasons for not debating indicate a variety of activity theory disconnections. In this regard, the activity theory framework was useful in isolating and naming these disconnections.

The easiest solution might be to loosen the requirements to merely “converse” or "communicate" with each other. This solution, however, undermines debate as a foundational design feature of Metacog. Debate involves defining and crafting one's own arguments while evaluating and critiquing those of others, with all of these processes being cognitively complex. Not surprisingly, many researchers have also incorporated debate as elements or the centerpieces of their cognitive and metacognitive tools (e.g., Veenman, 2000; Van Bruggen, Kirschner & Jochems, 2002; Bell, 1997; Lajoie, 1993).

Rather than changing the design of Metacog, the lack of debate might better be resolved other ways. First, graduate learners in education would likely be amenable to a better explanation of why debate is being required in the tool. While learners were given explicit instructions on the importance of a respectful tone during academic discourse, they weren't told why a certain kind of academic discourse (i.e., debate) was valuable for learning. The instructions to be respectful and work as a learning community may even have hindered debate by minimizing conflict. The end result, especially for those who were colleagues from cohort programs in similar domains (e.g., Special Education) who chose to flock together, was a lack of debate.

Another solution is to model the process of debate so that learners know how to answer the initial questions to make them debatable, as well as how to respond to initial answers in order to start and then continue a debate. The Metacog resources adequately told learners how to use the functionality of the tool, but not how to engage in debate.

One way to model and scaffold debate is to provide students with response-beginning prompts. For example, a prompt might begin "I disagree because…" Bereiter and Scardamalia (1986) use a variety of similar prompts in their metacognitive CSILE (now Knowledge Forum) tool to scaffold students during the inquiry process they are modeling. The functionality can be easily implemented. Even the latest generations of online learning management systems (e.g., Angel 7.4 from Blackboard) incorporate such configurable prompts as an optional design feature of their discussion boards. Metacog could be adapted in the same way.

Checking for Conversation Responses

As with the process of answering the initial questions, Metacog users displayed a variety of processes for checking for conversation responses once they had made their initial posts. Some checked constantly, some frequently at first, and some hardly checked at all. Many were frustrated not knowing when a response would be forthcoming; in some cases the lack of response resulted in not finishing the Metacog assignment.

Other metacognitive tool researchers have not specifically addressed this issue; however, it has become more evident that metacognition combined with peer support enhances learning (Waters & Schneider, 2010). Obviously, a social supportive metacognitive tool requires frequent social interaction. Social software designs in current popular web-based applications that were not as ubiquitous when Metacog was initially conceived and developed (e.g., Twitter, Facebook, etc.) offer more than enough design ideas for how such interaction might be facilitated. For example, learners could receive email or text message notifications when a fellow learner makes response. The first learner could either reply directly from the email or messaging application, or log back into the metacognitive tool to respond. (The latter approach provides the conversation context so would likely be more useful even if less flexible.) In addition, this notification process could be adapted for other areas of the conversation design that was evaluated as troublesome in Metacog, such as responding to a conversation partner, waiting for a conversation to continue, an ending a conversation.

This discussion also highlights how future versions of Metacog or another metacognitive tool might be constructed. Although this study did not address the issue directly, the ubiquity of social media applications, as well as (and more importantly) social media development environments (e.g., Ning), could allow future researchers to much more quickly develop metacognitive applications, and quickly test different designs though a rapid prototyping process, rather then building the environments from scratch.

The ability to more easily create tool prototypes can also be coupled with the finding from this study that learners felt that the 2-3 weeks they used Metacog was adequate for them to evaluate it. More tool variations and short evaluation times might practically allow for the variety of alternative tool evaluations suggested by Robertson, Elliot, and Robinson (2007) for researchers using cognitive tools. Once a workable prototype was in place, more extensive microgenetic designs could be employed to study metacognitive development over time when using metacognitive tools (Waters & Schneider, 2010).

Technical Issues

While perhaps a less glamorous aspect of educational research, Robertson, Elliot, and Robinson (2007) remind researchers that cognitive tools can require technical troubleshooting and other technology issues. Research involving the design, development, and implementation of technology-based learning tools in applied settings creates a layer of complexity for researchers arguably not found in other educational research. As this study shows (and activity theory greatly aids in analyzing), such research combines a variety of domains. In particular, in addition to metacognition, a researcher needs to be versed in instructional design, educational technology, web software design and development, and a host of technical implementation issues.

While this study did not experience any major technical issues which could not be resolved, the process was not without some difficulties. For example, similar to McMahon and Luca's (2007) metacognitive project teamwork tool, the Metacog tool could not be implemented as early in the semester as planned due to delays with the programming. This resulted in eliminating using the tool for some elements of metacognitive regulation. Likewise, the tool was never tested with dialup Internet connections, and was also never tested on browsers beyond the most popular browsers at the time of implementation (Internet Explorer and Firefox). Finally, learners who had technical difficulty could not easily receive technical support in a distance education environment due to the custom nature of Metacog, different individual computer configurations, and a variety of learner background knowledge and self-efficacy with technology.

The issue is not trivial for tool researchers. Practically, troubleshooting even one learner technical issue could literally take hours to resolve. The possibility is also present, though it did not occur in this small exploratory study, for such issues to limit research findings, i.e., one small functionality difference due to browser versions might impact overall findings and conclusions regarding tool use. In hindsight, this kind of research might better be accomplished by a multidisciplinary team, rather than an individual researcher, with testing and technical support distributed across the group.

Evaluating Cognitive Tools

Finally, Robertson, Elliot, and Robinson (2007) suggest that the products of cognitive tools are complex. Assessing the impact of the tools requires a variety of approaches. The evaluation of metacognitive tools, like metacognition itself, is a multi-faceted thing. Evaluation can cover aspects including design, development, implementation, efficacy, and efficiency. Evaluating Metacog , as well as assessing its products, can be guided by several conclusions of this study. In turn, these can guide future researchers and designers.

Perspective Change

The goal of using debate as a collaborative instructional method was to force learners to consider multiple perspectives in their thinking about the cognitive science domain knowledge they were studying. The findings suggest, however, that Metacog did not lead to significant perspective change based on this debate, for reasons discussed earlier including lack of any debate, preference for discussion and idea sharing over debate, and lack of knowledge about how to debate.

Even for those conversations that did involve debate, however, learners still claimed they did not actually change their perceptions. Instead the two learners in the dyad agreed to disagree, while both continued to hold to their initial beliefs. While debate may or may not be useful as an instructional method in future versions of Metacog, it is questionable whether perception change even needs to be considered as a criterion for success in the use of metacognitive tools. If the process of considering multiple perspectives and being metacognitively aware of that strategy is the goal of the tool, this could be assessed without actually looking for perspective change as an end result. Other instructional objectives (e.g., drug awareness education) may well strive for perspective change, but it does not need to be a necessary element or outcome in metacognitive tools.

Future Classroom Practices Inspiration

The teachers who used Metacog said they would implement metacognitive instruction into their own classrooms in a variety of ways. For example, many indicated they would use some variation of the metacognitive questions in their own lessons. While reaching audiences beyond the learners (who were teachers) in this course was not a stated initial goal of the use of

Metacog, it is a welcome outcome and strongly suggests the effectiveness of the tool for facilitating the learning of metacognitive knowledge and regulation. It is unlikely that the teachers would implement instruction in their classrooms that they did not understand and look favorably upon. Future research will need to determine how non-teacher audiences would relate to the tool. Finally, the enthusiasm for Metacog as an example of education in metacognition demonstrates an appreciation for such education by practicing teachers. This is discussed more in depth later in this chapter.

Internalization

This exploratory qualitative study was not designed to precisely measure the effectiveness of the Metacog tool on student learning in metacognitive knowledge and regulation; indeed such measurement is difficult (Sternberg, 2009; Schraw & Impala, 2000; Brown, 1987). But of course, student learning is the end goal of any instructional metacognitive tool.

Solomon (1988) outlined five steps for the internalization of a cognitive tool. The final step "entails processes of mindful abstraction, that is, deliberate, effortful and metacognitively guided decontextualization of a principle, main idea, strategy, concept or rule" (Salomon, 1988, p. 8). The findings in this study offer some tentative support that the Metacog tool was internalized by learners. Learners who used the tool reported that after a short exposure time to the tool, they began either explicitly or implicitly applying the metacognitive questions to their readings. As one learner commented:

> …at first I was a little like I don’t have time for this and then I just go through there and I do it but then right there towards the end I noticed maybe toward the last two weeks when we were doing it I was, I was asking myself those questions as I was reading and I

was like, oh, that's why we're doing this cuz I'm teaching myself.

The positive comments such as this, however, must be tempered with at least one caveat. Strategy learning in general is a thoroughly researched topic, and it is well known from early research (e.g., Flavell, 1977) to the present that students who have already learned a particular domain strategy may not actually use it, even under conditions where its use would be most appropriate. This finding likely applies to metacognitive strategy use as well. Learners who reported transferring use of the metacognitive questions during the study may well have failed to keep using the strategy after the study concluded. Future research will need to determine the lasting positive effects of metacognitive tools such as Metacog.

Metacognition Education

The teachers in these courses were not neophytes. The large majority of the group had a bachelor level and/or graduate level education in the field of teaching. Yet, nearly one-quarter of the teachers indicated a lack of prior knowledge of metacognition. This is consistent with earlier survey research where Arabsolghar & Elkins (2001) found that more than 20% of teachers said they had not been taught about metacognition. Given the present stature of metacognition in educational theory and research, however, the lack of prior knowledge in this study was surprising.

It might also be the case that some of the learners would eventually learn about metacognition in a future course. While metacognition was featured in the course readings for the course which was the context for this study, metacognition is normally not a major focus of the course.

It may also be the case that the teachers learned about metacognition under some other term such as study skills, critical thinking, self-regulation, or learning strategies (among others).

Metacognition is a blanket term that covers many areas, or at least has been used to mean a variety of things related to education. The teachers' relatively high scores on the MAI indicate that while they may not have been familiar with the term, they reported that they engaged in metacognitive practices themselves.

Finally, it could be the case that the teachers had the metacognitive knowledge (as learners) as measured by the MAI, but the knowledge was not applied in their teaching settings. This is consistent with the finding that pre-service teachers rarely apply their knowledge of metacognition (Thomas & Barksdale-Ladd, 2000). Flavell (1977) spoke of mediational deficiency when a learning strategy is not applied in an appropriate context even when knowledge of the strategy was present.

Even those teachers who had knowledge of metacognition, and reportedly used metacognitive strategies in their roles as graduate students, admitted that their knowledge was fuzzy at best and their skills at incorporating those strategies into instruction were lacking. Teachers said that in their prior coursework, metacognition had been mentioned as important, briefly discussed, and then left behind. There was no concerted effort to have students design metacognitive practices into their instructional activities, much less use metacognitive tools in those activities.

This suggests a need for more theoretical and applied education about metacognition for teachers. This is a theme that has been echoed before (Lifford, Byron & Ziemian, 2000; Ciariello, 1998; Shelley & Thomas, 1996). It is one thing to say "Monitoring is very important for your students," and quite another to provide teachers with concrete tools and training to achieve improved monitoring in their students.

Further, any education involving metacognition, especially involving technology (as in the case with Metacog), must meet the needs of teachers or they will not accept it. Teacher resistance to change and technology has been documented from the educational use of radio (Cuban, 1986) to virtual worlds (Desiderio et al., 2009). The uneven responses to the use of Metacog are a testament to this truism.

Metacognition as a Useful Construct in Education

Although a surprisingly large minority of the teachers in this study were not very familiar with metacognition, the majority had some familiarity with the term. For those who had some prior knowledge about the term, the range of ideas was consistent with the literature. The teachers mentioned such phrases and terms as "thinking about thinking," learning strategies, planning, monitoring, regulating, reflecting, and evaluating. No one was completely incorrect in their understanding of metacognition.

The variety of responses and the need to acknowledge some correctness in each of them, however, indicates that the term metacognition may have lost its usefulness for not only researchers, but as importantly, practitioners. A term that can mean just about anything learning-related lacks the specificity needed to either guide theory and research, or to allow teachers to effectively communicate best practices. It is ironic that Flavell (1977), the intellectual father of metacognition, spends a chapter of his seminal textbook *Cognitive Development* illuminating for students the challenges faced by psychologists in conceptualizing and assessing a mental construct in their field of study. The problem of the murkiness of metacognition has been acknowledged repeatedly throughout the more than quarter century of research (Brown, 1987; Schoenfeld, 1992; Borkowski, Chan, & Muthukrishna, 2000; Zohar & David, 2009), and the findings from this study suggest the issue has not subsided.

Perhaps a more fruitful path would be to study and use in practice the terms for various components of metacognition that have been better operationalized. For example, knowledge about memory, self-efficacy, accuracy in judgments of learning, and monitoring are constructs that have been productively studied over the years both independently and in the context of the overarching idea of metacognition. Of course, this is not to say that big messy ideas like metacognition are not worthy of study; instead the argument is that overused and amorphous terms create inefficiencies in research and practice. Specificity would be more productive. Indeed, the most recent comprehensive metacognition research (e.g., Dunlosky &Metcalfe, 2009) seems to takes this approach with separate emphases on such phenomena as feelings of knowing, judgments of learning, confidence judgments, and source judgments.

It is also worth noting that earlier metacognitive research focused on both the regulation *and* knowledge (learning strategy use) components of metacognition. The latest compendiums of theory and research seem to focus on one aspect or the other. For example, the Dunlosky and Metcalfe (2009) textbook mentioned above emphasizes the former. On the other hand, *Metacognition, Strategy Use, and Instruction* (2010), as the title conveys, focuses on the latter. Likewise, the *Handbook of Metacognition in Education* (2009) also leans heavily towards featuring metacognitive knowledge. It appears that the shift to the use of specific terms, as well as a long recommended distinction between metacognitive components is occurring at least somewhat. Future "metacognitive" tools such as Metacog with a strong focus on learning strategies might well be designed and studied starting with literatures beyond metacognition.

Chapter 5 Summary

This chapter offered several conclusions related to the findings of this study. Conclusions were offered for the use of metacognitive tools in a social supportive online learning environment, with a particular focus on the cognitive tool literature. Tool improvement ideas and future research ideas were suggested as appropriate in several areas: the variety of tools that can be used with different cognitive processes, meaningful engagement, scaffolding, intended and unintended uses by learners, technical issues, and the overall evaluation of cognitive tools, including learner internalization. After this, several broader conclusions were considered regarding metacognition education for teachers, and the viability of the construct of metacognition itself.

References

Afflerbach, P. & Cho, B. (2010). Determining and describing reading strategies: Internet and traditional forms of reading. In H.S. Waters, H.S. & W. Schneider (Eds.). *Metacognition, strategy use, & instruction*. (pp. 201-225). New York, NY: Guilford Press.

Alexander, P., Schallert, D., & Hare, V. (1991). Coming to terms: How researchers in learning and literacy talk about knowledge. *Review of Educational Research, 61*, 315-343.

American Psychological Association. (1997). *Learner-centered psychological principles: A framework for school redesign and reform*. Retrieved September 15, 2006, from http://www.apa.org/ed/lcp2/lcp14.html

Aleven, V., McClaren, B., Roil, I., & Koedinger, K. (2006). Towards metacognitive tutoring: A model of help-seeking with a cognitive tutor. *International Journal of Artificial Intelligence in Education, 16*, 101-130.

Anderson-Levitt, K. M. (2006). Ethnography. In J. L. Green, G. Camilli & P. B. Elmore (Eds.), *Handbook of complementary methods in education research* (pp. 279-296). Mahwah, NJ: Lawrence Erlbaum Associates.

Angeli, C., & Cunningham, D. J. (1998). Bubble dialogue: Tools for supporting literacy and the mind. In C. J. Bonk & K. S. King (Eds.), *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse* (pp. 81-101). Mahwah, NJ: Lawrence Erlbaum Associates.

Arabsolghar, F. & Elkins, J. (2001). Teachers' expectations about students' use of reading strategies, knowledge and behavior in Grades 3, 5, and 7. *Journal of Research in Reading 24*, 154-62.

Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning:

The role of self-regulated learning. *Educational Psychology*, *40*(4), 199-209.

Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*(3), 523-535.

Azvedo, R. & Witherspoon, A.M. (2009). Self-regulated learning with hypermedia. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 320-338). New York, NY: Routledge.

Baker, L. (1994). Fostering metacognitive development. In H. Reese (Ed.), *Advances in child development and behavior* (Vol. 25, pp. 201-239). San Diego: Academic Press.

Baker, L., & Cerro, L. C. (2000). Assessing metacognition in children and adults. In G. Schraw & J. C. Impara (Eds.), *Issues in the Measurement of Metacognition* (pp. 99-145). Lincoln: Buros Institute of Mental Measurements (University of Nebraska).

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Barab, S. A., Barnett, M., Yamagata-Lynch, L., Squire, K., & Keating, T. (2002). Using activity theory to understand the systemic tensions characterizing a technology-rich introductory astronomy course. *Mind, Culture, and Activity*, *9*(2), 76 - 107.

Barab, S. A., & Duffy, T. M. (2000). From practice fields to communities of practice. In D. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25-56). Mahwah, NJ: Lawrence Erlbaum.

Bell, P. (1997). Using argument representations to make thinking visible for individuals and groups. In *Proceedings of Computer Supported Collaborative Learning '97* (pp. 10-19). Toronto.

Bereiter, C., & Scardamalia, M. (1998). Beyond Bloom's Taxonomy: Rethinking knowledge for the Knowledge Age. In *International handbook of educational change* (pp. 675-692). Dordrecht: Kluwer.

Berg, B. L. (2004). *Qualitative research methods for the social sciences*. Boston: Pearson.

Biswas, G., Leelawong, K., Schwartz, D., & TAGV (2005). Learning by teaching: A new agent paradigm for educational software. *Applied Artificial Intelligence, 19*, 363-392.

Blackboard Academic Suite [Electronic. (2007). Version], Retrieved May 6, 2008, from http://www.blackboard.com/products/Academic_Suite/index

Borkowski, J. G., Chan, L. K. S., & Muthukrishna, N. (2000). A process-oriented model of metacognition: links between motivation and executive functioning. In G. Schraw & J. C. Impara (Eds.), *Issues in the Measurement of Metacognition* (pp. 1-43). Lincoln: Buros Institute of Mental Measurements (University of Nebraska).

Bransford, J.D., Brown, A.L., & Cocking, R.R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.

Bransford, J. D., Goldman, S. R., & Vye, N. J. (1991). Making a difference in people's ability to think: reflections on a decade of work and some hopes for the future. In R. J. Sternberg & L. Okagaki (Eds.), *Influences on children* (pp. 147-180). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Briggs, D. C. (2008). Comment on Slavin: Synthesizing Causal Inferences. *Educational Researcher*, *37*(1), 15-22.

Brint, S. (2001). *Gemeinschaft* revisited: A critique and reconstruction of the community concept. *Sociological Theory, 19*(1), 1-23.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, NJ: Erlbaum.

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In J. H. Flavell & E. M. Markman (Eds.), *Handbook of child psychology* (4th ed., Vol. III: Cognitive development pp. 77–166). New York: Wiley.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). London: MIT Press.

Brown, A. L., & Campione, J. C. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. S. R. Glaser (Ed.), *Innovation in learning: New environments for education* (pp. 289-325). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Bruer, J. T. (1993). *Schools for thought: A science of learning in the classroom*. Cambridge, MA: MIT Press.

Brush, T., & Saye, J. (2000). Implementation and evaluation of a student-centered learning unit: A case study. *Educational Technology Research and Development, 48*(3), 79–100.

Bull, S., Greer, J., & McCalla, G. (2003). The caring personal agent. *International Journal of Artificial Intelligence in Education, 13*, 21-34.

Butterfield, E. C., Alberston, L. R., & Johnston, J. C. (1995). On making cognitive theory more general and developmentally pertinent. In F. E. Weinert & W. Schneider (Eds.), *Memory performance and competencies: Issues in growth and development* (pp. 181-206). Hillsdale, NJ: Erlbaum.

Byrd, D. M., & Gholson, B. (1985). Reading, memory, and metacognition. *Journal of Educational Psychology, 77*, 428-436.

Cavanaugh, J. C., & Perlmutter, M. (1982). Metamemory: A critical examination. *Child Development*, *53*(11–28).

Chi, M.T.H., Glaser, R., & Farr, M.J. (Eds.) (1988). *The nature of expertise.* Hillsdale, NJ: Erlbaum.

Chiazzese, G., Ottaviano, S., Merlo, G., Chiari, A., Allegra, M., Seta, L., & Todaro, G. (2006). Surfing hypertexts with a metacognition tool. *Informatica, 30*, 439-445.

Ciardiello, A.V. (1998). Did you ask a good question today? Alternative cognitive and metacognitive strategies. *Journal of Adolescent & Adult Literacy, 42*, 210-19.

Clements, D.H., & Nastasi, B.K. (1988). Social and cognitive interactions in educational computer environments. *American Educational Research Journal*, 25, 87-106.

Clements, D. H., and Nastasi, B. K. (1999). Metacognition, learning, and educational computer environments. *Information Technology in Childhood Education Annual*. 1, 5-38.

Clifford, M. M. (1986). The comparative effects of strategy and effort attributions. *British Journal of Educational Psychology, 56,* 75-83.

Cognition and Technology Group at Vanderbilt (CTGV). (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19*(6), 2-10.

Cooney, D. H. (1998). Sharing aspects within ASPECTS: Real-time collaboration in the high school English classroom. In C.J. Bonk & K.S. King (Eds.), *Electronic collaborators:*

Learner-centered technologies for literacy, apprenticeship, and discourse (pp. 263-287). Mahwah, NJ: Lawrence Erlbaum Associates.

Costa, A. L. (1984). Mediating the metacognitive. *Educational Leadership, 42*(7), 57–62.

Cuban, L. (1986). *Teachers and Machines: The Classroom Use of Technology Since. 1920*. New York: Teachers College Press.

Curtis, S., Gesler, W., Smith, G., & Washburn, S. (2000). Approaches to sampling and case selection in qualitative research: Examples in the geography of health. *Social Science and Medicine* (50), 1001-1014.

Desiderio, A.C., Vitale, V., Piccolo, V., Esposito, G., & Faiella, F. (2009). Teaching in virtual worlds: educational experiences in Second Life. *Journal of e-Learning and Knowledge Society*, *5*(2), 87 – 93.

Dettori, G., Gianetti, T., & Persico, D. (2006). SRL in online cooperative learning: Implications for pre-service teacher training. *European Journal of Education, 41*(3-4), 399-414.

Dobrovolny, J. L. (2001). *Corporate training: Strategies adults use to learn from self-paced, technology-based training.* Unpublished Dissertation, University of Colorado, Denver.

Duffy, T.M., & Savery, J.R. (1994). Problem-based learning: An instructional model and its constructivist framework. In Brent G. Wilson (Ed.) *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs, NJ: Educational Technology Publications. [EJ 512 183]

Duignan, M., Noble, T., & Biddle, R. (2006). Activity theory for design: From checklist to interview. In T. Clemmensen, P. Campos, R. Omgreen, A. Petjersen & W. Wong (Eds.), *Human work interaction design: Designing for human work* (Vol. 221, pp. 1-25). Boston: Springer.

Dunlosky, J., & Metcalfe, J. (2009). *Metacognition.*Los Angeles, CA: Sage.

Dunlosky, J., Hertzog, C., Kennedy, M., & Thiede, K. (2005). The self-monitoring approach for effective learning. *Cognitive Technology, 9*, 4-11.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit Oy.

Engeström, Y. (1999). Introduction. In Y. Engeström, R. Miettinen & R. L. Punamaki (Eds.), *Perspectives on activity theory* (pp. 1-16). Cambridge: Cambridge University Press.

Ericsson, K.A., & Lehmann, A.C. (1996). Expert and exceptional performance: Evidence on maximal adaptations on task restraints. *Annual Review of Psychology*, *47*, 273-305.

Henning, E. (2003). ‘I click, therefore I am (not)’: Is cognition ‘distributed’ or is it ‘contained’ in borderless e-learning programmes? *International Journal of Training and Development 7*(4), 303-317.

Inaba, M. (2006). *A CSCL environment that promotes metacognition among learners in the community of practice.* Paper presented at the 5th International Conference of the Cognitive Science, Vancouver, British Columbia, Canada.

Flavell, J. (1971). First discussant’s comments: What is memory development the development of? *Human Development, 14,* 272-278.

Flavell, J. (1976). Metacognitive aspects of problem solving. In L. Resnick (Ed.), *The nature of intelligence* (pp. 231-236). Hillsdale, NJ: Erlbaum.

Flavell, J. H. (1977). *Cognitive development*. Englewood Cliffs, NJ: Prentice-Hall.

Flavell, J. (1979). Metacognition and cognitive monitoring: A new area of cognitive development inquiry. *American Psychologist, 34*, 906-911.

Flavell, J. H., Miller, P. H., & Mller, S. A. (2002). *Cognitive development* (4th ed.). Upper

Saddle River, New Jersey: Pearson Education, Inc.

Flavell, J. H., & Wellman, H. M. (1977). Metamemory. In J. R. V. Kalil & J. W. Hagen (Eds.), *Perspectives on the development of memory and cognition* (pp. 3-33). Hillsdale, NJ: Erlbaum.

Fletcher, J. D. (1996). *Does this stuff work? Some findings from applications of technology to education and training.* Paper presented at the Conference on Teacher Education and the Use of Technology Based Learning Systems, Warrenton, VA.

Forsyth, D. R. (1998). *Group Dynamics* (3rd ed.). Belmont, CA: Wadsworth Publishing.

Fosnot, C. T. (1996). Constructivism: A psychological theory of learning. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice*. New York: Teachers College Press.

Garcia, T., & Pintrich, P. R. (1994). Regulating motivation and cognition in the classroom: The role of self-schemas and self-regulatory strategies. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 127-153). Hillsdale, NJ: Lawrence Erlbaum Associates.

Garner, R. (1987). *Metacognition and reading comprehension*. Norwood, NJ: Ablex.

Garrison, R., Anderson, T. & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education, *The Internet and Higher Education, 2 (2-3)*, pp. 87-105.

Gay, G. (2002). The nature of metacognition. Retrieved September 15, 2006, from http://www.ldrc.ca/contents/view_article/146/

Goetz, J. P., & LeCompte, M. D. (1982). Problems of reliability and validity in ethnographic research. *Review of Educational Research, 52*(1), 31-60.

Gredler, M. E. (2001). *Learning and instruction: Theory into practice* (4th ed.). Upper Saddle River, NJ. : Prentice-Hall.

Hacker, D. J., Dunlosky, J., & Graesser, A. C. (Eds.) (1998). *Metacognition in educational theory and practice*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Hacker, D. J., Dunlosky, J., & Graesser, A. C. (Eds.) (2009). *Handbook of metacognition in education*. New York, NY: Routledge.

Harada, V. H. (2001). Personalizing the information search process: A case study of journal writing with elementary-age students [Electronic Version]. *School Library Media Research*, *5*. Retrieved May 1, 2008, from www.ala.org/ala/aasl/aaslpubsandjournals/slmrb/slmrcontents/volume52002/harada.cfm

Haythornwaite, C., Kazmer, M., Robins, J., & Shoemaker, S. (2000). Community development among distance learners: Temporal and technological dimensions. *Journal of Computer-Mediated Communication, 6*(1).

Hill, J. (1995). *Cognitive strategies and the use of a hypermedia information system: An exploratory study.* Unpublished Dissertation, The Florida State University, Tallahassee.

Hofer, B. (2002). Personal epistemology as a psychological and education construct: An introduction. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 3-14). Mahwah, NJ: Erlbaum.

Hyysalo, S. (2005). Objects and motives in a product design process. *Mind, Culture, and Activity, 12*, 19-36.

Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist, 22*, 255-278.

Jarvenpaa, S., & Leidner, D. (1999). Communication and trust in global virtual teams.

Organization Science, 10(6), 791-815.

Kaptelinin, V. (1996). Distribution of cognition between minds and artifacts: Augmentation or mediation. *AI and Society, 10,* 15-25.

Kaptelinin, V., & Nardi, B. A. (2006). *Acting with technology: Activity theory and interaction design*. Cambridge, Massachusetts: MIT Press.

Kaptelinin, V., Nardi, B. A., & Macauley, C. (1999). The activity checklist: A tool for representing the “space” of context. *Interactions 6*(4), 27-39.

Kling, R., & Courtright, C. (2004). Group behavior in electronic forums. In S. A. Barab, R. Kling & J. H. Gray (Eds.), *Designing for virtual communities in the service of learning*. New York: Cambridge University Press.

Kollack, P. (1998). Design principles for online communities. *PC Update 15*(5), 58-60.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review, 103,* 490-517.

Krathwohl, D. R. (1998). *Methods of educational and social science research: An integrated approach.* (2nd ed.). New York: Addison-Wesley.

Kurdek, L. A., & Burt, C. W. (1981). First- through sixth-grade children's metacognitive skills: Generality and cognitive correlates. *Merrill-Palmer Quarterly, 27,* 287-

Lajoie, S. P. (1993). Computer environments as cognitive tools for enhancing learning. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 261-288). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Land, S. M., & Hannafin, M. (1997). Patterns of understanding with open-ended learning environments: a qualitative study. *Educational Technology Research and Development, 45*(2), 47–73.

Lave, J. (1993). *Understanding practice.* New York: Cambridge University Press.

Leontiev, A. N. (1981). *Problems in the development of the mind*. Moscow: Progress Publishers.

Leontiev, D. (1993). Sense-system nature and functions of the motive. *Vestnik MGU. Serija 14. Psikhologija*(2), 73-81.

Levin, J. and Cervantes, R. (2002). Understanding the life cycles of network-based communities. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. 269-292). Mahwah, NJ: Lawrence Erlbaum Associates.

Lifford, J., Byron, B.E. & Ziemian, J. (2000). Reading, responding, and reflecting. *English Journal*, *89*, 46-57.

Lin, X. (2001). Designing metacognitive activities. *Educational Technology Research & Development*, *49*(2), 23-40.

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Liu, M., Bera, S., Corliss, S.B., Svinicki, M.D., Beth, A.D. (2004). Understanding the connection between cognitive tool use and cognitive processes as used by sixth graders in a problem-based hypermedia learning environment. *Journal of Educational Computing Research*, *31*(3), 309-334.

Maki, R. H., & McGuire, M. J. (2002). Metacognition for text: Findings and implications for education. In T. J. Perfect & B. L. Schwartz (Eds.), *Applied metacognition* (pp. 39-67). Cambridge, UK: Cambridge University Press.

Markman, E. M. (1977). Realizing that you don't understand: A preliminary investigation. *Child Development, 48,* 986–992.

Marshall, K., & Rossman, G. B. (1995). *Designing qualitative research* (2nd ed.). Thousand Oaks, California: Sage Publications.

Marshall, K., & Rossman, G. B. (1999). *Designing qualitative research* (3rd ed.). Thousand Oaks, California: Sage Publications.

Mason, J. (2002). *Qualitative researching* (2nd ed.). London, UK: Sage Publications.

Matlin, M.W. (2009). *Cognition.*(7th ed.). Hoboken, NJ: John Wiley & Sons, Inc.

Mayer, R. E. (2004). Teaching of subject matter. *Annual review of psychology, 55*, 715-744.

McCombs, B. L., & Vakili, D. (2005) A learner-centered framework for e-learning. *Teachers College Record*, *107*(8), pp. 1582–1600.

McCormick, C. B. (2003). Metacognition and learning. In W. M. Reynolds & G. E. Miller (Eds.), *Handbook of psychology* (Vol. *7: Educational Psychology*, pp. 79-102). Hoboken, NJ: Wiley.

McGregor, J. (1993). Cognitive processes and the use of information. *School Library Media Annual*, *12*, 124–133.

McMahon, M & Luca, J. (2007). Explorations in metacognition: The design, development, and implementation of an online teamwork-tracking environment. In *ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007*. Retrieved December, 2009 from: http://www.ascilite.org.au/conferences/singapore07/procs/mcmahon.pdf

McNamara, D. S., & Magliano, J. P. (2009). Self-explanation and metacognition: The dynamics of reading. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 261-281). New York, NY: Routledge.

McNamara, D. S., & Shapiro, A. M. (2005). Multimedia and hypermedia solutions for promoting metacognitive engagement, coherence, and learning. *Journal of Educational Computing Research*, *33*, 1-29.

Metacognition and Learning. Retrieved September 25, 2006, from http://www.springer.com/west/home/education?SGWID=4-40406-70-52589151-0

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Moreno, R. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback on discovery-based multimedia. *Instructional Science: Special Issue on Cognitive Load Theory*, 32, 99-113.

Murphy, E., & Rodriguez-Manzanares, M.A. (2008). Using activity theory and its principles of contradictions to guide research in educational technology. *Australasian Journal of Educational Technology, 24*(4), 442-457. Retrieved November 28, 2009 from http://www.ascilite.org.au/ajet/aject24/murphy.html

Mwanza, D. (2001). Where theory meets practice: A case for an activity theory based methodology to guide computer system design. In M. Hirose (Ed.), *Proceedings of INTERACT'2001: Eighth IFIP TC 13 International Conference on Human-Computer Interaction, Tokyo, Japan, July 9-13, 2001*.

Nastasi, B.K., Clements, D.H., & Battista, M.T. (1990). Social-cognitive interactions, motivation, and cognitive growth in Logo programming and CAI problem-solving environments. *Journal of Educational Psychology* (82), 150-158.

Nesbit, J.C., & Winne, P.H. (2007). Tools for learning in an information society. In T. Willoughby & E. Wood (Eds.), *Children's learning in a digital world* (pp. 173-195). Oxford, UK: Blackwell Publishing.

Nelson, T. (1996). Consciousness and metacognition. *American Psychologist, 51*, 102-116.

Nelson, C. P., & Kim, M. K. (2001). Contradictions, appropriation, and transformation: An activity theory approach to L2 writing and classroom practices. *Texas Papers in Foreign*

Language Education, *6*(1), 37-62.

Nelson, T.O. & Naren, L. (1990). Metamemory: A theoretical framework and some new findings. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 26, pp. 125-173). San Diego, CA: Academic Press.

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*, 328-346.

Nolan, D. J., & Weiss, J. (2002). Learning in cyberspace: an educational view of virtual community. In K. A. Renniger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. 61-95). Mahwah, NJ: Lawrence Erlbaum Associates.

Novak, J. (1999). The theory underlying concept maps and how to construct them [Electronic Version]. Retrieved April 1, 2008, from http://cmap.coginst.uwf.edu/info/printer.html

Oliver, K., & Hannafin, M. J. (2000). Student management of web-based hypermedia resources during open-ended problem-solving. *The Journal of Educational Research*, *94*, 75-92.

Osman, M. E., & Hannafin, M. J. (1992). Metacognition research and theory: Analysis and implications for instructional design. *Educational Technology Research & Development*, *40*(2), 83-99.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. New York: Cambridge University Press.

Ozhegov, S. (1982). *Slovar russkogo yazyka, 14-e izdanie.* [Dictionary of the Russian Language. 14th Edition]. Moscow: Russia Yazyk. (In Russian)

Palinscar, A. S. (1986). Metacognitive strategy instruction. *Exceptional Children*, *53*(2), 118–124.

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*(2), 117-175.

Palinscar, A. S., & Ransom, K. (1988). From the mystery spot to the thoughtful spot: The instruction of metacognitive strategies. *The Reading Teacher, 41*(8), 784–789.

Palloff, R. M., & Pratt, K. (1999). *Building learning communities in cyberspace: Effective strategies for the online classroom*. San Francisco, CA: Jossey-Bass.

Paris, S. G., & Winograd, P. (1990). How metacognition can promote learning and instruction. In B. J. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 15-51). Hillsdale, NJ: Erlbaum.

Paris, S. G., Lipson, M., & Wixson, K. (1983). Becoming a strategic reader. *Contemporary Educational Psychology, 8*, 293-316.

Paris, S. G., & Winograd, P. (1990). How metacognition can promote learning and instruction. In B. J. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 15-51). Hillsdale, NJ: Erlbaum.

Pea, R. (1985). Beyond amplification: Using computers to reorganize mental functioning. Educational Psychologist, 20 (4), 167-182.

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). Assessing metacognition and self-regulated learning. In G. Schraw & J. C. Impara (Eds.), *Issues in the Measurement of Metacognition* (pp. 44-97). Lincoln: Buros Institute of Mental Measurements (University of Nebraska).

Pressley, M., Forrest-Pressley, D. L., Elliott-Faust, D. J., & Miller, G. E. (1985). Children's use of cognitive strategies, how to teach strategies, and what to do if they can't be taught. In

M. Pressley & J. Brainerd (Eds.), *Cognitive learning and memory in children*. New York: Springer-Verlag.

Quintana, C., Zhang, M., & Krajcik, J. (2005). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist, 40*(4), 235-244.

Reed, S. (2004). *Cognition: Theories and applications* (6th ed.). Belmont, CA: Wadsworth Publishing.

Reiser, B. J., Tabak, I., Sandoval, W. A., Smith, B., Steinmuller, F., Leone, T. J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms. In S.M. Carver & D. Klahr (Eds.), *Cognition and Instruction: Twenty five years of progress*. Mahwah, NJ: Erlbaum.

Reid, M. K., & Borkowski, J. G. (1987). Causal attributions of hyperactive children: implications for training strategies and self-control. *Journal of Educational Psychology, 79*, 296-307.

Renkl, A., Mandl, H., & Gruber, H. (1996). Inert knowledge: Analyses and remedies. *Educational Psychologist, 31*(2), 115-121.

Renninger, K. A., & Shumar, W. (2002). Community building with and for teachers at The Math Forum. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. 61-95). Mahwah, NJ: Lawrence Erlbaum Associates.

Renninger, K. A., & Shumar, W. (2002). Preface and acknowledgments. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. xvii-xx). Mahwah, NJ: Lawrence Erlbaum Associates.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13-20.

Riel, M. (1993). Learning circles: Virtual communities for elementary and secondary schools.

Retrieved December 10, 2007, from lrs.ed.uiuc.edu/guidelines/Riel-93.html

Roberts, M.J. (Ed.).(2007). *Integrating the mind: Domain general versus domain specific processes in higher cognition.* New York: Psychology Press.

Robertson, B., Elliot, L., & Robinson, D. (2007). Cognitive tools. In M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology. Retrieved January 16, 2010, from http://projects.coe.uga.edu/epltt/

Roschelle, J. (1996). Designing for cognitive communication: Epistemic fidelity or mediating collaborative inquiry? In D.L. Day & D.K. Kovacs (Eds.), *Computers, communication and mental models* (pp. 15-25). Boca Raton, FL: CRC Press.

Salomon, G. (1988). AI in reverse: Computer tools that become cognitive. *Journal of Educational Computing Research, 11*, 623-637.

Savery, J. R. (1998). Fostering ownership for learning with computed-supported collaborative writing in an undergraduate business communication course. In C. J. Bonk & K. S. King (Eds.), *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse* (pp. 81-101). Mahwah, NJ: Lawrence Erlbaum Associates.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *Journal of the Learning Sciences, 1*, 37-68.

Schoenfeld, A. H. (1988). Problem solving in context(s). In R. Charles & E. A. Silver (Eds.), *The teaching and assessing of mathematical problem solving* (pp. 82-92). Hillsdale, NJ: Erlbaum.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 334-370). New York: MacMillan.

Schooler, J. W., Reichle, E. D., & Halpern, D. V. (2004). Zoning out while reading: Evidence for dissociations between experience and metaconsciousness In D. T. Levin (Ed.), *Thinking and seeing: Visual metacognition in adults and children* (pp. 204-226). Cambridge, MA: MIT Press.

Schraw, G. (2009). Measuring metacognitive judgments. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 415-429). New York, NY: Routledge.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19,* 460-475.

Schraw, G., & Impara, J. C. (Eds.). (2000). *Issues in the Measurement of Metacognition*. Lincoln, NE: Buros Institute of Mental Measurements.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*, 351-371.

Schwartz, D.L., Chase, C., Chin, B., Oppezzo, M., Kwong, H., & Okita, S. (2009). Interactive metacognition: Monitoring and regulating a teachable agent. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 341-358). New York, NY: Routledge.

Schwartz, N. H., Andersen, C., Hong, N., Howard, B., & McGee, S. (2004). The influence of metacognitive skills on learners' memory of information in a hypermedia environment. *Journal of Educational Computing Research, 31*(1), 77-93.

Schwonke, R., Hauser, S., Nuckles, M. & Renkl, A. (2006). Enhancing computer-supportive writing of learning protocols by adaptive prompts. *Computers in Human Behavior*, 22, 77-92.

Shelly, A. C., & Paul, L. T. (1996). Using metacognitive strategies to enhance learning in the English classroom. *The New England Reading Association Journal, 32*, 3-6.

Siegler, R.S., & Alibali, M.W. (2005). *Children's thinking* (4th ed.). Upper Saddle River, NJ: Prentice-Hall.

Sternberg, R. (1985). *Beyond IQ*. Cambridge, MA: Cambridge University.

Sternberg, R. (2009). Foreword. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of metacognition in education* (pp. viii-ix). New York, NY: Routledge.

Strauss, A., & Glaser, B. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine.

Swanson, H. L. (2001). Research on interventions for adolescents with learning disabilities: A meta-analysis of outcomes related to higher order processing. *Elementary School Journal, 101*(3), 331-348.

Symons, S., Snyder, B. L., Caringly-Bull, T., & Pressley, M. (1989). Why be optimistic about cognitive strategy instruction? In C. B. McCormick, G. E. Miller & M. Pressley (Eds.), *Cognitive strategy research: From basic research to educational applications* (pp. 3-32). New York: Springer-Vela.

Thiede, K. & Dunlosky, J. (1999). Towards a general model of self-regulated study: An analysis for selection items and self-paced study time. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 1024-1037.

Thomas, K. F. & Barksdale-Ladd, M.A. (2000). Metacognitive processes: Teaching strategies in literacy education courses. *Reading Psychology*, *21*, 67-84.

van Bruggen, J.M., Kirschner, P.A., & Jochems, W. (2002). External representation of argumentation in CSCL and the management of cognitive load. *Learning and Instruction, 12*, 121-138.

Veenman, M. V., Hout-Wolters, B. H. V., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations *Metacognition and Learning*, *1*(1), 3-14.

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences, 15*, 159-176.

Vermin, A. 2000. Computer-supported collaborative learning through argumentation. Utrecht: Interuniversity Center for Educational Research. Retrieved October, 2009 from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.126.8518&rep=rep1&type=pdf

Vovides, Y. (2005). *Investigating learning from hypermedia via the implementation of a computer-based metacognition training regimen and hypermedia program.* Unpublished dissertation, University of Iowa.

Vovides, Y., Sanchez-Alonso, S., Mitropoulos, V. & Nicknames, G. (2006). The use of e-learning Course Management Systems to support learning strategies and to improve self-regulated learning. Retrieved February 13, 2008 from: http://www.cc.uah.es/ssalonso/papers/EducationalReviewDraft.pdf

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

Wallace, R. M., Superman, J., Krajcik, J., & Solo way, E. (2000). Science on the web: Students online in a sixth-grade classroom. *Journal of the Learning Sciences, 9*, 75-104.

Wang, M. C., Hearten, G. C., & Walberg, H. J. (1990). What influences learning? A content analysis of review literature. *Journal of Educational Research, 84*(1), 30-43.

Waters, H.S. & Schneider, W. (2010). *Metacognition, strategy use, & instruction*. New York, NY: Guilford Press.

Waters H.S., & Waters, T.E.A. (2010). Bird experts: A study of child and adult knowledge utilization. In H.S. Waters & W. Schneider, (Eds.), *Metacognition, strategy use, & instruction*. New York, NY: Guilford Press.

Weiner, B. (1984). Principles for a theory of student motivation and their application within an attributional framework. In R. E. Ames & C. Ames (Eds.), *Research on motivation in education* (Vol. 1, pp. 15-38). Orlando: Academic Press.

Wenger, E. (1987). *Artificial intelligence and tutoring systems.* Los Altos, CA: Morgan Kaufman.

Wenger, E. (1998). *Communities of practice*: *Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.

Wellman, B., & Guile, M. (1999). Net-surfers don't ride alone: virtual communities as communities. In B. Wellman (Ed.), *Networks in the global village: Life in contemporary communities*. Boulder, CO: West view.

White, B.Y. (1993). Thinker Tools: Causal models, conceptual change, and science education.

Cognition and Instruction, 10(1), 1-100.

White, B. Y., & Frederickson, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction, 16*, 3–118.

White, B. Y., Shimoda, T. A., & Frederiksen, J. R. (*1999*). Enabling students to construct theories of collaborative inquiry and reflective learning: Computer support for metacognitive development. *International Journal of Artificial Intelligence in Education, 10*, 151-182.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*(25), 68-81.

Wiggins, G. P., & McTighe, J. (2005). *Understanding by Design* (2nd ed.). Washington, DC: Association for Supervision and Curriculum Development.

Winne, P.H. & Hadwin, A. (1998). Studying as self-regulated learning. In D.J. Hacker, J. Dunlosky, & A.C. Graesser, (Eds.), *Metacognition in educational theory and practice* (pp. 277-304). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Winne, P.H. & Hadwin, A. (2008). The weave of motivation and self-regulated learning. In D. Schunk & B. Zimmerman, (Eds.), *Motivation and self-regulated learning: Theory, research, and application* (pp. 297-314). New York, NY: Taylor & Francis.

Winne, P. H. & Nesbit, J.C. (2009). Supporting self-regulated learning with cognitive tools. In D.J. Hacker, J. Dunlosky, & A.C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 259-275). New York, NY: Routledge.

Witherspoon, A., Azevedo, R., Greene, J.A., Moos, D.C., & Baker, S. (2007). The dynamic nature of self-regulatory behavior in self-regulated and externally-regulated learning episodes. In R. Luckin, K. Koedinger, & J. Greer (Eds.), *Artificial intelligence in education: Building technology rich learning contexts that work* (pp. 179-186). Amsterdam, The Netherlands: IOS Press.

Wolf, S., Brush, T., & Saye, J. (2003). The Big Six information skills as a metacognitive scaffold: A case study. *School Library Media Research, 6*.

Yin, R. K. (2006). Case study methods. In J. L. Green, G. Camilli & P. B. Elmore (Eds.), *Handbook of Complementary Methods in Education Research*. Mahwah, NJ: Lawrence Erlbaum Associates.

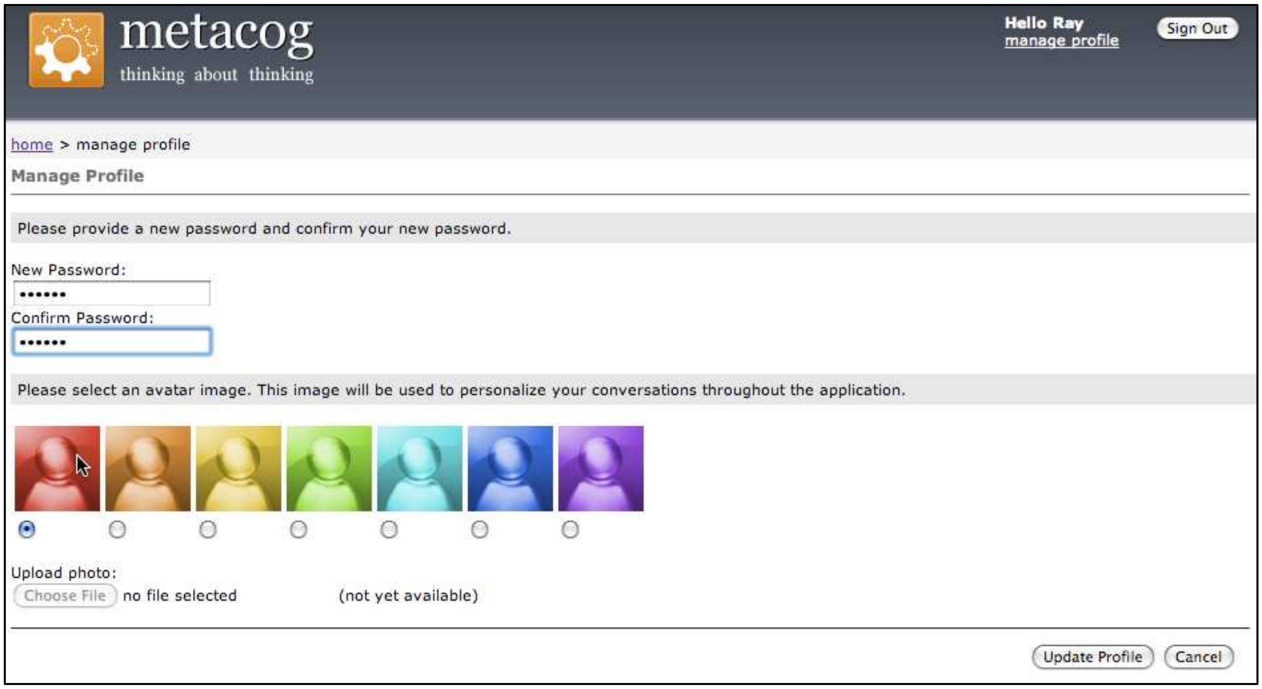
Yuen, J. (2009) Fostering collaborative knowledge building through advancing students' personal epistemology. In *Proceedings of the 9th international conference on computer supported collaborative learning* - *Volume 2*, 273-275.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39). New York: Academic Press.

Zohar, A. & David, A. B. (2009). Paving a clear path in a thick forest: A conceptual analysis of a metacognitive component. *Metacognition and Learning*, 4 (3), 177 – 195.

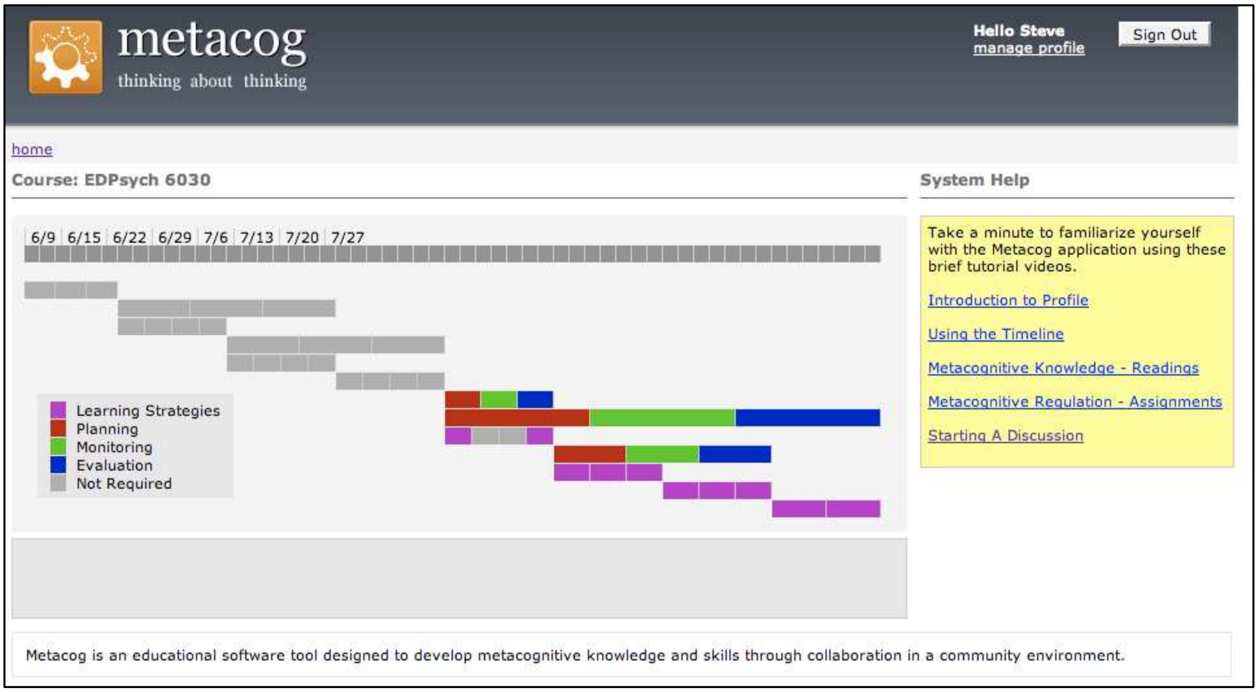
Appendix A

Metacog: Login and Profile Screen



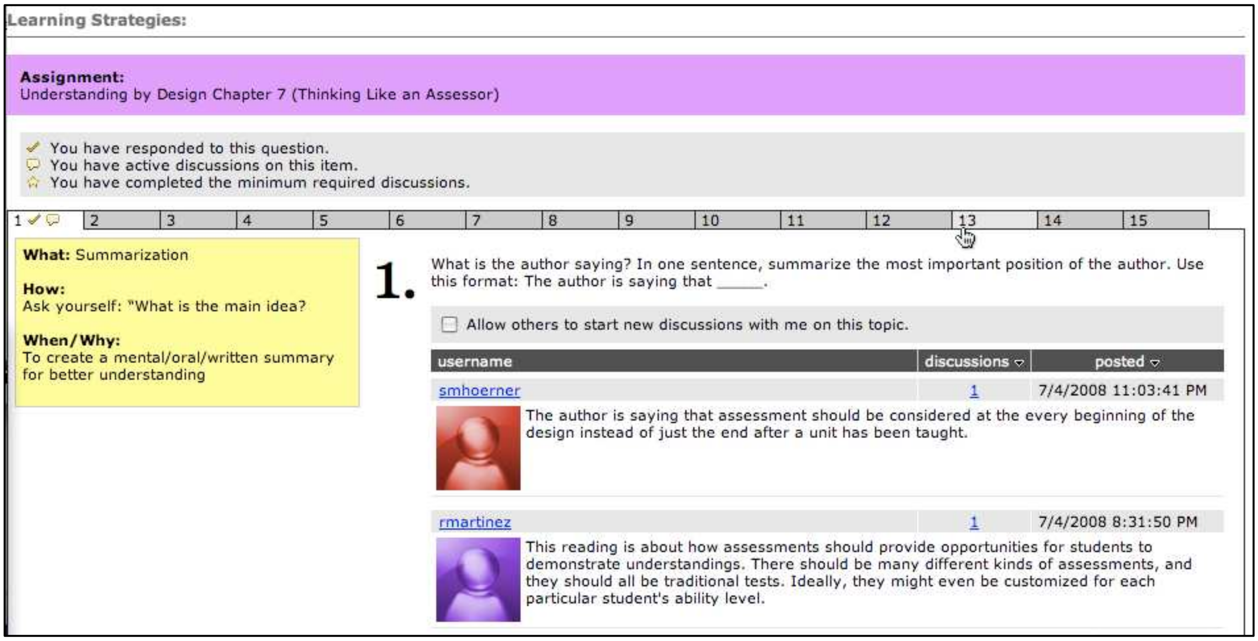
Appendix A

Metacog: Main Start Screen, Assignment Timeline, and Help Videos



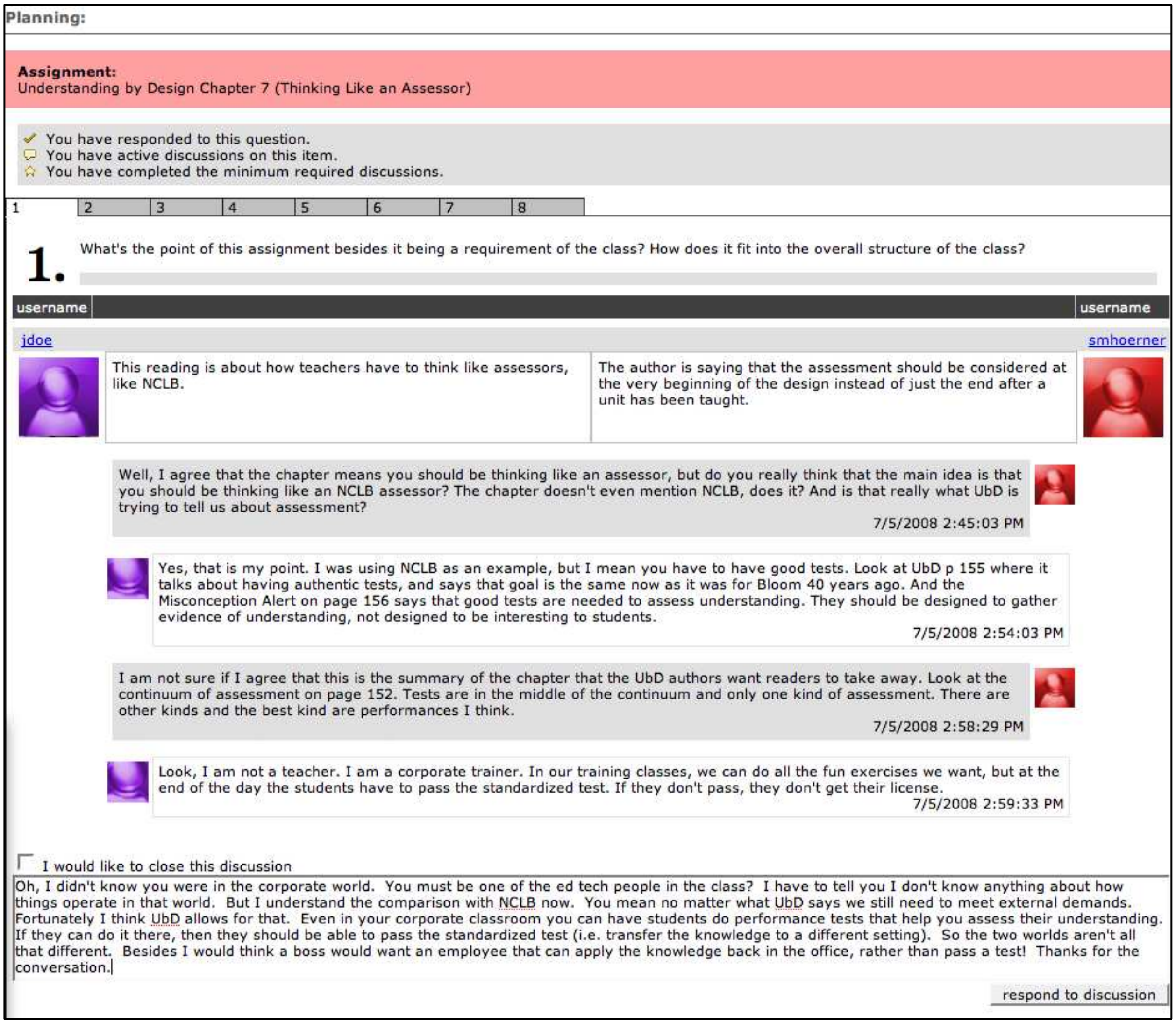
Appendix A

Metacog: Starting A Discussion
Metacognitive Learning Strategies Visual Indicator:
Declarative, Procedural, and Conditional Knowledge Support



Appendix A

Metacog: Metacognitive Regulation (Planning) Discussion Progress Status Indicators



Appendix A

Metacog: Closing A Discussion (Final Reflection)

☑ I would like to close this discussion

This will close your discussion. Please reply below whether the discussion has changed your mind from your initial response. Why or why not?

Did I change my mind from what I believed at the beginning about how to summarize this reading? I don't think so. I still believe the same thing as the UbD authors -- that we should provide a lot of different types of assessments and not rely only on the test. But the conversation, did make me think much more about how we still have to meet external standards. I want to become better at developing understandings in my classroom that will transfer to the MAP or any other test, whether it requires facts or skills or understanding.

respond to discussion

Appendix B

All questions included in the metacognitive tool by metacognitive subcomponent.

Learning Strategies

Strategy Categories (based on Vovides, 2005)

1. What is the author saying? In one sentence, summarize the most important position of the author. Use this format: The author is saying that _____. (Summarization)
2. What evidence does the author offer for his position? In one sentence, summarize how the author justifies his position (e.g., What research did he do, what reasons or examples does he give, what authority or experience is he citing, etc.)? Use this format: The author justifies his position with _______. (Selective Attention)
3. What does the author want me to do? What is one thing I can do to implement the author's position? In one sentence, summarize how you might use the author's suggestion in your own teaching? Use this format: If I believe this author, one concrete thing I would do in my teaching is _______. (Personalization)
4. Do I have any prior experience with the ideas mentioned by the author? How does this relate to what I already know or believe? How does it conflict with what I already know or believe? (Personalization)
5. How do I feel about this article? Why? (Personalization)
6. Why would I do this? When would I use this? When would it not be relevant or useful? Are there easier, faster, cheaper, more enjoyable, or better ways to do the same thing and get the same results? (Conditional Knowledge)
7. Do I really understand it? What do I need to know more about to understand it? (Monitoring)

8. How can I visualize what the author is saying? (For example, could the material be put into a concept map, flowchart, or other graphical representation?) Extra credit if you actually create the graphic! (Visualization/Problem Representation)
9. Could I do what the author is suggesting if I wanted to do it (e.g., do I have the ability and understanding)? How do I feel about this related to my own abilities? (Is it easy? Too hard?) (Personalization)
10. Do I have the resources to implement it if I wanted to? Would I need help and other resources? Like what? How exactly would I implement it? What would be the first thing I would do? (Find Resources and Procedural Knowledge)
11. Is this something I can work with others to implement? How would I go about this? (Cooperation)
12. What are the pros and what are the cons if I implemented this? If I implemented this, who would benefit? Who would be harmed? (Planning and Evaluation)
13. How would I measure if I was successful in my implementation or not? What would be the likely questions to ask myself to determine if it were successful? (Planning and Evaluation)
14. Compared to other things I could do, how much of a priority is this? Why? (Selective Attention)
15. Should I do it or not? Why? (Selective Attention)

<u>Planning</u>

1. What's the point of this assignment besides it being a requirement of the class? How does it fit into the overall structure of the class?
2. How will this assignment help you personally?

3. What is your plan for completing this assignment?
4. What difficulties or obstacles do you anticipate? How will you overcome them?
5. What resources will you need?
6. How will you monitor your progress?
7. What criteria will you use to evaluate whether you reached your goals at the end of the assignment?
8. What specific steps will you follow to carry out your plan?

Monitoring

1. What is proving to be the hardest part of the assignment?
2. How are you dealing with it?
3. How is your overall progress coming?
4. How are you monitoring your progress?
5. Have you had any new insights about how this assignment will help you personally?

Evaluation

1. Did you meet your criteria and overall goals? How do you know?
2. Did your plan help you to meet your goals? What changed from your original plan once you started the project?
3. How did you monitor your progress? How did you know when it was time to change part of your plan when it wasn't working?
4. Now that you are finished, what would you do differently next time that you did not do this time?
5. How will you decide how and when to use the new knowledge and skills you have gained from this project?

6. How specifically will you use your new knowledge and skills?

Appendix C

Syllabus of Online Course

Ed Psy/Tch Ed 6030: Instruction, Learning, and Assessment
Summer, 2008, June 9 – August 2, Online
Instructor: Ray Martinez
Office Hours: By Appointment
Phone: 314-497-6227 Email: remm79@umsl.edu

Once the course begins, you should frequently check the Announcements area of My Gateway, as well as the "General Course Questions" discussion under the Syllabus area of My Gateway, for updated information.

Note
If anyone has a health condition or disability, which may require accommodations in order to effectively participate in this class, please contact me privately as well as the Disability Access Services Office in 144 Millennium Student Center at 516-6554. Information about your disability will be regarded as confidential.

Description

This course uses learning as the basis for the design of classroom instruction. By applying learning theories, teachers can improve their own unit development, lessons plans, assessment strategies, and the use of technology for effective teaching. The course deals with the impact of cognitive educational research on the subject content and what is known about how people learn. Teachers will learn to critically evaluate and improve their own educational practices, design principled and appropriate assessments based on their instructional goals, and to assess their own professional development.

Objectives

1. Develop bridges between instruction and learning theory. How does theory explain instructional outcomes? What does it imply for instructional design?
2. Critique and evaluate case studies of instructional activity and outcomes to improve instruction, assessment, and use of technology.
3. Examine the subject matter domains one teaches (for instance reading, writing, mathematics, history, science), and what it means to be expert at different levels.
4. Develop one's own perspective on how people learn and its relation to instructional strategies and models.
5. Demonstrate ability to integrate technology meaningfully in instructional plans.
6. Demonstrate ability to design principled, appropriate assessments based on learning goals.
7. Critique, evaluate and improve one's own educational practices—including uses of teaching strategies, use of technology and assessment practices—based on what we know about how people learn.

Course Design

This class is entirely online, and uses online discussion boards and other tools extensively for collaboration. You should plan to check My Gateway and make new posts or responses at least every other day, if not more frequently.

Also, there is a lot of reading. The summer class has the same amount of reading as the 15-week semester version of the class, but is condensed into 8 weeks. Of course, since the class is online, you have at least six hours a week to read instead of being in a classroom. In any case, don't get behind on the readings.

The online and collaborative format of the class, combined with the readings, means that you should plan your schedule so that you can post as early in the week as possible and then have plenty of time to engage often in conversation with your fellow students during the week.

The class schedule listed below will run from Sunday to Saturday. While I suggest you read ahead and make your initial posts on Sunday or Monday, you must make your initial posts by Wednesday evening at the latest to allow time for follow-up conversation. All weekly discussion posts and conversations must be completed by midnight central time on Saturday night each week.

Required Textbooks and Readings

Bransford, J. D., Brown, A. L., and Cocking, R. R. (Eds.) (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Wiggins, G., and McTighe, J. (2005). *Understanding by design: Expanded edition*. Alexandria, VA: Association for Supervision and Curriculum Development.

Online and electronic articles as detailed within the schedule below. All readings besides the textbooks above are available on My Gateway under the Documents link.

Required Activities and Grading

There are three main activities associated with the course (% of final grade is included in parentheses; incremental grading will be used for final grades):

a) Completing readings weekly and actively participating in online activities and discussions (25%)
b) Leading and summarizing a discussion on one of the course readings during the course (5%)
c) Completion of 5 written assignments
   - #1: Analysis of Understandings in Jasper Woodbury (10%)
   - #2: Concept Map related to your teaching domain (15%)
   - #3: Analysis of Learning in Jasper Woodbury (10%)
   - #4: Analysis of the design of an enacted curriculum—science, math, literacy, or social studies (10%)
   - #5: Unit Plan (25%)

Class Schedule

This syllabus is subject to change based on the needs of the class as a learning community. Adjustments will be made that generally benefit the group's learning opportunities.

PART ONE: What is knowledge?

Week 1 June 9 – June 14
Knowledge and expertise
Readings (under Documents or in textbooks):

- Overview of Foundational Learning Theories
- *How People Learn* Chapter 1 (Learning: From Speculation to Science)
- *How People Learn* Chapter 2 (How Experts Differ from Novices)

Activities (under Activities>Week 1 Activities)
Note: Since Week 1 starts on a Monday, rather than a Sunday like other weeks, initial posts are due at the latest by Thursday, rather than Wednesday like other weeks.

- Make sure you have the required textbooks for the class. Post any questions about the textbooks to the "General Course Questions" discussion board (under Syllabus in My Gateway), or email me at remm79@umsl.edu.
- Review the syllabus, as well as the My Gateway site. Post any questions about the Syllabus to the "General Course Questions" discussion board (under Syllabus in My Gateway), or email me at remm79@umsl.edu.
- Complete the "Introductory Activity" activity (under Activities)
- Complete the "Meta-what?" activity (under Activities)
- Complete the Learning Strategies survey (under Activities)
- Complete the "Initial Perspectives on Community and Collaboration" activity (under Activities)
- Sign up for a week to lead and summarize the discussion (under Activities>Week 1 Activities)
- Review the extra credit "New Teacher Advice" activity (under Activities)
- Participate in Week #1 online discussions on the readings (under Discussions).

Week 2 June 15 – June 21
Knowledge and understanding
Readings (in textbook):

- *Understanding by Design* Chapter 1 (What is Backwards Design?)
- *Understanding by Design* Chapter 2 (Understanding Understanding)
- *Understanding by Design* Chapter 3 (Gaining Clarity on Our Goals)
- *Understanding by Design* Chapter 5 (Essential Questions: Doorways to Understandings)

Activities

- Participate in Week #2 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings
- View *Adventures of Jasper Woodbury* "Rescue at Boone's Meadow" video (under Activities)
- Conduct *Adventures of Jasper Woodbury* "Rescue at Boone's Meadow" activity in small groups (under Activities)
- Introduce and begin work on Assignment #1: Analysis of Understandings in Jasper Woodbury. Due June 28 at midnight central time.

Week 3 June 22 – June 28
Knowledge and teaching
Knowledge across the curriculum
Readings (under Documents and in textbook):

- Novak, J. The theory underlying concept maps and how to construct them.
- Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57,* 1-22.
- Stodolsky, S. S. & Grossman, P. A. (1995). The impact of subject matter on curricular activity: An analysis of five academic subjects, *American Educational Research Journal, 32* (2), 227-249.
- *Understanding by Design* Chapter 6 (Crafting Understandings)

Activities:

- Introduce and begin work on Assignment #2: Concept Map. Due July 5 at midnight central time.
- Participate in Week #3 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignment #2
- Continue work on Assignment #1: Analysis of Understandings in Jasper Woodbury due June 28 at midnight central time. Put in My Gateway Digital Drop Box (under Tools).

<u>PART TWO: What is learning? How does learning happen? What is evidence of learning?</u>

Week 4. June 29 – July 5
What is learning and how does it happen?
How is learning situated?
Readings (under Documents):

- *How People Learn* Chapter 3 (Learning and Transfer)
- Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, January-February, 32-42
- "Interaction between learning and development," from Vygotsky, L. S. (1978). *Mind in society*. Cambridge MA: Harvard University Press.
- Cole, M. and Wertsch, J. (1996). Beyond the individual-social antinomy in discussions of Piaget and Vygotsky. *Human Development, 39* (5), 250-256.

Activities

- Introduce and begin work on Assignment #3: Analysis of Learning in Jasper Woodbury. Due July 12 at midnight central time.
- Participate in Week #4 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignments #1, #2, and #3.
- Continue work on Assignment #2: Concept Map due July 5 at midnight central time. Put in My Gateway Digital Drop Box (under Tools).

Week 5. July 6 – July 12
Assessment: What is evidence of learning?
Readings (under Documents and in textbook):

- Understanding by Design *Chapter 4 (The Six Facets of Understanding)*
- Understanding by Design *Chapter 7 (Thinking Like an Assessor)*
- Understanding by Design *Chapter 8 (Criteria and Validity)*
- Bereiter, C., and Scardamalia, M. (1998). Beyond Bloom's taxonomy: Rethinking knowledge for the knowledge age. In A. Hargreaves A. Lieberman, M. Fullan, & D. Hopkins (Eds.), *International Handbook of Educational Change* (pp. 675-692). Dordrecht: Kluwer.

Activities

- Introduce and begin work on Assignment #5: Unit Plan by generating ideas for "Desired Results" in your Unit Plan. Complete assignment due August 2 at midnight central time.
- Participate in Week #5 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignments #2, #3, and #5.
- Continue work on Assignment #3: Analysis of Learning in Jasper Woodbury due July 12 at midnight central time. Put in My Gateway Digital Drop Box (under Tools).

PART THREE: What is teaching?
Week 6 July 13 – July 19
Learning in Knowledge Domains
Teaching as the Design of Learning Environments
Readings (under Documents and in textbook):

- *How People Learn* Chapter 6 (The Design of Learning Environments).
- *How People Learn* Chapter 7 (Effective Teaching: Examples in History, Mathematics, and Science)
- Savery, J. R., and Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology, 35*, 31-38.

Activities

- Introduce and begin work on Assignment #4: Analysis of the design of an enacted curriculum. Due July 26 at midnight central time.
- Participate in Week #6 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignments #3, #4, and #5.
- Continue work on Assignment #5: Unit 5 by generating ideas for "Acceptable Evidence" in your unit plan. Complete assignment due August 2 at midnight central time.

Week 7 July 20 – July 26
Readings (in textbook):

- *Understanding by Design* Chapter 9 (Planning for Learning)
- *Understanding by Design* Chapter 10 (Teaching for Understanding)

1. *Understanding by Design* Chapter 11 (The Design Process)

Activities
- Participate in Week #7 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignments #4 and #5.
- Continue work on Assignment #5: Unit 5 by generating ideas for "Learning Experiences and Instruction" in your unit plan. Complete assignment due August 2 at midnight central time.
- Continue work on Assignment #4: Analysis of the design of an enacted curriculum. Due July 26 at midnight central time. Put in My Gateway Digital Drop Box (under Tools).

Week 8 July 27 – August 2
Readings (in textbook):
- *Understanding by Design* Chapter 12 (The Big Picture: UbD as Curriculum Framework)
- *Understanding by Design* Chapter 13 (“Yes, but…)

Activities
- Participate in Week #8 online discussions on the readings (under Discussions).
- Access the Metacog tool (Metacog link in My Gateway) and participate in the required discussions on the readings and Assignments #4 and #5.
- Continue work on Assignment #5: Unit 5. Due August 2 at midnight central time. Put in My Gateway Digital Drop Box (under Tools).
- Complete course evaluation.

Appendix D

Post-Course Semi-Structured Interview Questions

Based on the Activity Checklist (Kaptelinin, Nardi, and Macauley, 1999) and the Activity Interview (Duignan, Noble, and Biddle, 2006).

1. What was your role in using this metacognitive tool?
2. Please take me through the steps of how you used and worked with the metacognitive tool.
3. What was your process for answering the initial metacognitive questions?
4. How did you initially decide how to pick a discussion partner?
5. Once a discussion started, what was your process?
6. How could you tell if you were having a successful discussion?
7. [If mention having to wait for a discussion partner to reply] How do you think that process could be improved?
8. Do you think the goals of the metacognitive tool could have been accomplished differently?
9. What were the explicit rules involved in using the metacognitive tool?
10. Was there anything that was confusing about using the metacognitive tool?
11. Were there any contradictions between how you were instructed to use the metacognitive tool and what you saw other learners doing? Were there any other contradictions you saw?
12. Tell me about your use of metacognitive knowledge and regulation in your day to day activities. What tools do you use? Could you integrate something like the metacognitive tool or processes you used during the course into your daily practices?
13. Did you have easy access to the metacognitive tool?
14. How easy was it to use the metacognitive tool? Should it have been easier?
15. Did it require a large amount of time to and effort to learn the tool?
16. Has the metacognitive tool affected the way you think about metacognition?
17. Did you notice there were learning strategies associated with each question in the tool? How did you use that information?
18. When you needed help, did you know what to do to get it?
19. How could the tool be improved?
20. Do you think this tool could be used outside of a classroom environment? What are some other possible uses for it?
21. What is your attitude in general towards using new technology? What about in using technology in your teaching? Has the use of this metacognitive tool changed that at all?
22. Could you do everything you needed to do in the metacognitive tool, or did you need to switch to other course tools or materials?

23. Were the terminology and concepts used within the metacognitive tool clear or hard to understand or confusing?
24. How integrated were the metacognitive tool with the other parts of the course?
25. Did you get any benefits out of using the metacognitive tool? Did the benefits increase or decrease as you used the tool more? Were there any negative side effects to using the tool?
26. Did your attitude towards using the tool increase or decrease as you used it more?
27. Do you think you had enough time to really learn how to use the tool and evaluate it?
28. Is there anything else you want to add about the metacognitive tool?

Appendix E

Metacog Evaluation Questions

1. Metacog was designed based on cognitive science principles to improve metacognitive knowledge and skills. Please reflect on your use of the tool. What did you think of the tool? How do you believe it succeeded or did not succeed?
2. Please describe your process for using Metacog. (For example, did you answer all the questions at once or not? How often did you check for discussion responses? When you received a response what did you do?) Keeping in mind our readings about cognition being situated and context influencing learning, how do you think your process influenced your learning?
3. How useful were the Help videos in telling you what you needed to do? How useful were the instructor instructions in telling you what you needed to do?
4. What was the effect of having to answer the questions first before seeing the responses of others?
5. Was Metacog more useful for the readings or for the unit planning and monitoring? Why?
6. Considering only your use of Metacog with the Bereiter reading (Beyond Bloom's Taxonomy) and the Savery and Duffy reading (Problem-Based Learning), was Metacog more helpful for one of these two readings than the other? Why?
7. Considering only your use of Metacog with the unit plan, was Metacog more helpful for planning or monitoring? Why?
8. How did you decide with whom to start a discussion?
9. In general, how did your discussions with others change your perspectives from your initial responses?
10. How would you improve Metacog to help you increase your metacognitive skills and abilities?
11. How do you think you might use any lessons learned from the Metacog tool in your own instructional designs?
12. Over the course of the semester we have attempted to create a trusting online community where students are safe to experiment, even fail and learn. To what extent was a community created? What created it? How did Metacog contribute to this?
13. Any other comments about Metacog?

Appendix F

Raw content analysis codes after initial coding of six in-depth interviews:

1. Attitude towards Metacog
2. Attitude toward technology
3. Benefits increasing or decreasing
4. Benefits of Metacog for readings versus assignments
5. Benefits of using Metacog
6. Benefits transfer
7. Choosing A Conversation Partner
8. Clarity of terminology
9. Closing a discussion
10. Community Building
11. Computer Efficacy
12. Contradictions in tool
13. Conversation-discussion Quality
14. Declarative, Procedural, Conditional Knowledge of Learning Strategies in Metacog
15. Designer-Researcher Design Intent
16. Effect of waiting for someone to start or answer in a conversation
17. Enough time to evaluate Metacog
18. Evidence of successful completion of task
19. Exposure time to Metacog
20. FAQs Use
21. Finding help when needed
22. Help Video Use
23. Impact of using Metacog on student thinking about metacognition
24. Importance of metacognition in learning
25. Inaudible - To Check
26. Initial perceptions of Metacog
27. L2D-Subject-Community
28. Link to readings from within Metacog
29. LR - Importance of metacognition
30. LR - Important components for learning
31. LR - Metacognition Defined
32. Metacog possible use in other contexts or classes
33. Metacognition Use in Classroom Before Course
34. Metacognition Use Personally Before Course
35. Metawhat - Other
36. NA - Concept Teaching
37. NA - Construction of knowledge
38. NA - Good Teaching Strategies
39. NA - Lecture
40. NA - Prior knowledge is important for learning
41. Negative effects of Metacog
42. Non-Metacog Comments about the Course

43. Number of questions
44. Other tools used to enhance metacognitive skills
45. Physical Access to Metacog
46. Positive effects of Metacog
47. Process answering questions
48. Profile - As Implemented
49. Questions - Overlap of Answers
50. Questions being the same for each reading
51. Regulation versus reflection
52. Relationship between Metacog and discussion board
53. Relevance of questions to class
54. Role of student in using Metacog
55. Rules about community
56. Rules to use Metacog
57. Star Icons
58. Strategy Learning
59. Subject
60. Suggested improvements to Metacog
61. Switching between applications
62. Technical Issues
63. Thoughts about metacognition - beginning of class
64. Time between answering questions and choosing conversation partner
65. Time between choosing a partner and responding then checking back for responses
66. Time Commitment - Online Education
67. Time Commitments Besides 6030
68. Time in semester when Metacog started
69. Time investment to complete Metacog assignments
70. Time Investment to learn Metacog
71. Time to complete answering questions
72. Time to complete questions - impact of 1-3 sentences length limit rule from instructor
73. Usability of Metacog
74. Use of metacognitive strategies before Metacog
75. When and how metacognition develops in children
76. When and how reflection develops in children
77. When and how self-regulation develops in children