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EXPLORING COGNITIVE PROCESSES OF TEACHERS
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Abstract

This study explores professional learning of teachers in a web-based Open-Ended Learning Environment (OELE). Adult learning theorists suggest that adults are self-directed, experience-based, personally- and socially-related, problem-oriented, and application-focused learners. Constructivists suggest that the OELE affords learners opportunities to construct knowledge by engaging in mental and cognitive processing on an individual level and social-dialogical negotiation among learners, thus, the OELE promotes high levels of cognitive functioning. However, current research has not yet provided any direct observation on the learning processes that mediate the cognitive functioning of a teacher's professional learning in the OELE. Therefore, six teachers were selected and think-aloud protocols were employed in this study to explore the nature of their thought processes in the context of independent and group learning. The results indicated individual differences in demonstrating conceptual understanding, applicability, and authentic discernment when solving authentic problems through interacting with learning content, peers, and instructors. Some suggestions were made pertaining to instructional conditions that fostered professional growth of teachers in web-based, OELE training.

Chapter I: Study Overview

The need for Continuous Professional Development (CPD) to improve teaching practice is a shared vision for many. The American Federation of Teachers (AFT, 2010) reported that most teachers consider professional development among one of the essentials to helping them fulfill their job responsibilities. In addition, a 2006 report from National Education Association indicated that an increase in the number of teachers participating in training programs can be considered as evidence of improvements in teaching quality. Some even argue that professional development holds the key to transform an ordinary teacher into a professional educator (U.S. Department of Education, 1996).

Professional development may serve as a critical element in helping teachers become more effective in the classroom, however, what constitutes effectiveness of a CPD program is still an open question. Some researchers (e.g. Cervero, 2001; Forsyth, 2002) focus on the potential of web technology to enable a unique design and implementation of professional development programs. They argue that web-based learning is becoming an increasingly important method, serving as a viable alternative to traditional classroom-based instruction. Web-based instruction provides unconventional access that overcomes barriers of classroom-based instruction, such as time constraints, scheduling conflicts, and limited physical spaces (Perdue, 2003).

The widespread growth of web technologies in the application of training and development has created tremendous research interest (Moore, 2003). Some researchers (e.g. Barron, 1998; Chuang, 2002) conducted empirical studies focusing on technology as a delivery method for the professional development of teachers. However, Hatfield

(1996) found that this web-based delivery has had little impact on the effectiveness of teacher training.

Conversely, a learner-focused design (Bonk & Dennen, 2003; Hannafin, Hill, Oliver, & Glazer, 2003) has attracted significant attention in the literature on web-based learning. The discussion of the learner-focused instruction is predominantly derived from constructivist theory.

Knowledge construction, according to constructivist theorists, requires cognitive processing on an individual level (Piaget, 1973) and dialogical negotiation among a group of learners (Vygotsky, 1987). Duffy and Cunningham (1996) argue that learning is an active process requiring an individual to interact with learning content, peer learners, and instructors. Under these assumptions, constructivist pedagogy affords an opportunity for interactive, technology-rich, learning environments to engage learners in a variety of thinking activities facilitated by instructors and enabled by technology (Jonassen, Peck, & Wilson, 1999). In contrast to traditional, instructor-led, technology-focused instruction, constructivist learning environments (Wilson, 1996) support learners in a technology-mediated space of learning.

Therefore, constructivist learning environments can be a feasible CPD approach to engaging teachers in web-based learning. Accordingly, this research explores the learning processes of teachers in a web-based environment for professional learning.

Study Background

Empirical research reveals that constructivist pedagogy facilitates professional learning of teachers through creating projects (e.g. Levin, Waddoups, Levin, & Buell, 2001), solving problems (e.g. McConnell, 2002), engaging in activities (e.g. Littlejohn,

2002), building professional learning communities (e.g. Lieberman, 2000; Selwyn, 2000), and sharing professional dialogue and expertise (e.g. North, Strain, & Abbott, 2000). As an instructional strategy gearing toward knowledge and skills applicable to practitioners, constructivist pedagogy orients learners toward critical thinking (Garrison, Anderson, & Archer, 2001) and reflection (e.g. Burge, Laroque, & Boak, 2000), professional networking and discourse (e.g. Conrad, 2002; Carr-Chellman, Dyer, & Breman, 2000) to promote collected intelligence (Gunawardena, & Anderson, 1997) of teachers in a professional learning community.

Furthermore, constructivist pedagogy embraces an ideology of authenticity. Learning ways of knowing (Grant & Wieczorek, 2000), learning ways of thinking (Cervero, 2001), and learning ways of meaning making (Brockett, 1991; Jenlink & Kinnucan-Welsch, 1999) are central to developing knowledgeable, skillful, and artistic professionals in real-world practice (Clark, Feldon, Haward, & Choi, 2006). Situated in authentic context (Brown, Collins & Duguid, 1989), constructivist learning environments can be designed to support a teacher's effort to know, to think, and to make meaning.

The proponents of constructivism have argued that constructivist learning environments are an effective approach to web-based instruction. Hence, Open-Ended Learning Environment (OELE), the instructional design model underpinning constructivist pedagogy (Land & Hannafin, 2000), which capitalizes on the capability of web technologies (Hannafin, Land, & Oliver, 1999) may be feasible in the design of training programs for teachers.

According to Land and Hannafin (1996), the OELE promotes conceptual understanding, critical thinking, and meaningful learning. Equipped with interactive

technology, the OELE may enable the teachers to interact with training content, peers, and instructors to test their personal conceptions for understanding. In addition, the OELE may encourage the teachers to think critically through articulation, negotiation, reflection, conversation, and collaboration that stimulate new insights and concepts obtained from relevant and useful information to replace preconceived notions and biases. Hyperlinked with resources and embedded with tools, the OELE may allow the teachers to select learning tasks based upon their unique needs, perceptions, and experiences.

In the context of professional development, training goals include developing a teacher's professional sense of self, reconnecting to professional responsibilities, and cultivating professional voices and identities (Brockett, 1991; Mintzberg, 2000), which implicates an abstract and complex task. This task may be accomplished through the OELE, for it serves as a system enabling tangible, concrete, experiential learning, so "the learner does not merely respond to the system; rather, he or she is integral to it" (Land & Hannafin, 1996, p.37). According to Land (2000), the OELE promotes a learner's "sophisticated levels of cognitive functioning" (p.61). Therefore, this study purports to explore cognitive processes of teachers' professional learning in the Open-Ended Learning Environments.

Examining the pool of literature in training and development, some scholars have suggested scrutiny of traditional assumptions and approaches to professional development. Schon (1987) argues that the emphasis on rigorous technical information and textbook cases and examples has failed to meet the demands of real-world practice. In addition, Clark and his colleagues (2006) argue that focusing on updating technical knowledge and facts has not helped practitioners accomplish the complex tasks they

encounter on a daily basis. These traditional assumptions have been criticized as lacking in "intuitive understanding", strategic "improvisation" (Schon, 1987, p.5), and "complex, integrated skills" (Clark, Feldon, Howard, & Choi, 2006, p. 348) necessary to solve ill-defined or ill-structured problems, which teachers actually confront in practice.

Moreover, Cervero (2001) argues that traditional training approaches that aim for information dissemination have failed to accommodate needs, interests, and concerns of the teachers. Accordingly, information-focused approaches (distribution of training materials) often result in passive learning that is either irrelevant or insignificant to the challenges teachers encounter in the classroom.

According to National Center of Educational Statistics (NCES, 1999), teachers often participate in formal professional development that is propagated by the school district staff and principals who determine participants, content, logistics, and implementation. These so called, staff-development programs (e.g., workshops, conferences) usually involve a short-term focus and allow little opportunity for experiential or interactive learning with colleagues or experts. Teachers in some schools and school districts are highly encouraged or even required to attend these learning events and pursue designated goals and agendas prescribed by their administration. Such programs seem proprietary and authoritative, for they impose a top-down, administrator-to-teacher, and instructor-to-learner approach to professional development.

Conversely, distance education (DE) offers an opportunity to shift from instructor-directed to learner-focused approaches. The leading DE theorist Michael Moore (1973) characterizes distance learners as independent, autonomous, and self-directed individuals separated physically from an instructor and peer learners. Due to this

physical separation, Moore (2003) argues that learners need to be the central focus of DE systems, and technology serves as an imperative link of the systems. Personal computers equipped with advanced web technologies become a transformed new medium that serve as "carrier, distribution, display, instruction, and interactive medium" (Peters, 2003, p.89), so learner-focused instruction can now be made possible.

Moreover, Brookfield (1995) argues that distance education, web-based instruction, and open learning systems have become emerging trends in studying adult learning, exemplifying the principles of androgogy (Knowles, 1990), which places emphasis upon the development of self-concept, the learner's experience, the personal and social roles the learner plays in life, readiness to learn, and immediacy of application (Cross, 1981). According to Cross, adult learning is self directed, experienced based, personally and socially related, problem oriented, and application focused.

Additionally, web-based learning is epitomized in constructivist principles (Duffy & Conningham, 1996; Jonassen, Peck, & Wilson, 1999). The constructivists argue that knowledge construction involves an individual learner in mental and cognitive processing (Piaget, 1973), as well as a group of learners in social, dialogical, and reflective processing (Vygotsky, 1987).

Examination of these two strands of theory (adult learning and constructivist learning) shows differences in perspectives, as well as similarities of assumptions. The adult learning strand adopts humanist perspectives focusing on the learners, while the constructivist strand adapts to the view of cognition, emphasizing the learning process. Both strands of theory identify influential factors critical to distance adult learners. Adult learning and constructivist learning converge on a learner-focused, instructional design

that accommodates the needs of adults' web learning quest. Therefore, web-based instruction has the potential to combine the two strands' views on humanistic approaches to development and cognitive processing required in learning.

Web-based instruction relies heavily on the technological development of the Internet. Internet technology, precipitating access to an enormous amount of information and fluid, dynamic learning content, has engendered a new teaching and learning paradigm, shifting from content to process (Vogel & Klassen, 2001). Accordingly, process-based approaches promote authentic learning of practical knowledge and applicable skills (Slavkin, 2004), which empowers the learners to become "sensitive to process, adaptable to change, and aware of the benefit of information technology" (Vogel & Klassen, 2001, p.104).

These technologies hold the promise of supporting and mediating knowledge construction in web-based learning environments. However, in the context of teacher training, several researchers have placed their emphasis on evaluating web-based programs by measuring the change in participants' attitudes (e.g. Meichtry & Smith, 2007; Villar & Alegre, 2007) and in their perceptions (e.g. Liu, Theodore, & Lavelle, 2004) through a pre- and post-test comparison. Some studies explore the effectiveness of training programs based on the subjects' opinions and feedback (e.g. Connolly, Jones, & Jones, 2007; Lueck, 2001; Hur & Hara, 2007). Incorporating various inquiry methods including questionnaires, focus groups, or interviews-- either immediately or at a convenient time after the training has already taken place-- these studies rely on a teacher's memory to recall information in order to gauge the impact of training processes or outcomes of learning. Yet, current literature has not provided any insight about

observing and monitoring the change of a teacher's cognitive and reasoning state during a professional development program. Therefore, the purpose of this study is to delineate this cognitive process of teachers in web-based training by using an observational method called think-aloud protocols.

Think-aloud protocols are employed in this study to observe the teacher's independent as well as collaborative processes of professional learning. According to Ericsson & Simon (1993), asking the teacher to verbalize thoughts concurrently when solving an authentic problem can generate concurrent verbal protocols for studying cognitive processes of self-directed, individualized learning. Additionally, to explore the impact of interaction and meaning negotiation among learners, each teacher is interviewed after completing the OELE instruction to obtaining retrospective verbal protocols about collaborative learning.

Problem Statement

The OELE has the potential to optimize web technology to support a learner's cognitive functioning. Reviewing the literature indicates that constructivist approaches to teacher training may promote conceptual understanding and critical thinking to elicit a real-world connection between knowledge and practice as learning outcomes. However, current research has yet to provide empirical evidence on how a learner's cognitive functioning is mediated in the learning process in order to develop a teacher's professional expertise in a web-based, OELE program.

Purpose

This study purports to explore cognitive processes of teachers in web-based, OELE modules. These modules include learning activities that prompt the teachers to solve ill-structured, authentic problems in the classroom. Embedded with resources, equipped with tools, and provided with scaffoldings, the OELE modules engage a teacher in cognitive activities in order to develop professional expertise. Therefore, the purpose of this study is to observe the actual practice of the OELE instruction from the vantage point of a teacher engaged in professional learning.

Theory suggests that the OELE instruction enables learners to construct knowledge individually and collectively as a group. Moreover, the proponents of constructivism assert that learning requires, mindful, cognitive processing on an individual level (Piaget, 1973; Wink & Putney, 2002) and dialogical negotiation among a group of learners (Vygotsky, 1978; Daniels, 2001). Accordingly, a teacher's thinking processes are mediated by various learning activities embedded in the OELE modules, and interacting with these activities, independently and collectively as a group can impact individual teacher's thoughts in performing problem-solving tasks. Therefore, the interest of this study aims for exploring thought processes of teachers and identify factors that contribute to the development of professional teaching expertise in web-based, OELE modules.

Research Questions

This study purports to explore cognitive processing of teachers in a web-based, professional development program guided by the following research questions:

1. What is the nature of a teacher's thought process when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?
2. What is the nature of a teacher's thought process in the context of group learning when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?

Significance

This research explores the learning process of the OELE instruction in the application of teacher training. The existing literature is dominated by discussions of post effect of web-based instruction, yet very few focus on observing a learner's cognitive functioning while engaging in the learning process due to the time/place independence. In the few studies dealing with direct observations, the research is designed to evaluate the impact of an open learning environment upon primary (e.g. Veermans & Tapola, 2004), middle (e.g. Davis & Linn, 2000), and high school students (e.g. Ge, Thomas, & Greene, 2006), or undergraduate students in colleges and universities (e.g. Ge & Land, 2003; Lin & Lehman, 1999, Cotton & Gresty 2007). These studies have contributed to the understanding of human thinking and provide insights into cognitive processes of children and young adults. To build upon these findings, this study focuses on thinking processes of professional adult learners in the OELE, problem-based training.

Investigating the effect of the OELE model in this study may contribute to web-based learning theory and provide an understanding of instructional techniques and methods that impact learning. Moreover, studying a teacher's thought processes in

problem-solving contribute to adult learning theory with regards to various factors impacting thinking and learning of professionals.

This effort may also contribute to the practice of professional development of teachers and provide the stakeholders with information for decision-making. Examining the effect of an instructional model may increase the likelihood of developing a pedagogically sound training program that capitalizes time, money, and manpower allocated to improve teaching practice.

Limitations

Employing think-aloud protocols to explore a teacher's cognitive processes in the OELE instruction has several limitations. Firstly, the study is limited by the difficulty of recruiting a group of participants who represent a wide spectrum of teachers in terms of the knowledge, skills, experience, and expertise. In addition, the ability to generalize is limited when selecting only a small number of study subjects due to the demand in time and effort for in-depth research inquiry. Therefore, a convenient sampling technique in the selection of a relatively small size of research subjects is rendered as a research decision that focuses on presenting a qualitative, holistic, and in-depth understanding of the phenomenon.

Another study limitation exists for data collection in real time settings due to the inability to control the research setting. Moreover, it is fairly difficult to completely eliminate a researcher's bias in interpreting study findings due to personal friendships with the subjects and the proximity of the study context. Influenced by these factors, the emphasis of study is placed upon portraying a teacher's cognitive functioning in the OELE instruction in the light of uniqueness bounded by the context of this study.

Definition of Terms

- Open-Ended Learning Environment (OELE): an instructional model designed to situate learning in an authentic context that allows for formalizing and testing personal conceptions.
- Web-based instruction: a means of providing training and development to teachers through multimedia and computer networking to mediate and support time and place independent learning.
- Ill-structured problems: problems that allow for multiple solutions or solution paths, and unstructured goals, and solving ill-structured problems require both domain-specific and structural knowledge in the field of teaching.

Summary

Continuing professional development can be instrumental in improving teaching practice, when it is effectively implemented. The web can be a powerful tool for learning when it is wisely utilized. If the aim of learning is "the acquisition of the art of the utilization of knowledge" (Whitehead, 1929, p.4), the essence of web-based, professional learning is about the mastery of the art.

Web-based learning in the application of teacher training may resolve the issue of time and place dependence; however, it cannot achieve the aim of improving teaching practice based on that reason alone. Therefore, it is imperative to understand how teachers as learners think and learn in order to devise a training program that is effective in helping these professionals apply their learning and refine their practice.

Chapter II: Literature Review

The research effort to understand a teacher's thought processes in a web-based learning environment continues in this section. This review includes two bodies of literature: theoretical explanation and empirical research. Examining adult learning theory and constructivist pedagogy serves as a theoretical foundation to explore the training and development process of teachers as professionals in the Open-Ended Learning Environment (OELE). This is followed by a review of related empirical literature, which provides an understanding of the implementation and current practice in the application of constructivist approaches to professional development of teachers.

Theory

Web-based learning has become a prevalent mode of professional training and development. This mode of learning can be defined as Distance Education (DE), in which the instructor and the learner are separated; so that interaction between the two (Moore, 1973) is facilitated by computer-based communication technologies (Moore, 2003). Web-based training often serves adult learners who are professionals (Perdue, 2003) and encompasses networked, multimedia, computing technologies (Peters, 2003); and instructional design (Shearer, 2003) to form DE systems. Thus, in order to understand web-based professional learning of teachers, the literature review begins with the discussion of adult learning literature.

Adult Learning Theory. Tough (1979) argues that professionals are goal-, activity-, or learning-oriented. Having a strong sense of self direction in determining learning projects, professionals desire intrinsic rewards such as enjoyment, self-esteem,

and achievement (Knowles, 1990). In supporting professional learning, Moore (1973) argues that the DE learners seek independence in planning and organizing learning events, identifying the means and the goals of learning projects, and even evaluating learning outcomes.

Moreover, self-directed, independent professionals rely on their real-world experiences as valuable resources (Lindeman, 1961) to guide their learning (Dewey, 1984). Professionals often play complex, social roles in life (Kegan, 1994; Merriam, 1994) that compel them to fulfill family and career-related demands. Problems may arise in work situations, and crises may pose threats to personal and family livelihood, thus, the desire to solve the problem or to cope with the crisis becomes a driving force to learning.

Driven by external forces such as marital failure, parenting frustration, or career change, or internal issues such as dissatisfaction, loneliness (Houle, 1961), or a "disorienting dilemma" (Mezirow, 1991, p. 168), professionals learn to manage the reality of life. Therefore, practical solutions and immediate applications are especially useful for the professional "knowledge workers" who are constantly engaged in "analyzing available information for relevance and value" (Perdue, 2003, p. 617) and applying knowledge creatively.

In summary, reviewing adult learning theory indicates that teachers are self-directed, experienced-based, personally- and socially-related, problem-oriented, and application-focused learners. These factors identified in the literature provide insight into understanding the needs of a teacher engaged in web-based, professional learning.

Additionally, integrating Computer-Mediated Communication (CMC) technologies into a learner focused instructional design that allows for experiential, interactive, reflective, collaborative knowledge construction (Garrison, Anderson, & Archer, 2003) has become a major research interest in the literature of web-based distance education (Bonk & Dennen, 2003). This line of research, derived from constructivist pedagogy, examines critical factors that impact adult learning in a "web-based learning environment" (Hannafin, Hill, Oliver, & Glazer, 2003, p. 246). To understand web-based learning, the next section focuses on theoretical assumptions of constructivism for professional learning of teachers.

Constructivist Pedagogy in the Context of Adult Learning. Originating from a dual notion of egocentric speech (Piaget, 1973) and social speech (Vygotsky, 1987) in human language development, constructivist pedagogy includes two orienting assumptions emphasizing cognitive processing of an individual (Wink & Putney, 2002) and dialogical negotiation among a group of learners (Daniels, 2001). These constructivists argue that knowledge construction involves internalization (engagement in cognitive activities) and appropriation (participation in socio-cultural activities) to transform learners' thinking and skills and to help them adapt to the social and cultural context of their personal and professional lives (Daniels, 2001; John-Steiner & Meehan, 2000).

Internalization and appropriation require an individual mind interacting with social, collected minds in a social environment (Duffy & Cunningham, 1996). The authors argue that "the activity of mind is always dialogic, connected to another" (p.176); and it creates intrapersonal and interpersonal speech, which can be shared and distributed

in different social, cultural, historical, and institutional contexts to form socio-cultural communication. Forms of communication may vary. Direct communication (e.g., languages and action) and indirect communication (e.g., signs and tools) are utilized to express thoughts, values, and beliefs in cultures that represent human intelligence.

According to Duffy and Cunningham (1996), learning is navigating knowledge through one's local, socio-cultural communication. This locality may suggest individual differences in intelligence including academic and practical knowledge (Wagner & Sternberg, 1986); in social and cultural backgrounds, such as socioeconomic status, gender, and race (Merriam, 1994); in prior knowledge and experiences (Dewey, 1984; Knowles, 1990); in meaning perspectives, that is "the structure of psycho-cultural assumptions within which new experience is assimilated and transformed by one's past experience" (Mezirow, 1984, p.124); and in cognitive ability (Merriam & Caffarella, 1999). All these factors can have an impact upon adult learning. Hence, knowledge is inherently multi-faceted, and there exist "multiple perspectives" (Duffy & Cunningham, 1996, p. 178) of knowing, thinking, and meaning making.

Learning transforms one's mental functions (Duffy & Cunningham, 1996), which may involve developing mental complexity (Kegan, 1994) or expanding consciousness (Weiser, 1987) to reach maturity (Lindeman, 1961), to obtain wisdom (Sinnott, 1994), and to increase intellectual strength (Kegan, 1994). This transformation may be achieved in a "social, communicative, and discursive process" (Duffy & Cunningham, 1996, p.181) that engenders a "self-referential awareness and understanding" named "critical reflexivity" (Brookfield, 1987, P. 74) in order to help adults examine personal or social problems in a new light (Freire, 1970).

Critical reflexivity activates cognition and metacognition to channel one's thinking effort into "the development of strategies for efficient processing (Duffy & Cunningham, 1996, p.181). Professionals who are aware of their cognitive effort and perceptually tune into the information with data stored in their memory (Deters, 1999), or systematically analyze the information achieve mastery (Fox & Miner, 1999).

According to Sinnott (1994), adult learning may involve a broad spectrum of activities to develop basic skills, philosophies, and worldviews, as well as advanced "expertise in managerial skills, mystical skills, and sophisticated interpersonal and organizational relations" (p. 451). In addition, prior knowledge or the professional expertise of adult learners in their field or profession needs to be acknowledged and identified in order to develop and design meaningful learning experiences that enable them to think deeply about different situations and utilize their problem solving skills accordingly (Merriam & Caffarella, 1999).

To sum up, constructivists assert that learning is a cognitive and interactive process. In relating to professional learning, constructivist pedagogy focuses on engaging teachers in cognitive and dialogical processing both individually and collectively as a group. These pedagogical assumptions have an implication for designing web-based environment to support a teacher's learning quest. Thus, it is logical to examine literature regarding constructivist pedagogy in the application of web-based, open learning environment.

The Open-Ended Learning Environment. Constructivist pedagogy, as a mindful, negotiated learning approach, encompasses the learners, instruction, and technology as an "open learning system" (Blackwood & White, 1991, p.136). The

proponents of constructivism have argued that this open system be embedded with resources and tools built as an environment of learning (Wilson, 1996) allowing the learners to assume a dominant and active role, with the instructor serving as a facilitator, and using technologies as a support mechanism (Jonassen, Peck, & Wilson, 1999).

Based on these constructivist principles, Hannafin, Land, and Oliver (1999) devised the Open-Ended Learning Environment (OELE), accommodating learner-determined "goal(s), the means through which learning goals are pursued, or both learning goals and means" (p.119). The OELE instruction is comprised of four components: enabling context, resources, tools, and scaffolds, allowing for learner autonomy, control, and pacing over the structure and sequence of learning tasks.

Enabling context, according to Hannafin, Land, and Oliver, whether externally imposed or induced or generated by learners, situate learning based on individual needs, perspectives, or interpretation to solve a problem. Resources including static and dynamic media provide information to help learners search for solutions to the problem. Tools provide learners with a means of processing and manipulating learning content and also communicating with instructors or peer learners. Scaffolds that vary in conceptual, metacognitive, procedural, and strategic support guide learners' effort in problem solving.

In the context of professional learning, these components embedded in the OELE may support cognitive and dialogical processing of teachers in problem solving, so they can think critically in terms of conceptualizing the problem, developing understanding, considering ways to apply learning, and reflecting authentically to develop awareness and discernment. Hence, how the OELE supports a teacher's learning effort in order to

cultivate conceptual understanding, abilities to apply, and authentic discernment are discussed as follows.

Conceptual understanding. The OELE allows the learners to construct mental "representations or models" (Jonassen, Peck, & Wilson, 1999, p. 3) in order to build intuitive theory (Land & Hannifin, 1996). Whether to explain initial, naïve conceptions (Land, 2000) based on prior knowledge and experiences (Gagne & Glaser, 1998; Land & Hannifin, 2000), to interpret multi-faceted perspectives, to visualize or manipulate abstract ideas (Land & Hannafin, 2000), or to assimilate an "operational model" (Piaget, 1980, p.85), the learners hypothesize, experiment, and test their intuitive theories. Hence, through confirming or refuting the validity of prior intuitive theory, the learners modify the existing one or recreate new theory in order to develop intuitive understanding.

Moreover, the OELE engages learners in articulation, reflection, conversation, and collaboration, which facilitates the development of intuitive theory (Jonassen, Peck, & Wilson, 1999). Therefore, conceptual understanding is achieved when learners articulating concepts, meanings, and propositions to interpret or explain their conceptualizations (Hannafin, Land, & Oliver, 1999) in verbal, written, visual, or auditory forms is an "expression or representation of what is learned" (Jonassen, Peck, & Wilson, 1999, p. 5).

Abilities to apply. In the OELE, learners are engaged in reflective activities for self-examination, which is learning to ask "provoking questions" (Jonassen, 1999, p. 233). Whether to logically rationalize ways to integrate prior and new knowledge (Land, 2000); to pragmatically consider the "events of instruction" including directing attention, informing objectives, presenting materials, and providing feedback (Gagne, Briggs, &

Wager, 1998, p.28); to strategically present conceptions or challenge assumptions (Jonassen, Peck, & Wilson, 1999); or to monitor understanding (Land & Hannifin, 1996), reflection entails an incremental as well as a holistic examination of intuitive theory.

Authentic Discernment. The OELE also facilitates negotiation and validation of collective, intuitive theory through conversation and collaboration (Land & Hannafin, 2000). The learners may differ personally, professionally, or collectively as a culture (Duffy & Cunningham, 1996); thus, promoting discernment as well as acceptance is crucial to successful, social discourse and co-construction of collective knowledge (Gunawardena & Anderson, 1997).

In addition, the OELE enables the learners to share interests and experiences (Jonnassen, 1999), and it promotes open communication of different perspectives and beliefs, which connect the learners and facilitate the formation of a community of "networked minds" (see Carabajal, LaPointe, & Gunawardena, 2003, p.217). Communication among community members including the learners, instructors, and peers is validated through critical discourse (Grabove, 1997), serving as a reality check to avoid distortion or misunderstanding. Thus, co-constructed knowledge must be contextually and authentically guided, supported, and scaffolded (Brown, Collins, & Duguid, 1989) to serve the freedom rather than the oppression of truth and knowledge (Tennant & Pogson, 1995).

To summarize, engaging teachers in the OELE may promote their conceptual understanding by immersing them in an authentic context for problem-solving. Moreover, providing scaffoldings to guide teachers' learning effort in the OELE may develop their abilities to apply logical reasoning, strategic thinking, and pragmatic planning.

Furthermore, utilizing resources and tools embedded in the OELE help teachers discern real-world situations and respond to problems they encounter with a course of action (Hannafin, Land & Oliver, 1999).

The OELE proponents argue that the OELE be situated in an authentic context in order to make learning meaningful. In order to understand the implication of the OELE for professional learning of teachers, related literature in authentic learning context is discussed next.

Authentic learning context. Constructivist theorists have argued for the importance of authenticity in the learning context (Hannafin, Hill, Oliver, & Glazer, 2003) and its critical role of engaging the learners in real-world problem solving (Clark, Feldon, Howard, & Choi, 2006) or evoking intuitive reasoning in everyday practice (Brown, Collins, & Duguid, 1989).

According to Piaget (1980), "All new knowledge presupposes an abstraction… and draws its elements from some preexisting reality" (p.89); thus, constructing knowledge in authentic situations may create tangible, concrete, real-life experiences valuable to adult learning (Merriam & Heuer, 1996).

If knowledge is an abstract conception of reality, it cannot be divorced from practical needs, wishes, and interests of the learners (Vygotsky, 1987). An authentic context may engender social interaction or social linkage enabling the learners to "adopt the behavior and belief systems of new social groups" for "enculturation" (Brown, Collins, & Duguid, 1989, p.34). Therefore, conceptual understanding is achieved when the learners transform knowledge of real-world, everyday situations into conceptions (Hill, 2001), and examine their existing conceptions in the context of biographical,

historical, and cultural practice in the real world to develop contextual understanding (Mezirow, 2000).

Moreover, Vygotsky (1987) argues that when examining facts, one "inevitably considers them in the light of one theory or another" (p.55). The acquisition of new knowledge requires not only "a conceptualization of how the world works according to its theorist" (Jonassen, 2006, p.45) but also "a full cycle of cognitive abilities" (Kolb, 1984, p.31) involving observing, reflecting, conceptualizing, and experimenting in order to apply the theory under different conditions of reality. Hence, higher order thinking (Gunawardena, Lowe, & Anderson, 1997; Garrison, Anderson, & Archer, 2003) is engendered when the learners demonstrate that they have obtained these abilities of applying new knowledge in everyday situations.

Furthermore, authenticity in the context of constructivism can also be considered as an "outcome of rhetorical processes" (Petraglia, 1998, p.8) to reconcile the role of an educator to constructivist epistemologies. This reconciliation may involve transformation of perspectives (Mezirow, 1984) entailing the formulation and reflection of a new self view, world view, and the view that connects the self to the world to attain self-authorship (Kegan, 1994). Becoming the author of one's self enables the individual to assert a more inclusive, discriminating, and integrative perspective to deal with circumstances in a diversity of contexts. Accordingly, these new views may empower learners to become more autonomous and discerning (Merriam, 2004).

Cultivating self-authorship can also help connect the learner to knowledge. When learners recognize an intimate relationship between the self and knowledge in the light of human "commonality, connectedness, and the shared history as a species…on a

transpersonal level" (Weiser, 1987, p.108), their horizon expands. In addition to traditional views in the west, Chen (2004) synthesizes from another culture (Chinese philosophies of Confucianism and Taoism) and defines this connection of self to knowledge as "authenticity…the true unity of our being" (p.3).

Furthermore, self-authorship must confine itself to the reality of truth. Under this condition, awareness may develop to prompt learners to listen for and discern knowledge of truth in order to sustain a variety of circumstances of real-world practice (Hill, 2001). Hence, authenticity is manifested in the discernment of real-world connection that calls for an individual to faithfully live up to the truth of knowledge, which is the spirit of education (Palmer, 1993).

In short, authenticity in the OELE context may foster the development of a teacher's conceptual as well as contextual knowledge, cognitive abilities of applying newly learned knowledge or skills, and authentic discernment to promote autonomy and awareness of real-world connections.

Summary of Theory

Reviewing literature regarding adult learning theory and constructivist pedagogy explains several trends about teachers as adults in web-based, OELE professional learning.

Teachers are self-directed learners and are rich in experiences. A teacher's readiness to learn is situated in the developmental tasks required by his or her social roles. Teachers are also problem-oriented learners so their learning aims for immediate application.

In addition, constructivists argued that the OELE be situated in authentic learning context in order to engage teachers in cognitive and dialogical processing to promote conceptual understanding, applicability, and authentic discernment.

In examining the two strands of theory (adult learning and the OELE, constructivist learning), there lies a similarity as well as difference. Both strands identify important factors that influence learning. These factors display various aspects that are personal, psychological, social, cultural, and spiritual. On the other hand, the difference between the two strands resides in a dialectic relationship that adult learning adopts a humanistic approach looking from human perspective, while constructivist learning adapts to a systems view focusing on cognition and collective interaction of human and the world. Humanistic approaches respect a teacher's professional discretion over his or her work, and recognize the learning needs of autonomy, independence, and authenticity. Meanwhile, constructivists presume a systems view emphasizing an active, cognitive, and interactive process of professional learning within a technology-rich environment situated in an authentic context.

Adult learning and constructivist learning appear to converge on a learner-focused, instructional design. Therefore, web-based, distance learning designed based on the OELE principles bridges key ideas from adult learning and constructivism to improve professional learning of teachers. The OELE can be designed not only to accommodate individual needs and learning styles of teachers but also to mediate their cognitive and dialogical processing in a web-based learning environment to promote teachers' conceptual understanding, applicability, and authentic discernment, so learning becomes practical and meaningful.

Empirical Literature

The review of empirical evidence examines constructivist approaches to training and development focusing on learning processes and outcomes in relation to the development of professional expertise including "the rich amalgam of knowledge, skills, and dispositions and professional judgment" (National Board Professional Teaching Standards [NBPTS], 2010, The five core propositions, para.1). The review of adult learning theory and constructivist pedagogy has provided a framework identifying three themes: conceptual understanding, applicability, and authentic discernment. These themes also serve as major topics for discussion in examining empirical literature regarding constructivist approaches to teachers' professional learning.

Conceptual Understanding. Constructivist approaches to promote a teacher's conceptual understanding include cognitive apprenticeship, project-based learning, and social discourse. Firstly, the discussion of cognitive apprenticeship involves internship or mentoring programs to "embed learning in activity and make deliberate use of the social and physical context" (Brown, Collins, & Duguid, 1989, p.32). These programs in essence rely on a community of experienced teachers and university faculty to provide mentoring and coaching support for student teachers or novices while they perform tasks as a regular classroom teacher.

Some researchers examined the approach of cognitive apprenticeship to professional learning of pre-service (Dawson, 2005; Wright & Wilson, 2005; Windschitl, 2002) and novice (Pierson, 2005; Babinski, Jones, & DeWert, 2001) teachers. However, results of these studies presented contradictory findings regarding the impact of internship or mentoring programs.

Pierson (2005) explored the impact of an undergraduate, teacher preparation course of educational technology in influencing four pre-service teachers' practice in real classroom settings. The researcher employed case study method and gathered data through interviews, classroom observation, and the teachers' reflective journals. The study revealed that the novices failed to transfer collegial, declarative knowledge such as facts, lists, names of organized content knowledge (Smith & Ragan, 1999) into practical, contextual knowledge (interpretations of concepts, meanings, or propositions) in relation to the environment, procedures, and expectations of school culture.

In another study, Dawson (2005) explored the impact of an internship program that provided mentoring and coaching support to 30 pre-service teachers. The teachers were asked to collaborate with an in-service teacher to integrate technology in classroom. The researcher obtained the teachers' weekly journals and synthesis paper documenting the reflection and analysis of their field learning experience. The results showed evidence of egocentric conceptualizations including limited consideration of technology impact upon students, superficial understanding about technology implementation, and ignorance of contextual factors impacting technology integration, which led the researcher to conclude that the teachers demonstrated limited understanding of contextual knowledge in the domain of teaching practice.

Conversely, Wright and Wilson's (2005) study indicated that internship programs provided practical and useful field experience for student teachers. Attempting to explore the impact of a series of instructional method courses and technology infusion, the teachers were asked to develop a project of Electronic Portfolio (EP) and post it online to document their field learning. The researchers selected three subjects based on their

performance on the EP projects and employed case study method involving interview and classroom observation to explore the effect of project-based learning. The study revealed that the teachers integrated pedagogical and technological applications learned from developing an EP project into teaching practice. In addition, the researchers concluded that project-based learning enabled teachers to consolidate their knowledge of course work, field experience, and pedagogy.

Windschitl (2002) also conducted a case study to explore the impact of a teacher education course involving inquiry project and teaching practicum of six pre-service teachers. In addition to situated field learning in a classroom setting, the teachers were engaged in open discussion, reflective journaling, scaffolding activities, and group collaboration to develop science inquiry projects. The researcher collected data from reflective journals, writing projects, interviews, and field observations and found evidence of the teachers making a connection to content knowledge, questioning under a variety of scenarios, and generating propositional interpretations. In addition, the researcher noted that teachers' conceptualization of inquiry projects was associated with previous, meaningful professional experiences serving as a basis for developing conceptualizations.

Professional development of teachers may involve different methods of delivery. North, Strain, and Abbott (2000) studied the impact of a staff development program using CD-ROM modules participated by nine administrators and 19 teachers. Data were obtained through questionnaires, interviews, and observations. The researchers found that the teachers became more receptive toward domain knowledge.

In another study, Ivers, Lee, and Carter-Wells (2005) explored the impact of an online, graduate course in Instructional Design (ID) upon 18 professional educators. The researchers emailed a survey to all teachers enrolled in the course, and 15 of them responded. The survey results showed that the teachers had a positive attitude toward this mode of delivery. In addition, an online discussion board was utilized as a primary mode for knowledge sharing and exchange, and data was gathered for content analysis. The online transcript results revealed that the formation of a learning community allowing for sharing of professional experiences and field expertise was conducive to "a holistic understanding of the ID field" (p.7).

Additionally, Chung (2005) explored the effect of a professional development program using asynchronous online forums to build a professional learning community of 36 in-service teachers. Data were collected through discussion transcript, and the researcher conducted content analysis to analyze the data. The study indicated that discussion forums facilitated learning, and the teachers were found to have gained new knowledge. Statements of concept definitions, propositional synthesis, question posing, clarification of meanings, and personal insights and opinions found in the data led the researcher to conclude that the development of teachers' conceptual understanding as a result of social discourse was evident in the study.

In summary, research on constructivist approaches involving cognitive and social learning tasks suggests that these approaches have a positive effect upon teachers to obtain content, conceptual, and contextual knowledge in the domain of their learning. Moreover, some studies indicated that engaging teachers in critical reflection, project-

based learning, and social discourse in an electronic or online learning environment promoted conceptual understanding.

Studies reviewed above indicated that teachers perceived constructivist approaches helpful in promoting understanding of learning content. In the next section, the focus is placed upon the discussion of the link of constructivist approaches to developing a teacher's ability to apply their learning.

Applicability. Carr-Chellman & Breman (2000) found that applicability was associated with a teacher's professional experience. The researchers employed case study to explore the impact of an instructional design course delivered by two distinct modes, distance education and traditional residential program. To compare difference of learners in collaborative problem-solving, the distance group met initially for a three-day workshop and afterwards via online chat, web discussion board, and emails, while the traditional group met in class once a week throughout the entire semester. Data were collected through surveys, interviews, journals, online conferencing and discussion, and classroom observation. The study revealed that the distance group showed higher skills in instructional design and had more completed coursework and experience than traditional group. Because of this experience, the distance group exhibited applicability in their thinking. In addition, the teachers' responses indicated that obtaining collaborative problem-solving skills in the learning process were critical in the practice of real world settings.

Ge, Chen, and Davis (2005) also found that applicability was associated with a teacher's background knowledge and mental schema. To investigate the effect of web-based, graduate course in instructional design on eight novice designers, the researchers

employed a multiple case study and collected data through think-aloud protocols and interviews. Results of the study indicated that relevant, prior knowledge and sufficient mental schema had a positive impact on the subjects' ability to apply newly learned strategies to solve an ill-structured problem.

In studying the effect of an online master degree program for teachers, Levin, Waddoups, Levin, and Buell (2001) surveyed 26 teachers and followed up with case studies of four individuals. Data collected using case study method included interviews, classroom observation, online discussion, and course assignments. The study revealed that the online program helped teachers prepare curriculum, develop practice, and stimulate thinking in connection of instructional practice, which was relevant and applicable to their profession.

In the case of pre-service teachers, Sahin (2003) explored the impact of a teacher education course on the topic of Instructional Technology (IT). Eighty Turkish, pre-service teachers were initially given basic knowledge of IT theory and later were divided into two groups, 30 in constructivist treatment while 50 in individualized treatment. The constructivist treatment was engaged in school site visits, small group discussion, and collaborative, project-based learning, while the teachers in the individualized treatment did not visit a school and each worked independently on a project. The researcher employed an open-ended questionnaire and followed with interviews only to participants of the constructivist treatment. In the analysis of the teachers' responses, the researcher found that the constructivist treatment promoted active engagement, and the teachers were able to connect their prior knowledge to the learning experience and apply the project to field teaching.

From above studies, constructivist approaches were found to connect a teacher's prior knowledge and experiences to practical application. Brown, Collins, and Duguid (1989) argue that constructivist approaches also prepare learners to utilize "a domain's conceptual tools" that enable them to think as a specialist and perform tasks according to "the ordinary practices of the culture" (p. 34). In the context of teacher training, these conceptual tools are pedagogical strategies (e.g., strategic thinking, logical reasoning, and pragmatic planning) that develop cognitive ability of the teachers in applying (i.e. applicability) newly learned knowledge to practice. Thus, these three dimensions of applicability were discussed respectively as follows.

Strategic thinking. Swaminahan, Tawick-Smith, and Barbut (2005) studied in-service training through workshops and sites visits of training consultants. The researchers collected data from 46 teachers through field observations, interviews, and pre and post surveys with regards to the participants' perceptions about the training. The study revealed that coaching support from the training consultants reinforced the application of newly learned pedagogical strategies.

In another study, Truscott and Truscott (2004) explored the impact of a socioconstructivist approach to Professional Development (PD) of 12 elementary teachers. The program was based on a consultation model to engage the teachers in workshops, demonstration lessons, group inquiry, and coaching. The researchers collected data through interviews, questionnaires, and field notes. The result indicated that the PD provided opportunities for interaction and immediate feedback from peers and coaches as a "more knowledgeable other" (p. 59) and access to "a larger repertoire strategies and techniques" (p. 60). The study showed that teachers perceived

constructivist approaches more applicable and practical than traditional in-service training.

Furthermore, Dornisch and Duate (2005) found that negotiation via Computer Mediated Communication tools stimulated strategic thinking. In an online, cohort-based graduate program, the researchers analyzed online conferencing transcripts contributed by six in-service teachers and found evidence of teachers brainstorming project ideas, elaborating further ideas, summarizing completed tasks, and requesting information.

Hew and Hara (2007) examined knowledge sharing online by exploring the effect of an Electronic Mailing List (listserv) in supporting a learning community of literacy teachers. Online postings on the listserv were collected, and data were analyzed, which generated themes involving different knowledge types teachers shared on listserv. The results of the study showed evidence of strategic thinking involving practical knowledge (personal opinions and suggestions) shared by the teachers to resolve issues or solve problems in order to support one another through listserv.

Logical reasoning. Social discourse is found in association with developing a teacher's logical reasoning and critical thinking. Ivers, Lee, and Carter-Wells (2005) investigated the effect of an online master degree program in instructional design and explored factors impacting educators' attitude and perceptions of online instruction. Data were collected through an online discussion board. In analyzing the online postings to explore the nature of discussion through asynchronous format, the researchers found evidence of logical reasoning that contained challenging thought, argument, and clarification of issues.

In addition, Chung (2005) found evidence of critical thinking exemplified in discussion forums contributed to by 36 elementary science teachers. Analyzing professional dialogues based upon Garrison's (1991) Practical Inquiry Model, the researcher found four levels of critical thinking (triggering, exploration, integration, and resolution) advancing over time, which indicated an increase in the quality of discourse.

Pragmatic planning. Cheung and Hew (2004) found that engaging teachers in problem-solving engendered pragmatic planning. The researchers studies 47 Singaporean, pre-service teachers to explore the use of asynchronous discussion for solving an ill-structured problem. The study revealed that the teachers generated a great volume of discussion on problem solving processes in three areas: articulating problem space, evaluating contextual constrains, and generating possible problem solutions. However, due to the delay in time of asynchronous, text-based discussion, the researchers reported that the teachers focused more on expressing their own personal opinions and perspectives of the problem/solution process rather than responding to queries or interests of others.

In another study, Dail, Wright, and Gerber's (2006) explored the impact of a series of method courses involving 11 pre-service English teachers' production of digital video to document their clinical experience. The researchers employed a rubric assessment to evaluate video projects and found that teachers pragmatically planned a beginning and/or end of the story to embody the metaphor of teaching as a journey in their digital movie projects.

Moreover, in Windschitl's (2000) case study of six pre-service teachers' field teaching experience and project-based learning, the evidence of a step-by-step, procedural plan was found in teachers' science inquiry projects

Furthermore, McConnell (2002) investigated the effect of an online course in problem-based learning using grounded theory research. The researcher collected data through online discussion, projects, and interviews from seven educators enrolled in the program and found evidence of distributed, problem-based training facilitating negotiation of project timelines, goal and outcomes, assignment for individual responsibilities, and project requirements and assessment.

To summarize, constructivist approaches impacting applicability of teachers through a variety of pedagogical strategies (e.g. demonstration, modeling, coaching, project/problem-based learning, and dialogical negotiation) is evident. The emphasis in the majority of the studies was placed upon whether the training impacting teachers in their thinking of incorporating these strategies into practice. The research showed an encouraging trend in promoting a teacher's cognitive functioning in terms of strategic thinking, logical reasoning, and pragmatic planning.

Helping teachers apply newly learned knowledge or skills to practice is considered as one of the goals of professional learning. To cultivate a teacher's discernment from a vast of information through reflecting upon perspectives and personal and professional experiences in order to develop an authentic, real-world connection to teaching practice is also critical. Therefore, the next section focuses on the discussion of constructivist approaches to fostering authentic discernment of teachers.

Authentic discernment. Authenticity can be viewed as a reconciliation of a teacher's epistemological beliefs to his or her teaching practice. Brownlee (2003) explored the effect of a graduate program upon 29 pre-service teachers. In order to observe the change of the teachers' epistemological beliefs as a result of reflective practice involved in the program, 11 teachers were selected for interviews. Three consecutive interviews were conducted with each teacher during a three-year period, and the researcher found change in teachers' personal beliefs toward constructivist epistemologies as a result of reflecting upon constructivist principles.

In another study, Reid (1994) explored the impact of a graduate course upon 38 pre-service teachers. Data were collected through video taping of student teaching practice. In addition, the teachers' writing assignments including essays, journals, and class discussions were gathered to compare the teachers' beliefs in relation to their actual teaching practice. In analyzing 21 videotaped classroom performances and writing assignment, the researcher found little connection of the teachers' beliefs to their performance in the classroom. Thus, the research concluded that the teachers appeared to incorporate constructivist principles into the written and oral discussions; nevertheless, their teaching performance did not reflect these epistemologies.

Using a comparative research design, Al-Weher (2004) investigated the impact of two different instructional approaches (constructivist and lecture) upon Jordanian, pre-service teachers' perceptual change toward a constructivist viewpoint. The teachers were divided into two treatment groups; 121 were assigned to the constructivist treatment, and 124 were assigned to the lecture treatment. The constructivist treatment involved approaches of group discussion, metacognitive learning activities, learner directed,

instructor-facilitated presentation, and design of lesson projects. On the other hand, the lecture treatment included the same course materials taught by the same instructor through lectures. All participants took a multiple-choice, researcher-created test based on a constructivist viewpoint prior to and after the course, and test results were compared based on gain scores after the two administered treatments. The researcher employed Multivariate analysis of covariance (MANCOVA) to examine differences in gain scores of the two approaches and found a significant difference in perceptual change between these two groups. The researcher concluded that constructivist approaches were more effective in reconciling the teachers' beliefs to constructivist epistemologies than lecture.

In summary, the three studies reviewed above indicated that constructivist approaches had a positive impact upon teachers' perceptual change toward a more constructivist viewpoint, however, their classroom practice did not reflect these epistemological beliefs. These studies indicated that the teachers' action failed to reflect their beliefs, thus authenticity was not evident in teachers' practice.

In a different light, Cranton and Carusetta (2004) examined authenticity in ways of teachers learning and discerning from real-world connections. The researchers employed a grounded theory method to study 22 university faculty and found five dimensions: self-awareness, awareness of others, relationships with students, awareness of context, and a critically reflective approach to practice. The researchers found that these dimensions are associated with showing authenticity in teaching performance, indicating that "as awareness develops, so does authenticity" (p.20).

Consequentially, these dimensions serve as a framework to review empirical research that explored a teacher's authentic discernment developed through the course of professional learning.

Self-awareness. According to Cranton and Carusetta (2004), self-awareness involves the discussion of individuals as people and as teachers, their journey of becoming teachers, their values and perspectives, the conflict and challenges they encountered in reality, and "the ways in which they brought themselves as people into their practice" (p.12). In relation to a teacher's professional learning, this self-awareness brings about an intimate relationship between learning and self, thus, learning becomes personal.

Evidence of self-awareness was found in the following studies. In analyzing teachers' reflective journals documenting their field experience and developing a science inquiry project, Windschitl (2002) found that the teachers expressed a personal interest in developing their projects. Moreover, Pierson (2005) interviewed four novice teachers, and in their response the researcher found evidence of teachers realizing personal use of newly learned knowledge in everyday situations. Furthermore, Dail, Wright, and Gerber (2006) analyzed video projects produced by 11 teachers and found the teachers developing new perceptions about their teaching roles, viewed themselves as facilitators rather than directors.

To study the impact of weblog that Kline and Burstein (2005) defined as a website used as online diaries in facilitating professional learning community, Dickey (2004) collected postings of a communal blog contributed by 111 pre-service teachers. In the analysis of these postings, the researcher found that the teachers expressed personal

feelings including stress, anxiety, excitement, or satisfaction. The researcher concluded that the use of blogs allowed self-expression of affective factors, which could have a positive effect on preventing feelings of isolation and alienation of teachers engaged in web-based, professional learning.

Alsup (2004) found that constructivist approaches were more effective in promoting learner autonomy than the lecture style of teaching. This study investigated the effect of the two approaches (constructivist vs. lecture) on three affective dimensions including anxiety, teaching efficacy, and the sense of autonomy and empowerment. Learning content and materials of the two courses were similar and were taught by the same instructor. The lecture treatment used a traditional lecture-recitation format of instruction, while the constructivist treatment included explicit instruction of key concepts, learner-led group discussion, and collaborative problem-solving tasks. All participating teachers were given a self-evaluated survey prior to and after the completion of the course. Analysis of Covariance (ANCOVA) was conducted to examine the post-test scores (with the pre-test scores as the covariate) between the constructivist group (27 teachers) and the lecture group (17 teachers). The study revealed no significant difference in anxiety or teaching efficacy; however, the constructivist group demonstrated a significant gain in autonomy. The researcher concluded that the constructivist approach was more empowering in learner autonomy than the lecture approach.

In summary, evidence was found in the above studies that constructivist approaches promoted self-awareness of teachers and allowed them to gain perspectives, express personal feelings, establish a personal connection to learning, and enable them

become autonomous learners. In a professional setting, teachers work and learn with others, so it is critical to examine their awareness of others, which may influence their perspectives and impact their experiences.

Awareness of others. Cranton and Carusetta (2004) discussed this awareness as a teacher's perceptions and knowledge toward individuals or through interacting with others in a teaching and learning environment. Therefore, reviewing literature in this dimension focuses on exploring the nature of relationships between teachers and their colleagues or peer learners.

North, Strain, and Abbott (2000) explored the impact of a multimedia training program for 28 teachers in the use of Information Communications Technology (ICT). The teachers were engaged in independent distance learning through CD-ROM modules and video conferencing. Focusing on the teachers' perceptions of the training, the researchers collected data through interviews. The study revealed that the senior teachers (yet still novice learners in ICT) preferred private exploration through CD-ROM modules to traditional training workshops, which helped refrain from professional embarrassment and peer pressure. In this study, awareness of others was viewed as a negative factor impacting professional learning of teachers.

On the other hand, some studies revealed that professional exchange among peers facilitated learning. Burge, Laroque, and Boak (2000) explored the nature of their research process in a professional development event. The study utilized reflective journals as a research tool to document intrapersonal dialogues about the three researchers' experiences in moderating an asynchronous discussion participated by educators and trainers. The researchers conducted a meta-reflection analysis and found

that reflecting upon their own experiences and exchanging dialogues with peers aided to their understanding of a moderator's role as facilitator in a professional learning community.

In addition, Rodgers and Chaille (1999) documented their interpersonal dialogues with special education, pre-service teachers for the purpose of observing the researchers' own teaching practice. The research revealed that intrapersonal or interpersonal dialogues provided insight into refining one's role in teaching, facilitating, and learning as both an educator and researcher.

Awareness of others with reference to the role one serves in a learning community may lead to the development of professional identify. In exploring the collaborative problem-solving process of seven educators in an online course, McConnell (2002) found that recognizing one's role in relation to peers in a learning community had an impact on constructing professional identity. The study revealed that the identity constructed in the learning community intersected the professional identity of real world.

To study the impact of social discourse on forming a learning community, Chung (2005) conducted interviews with six teachers via synchronous chat. The researcher found change in teachers' perceptions about the traditional view of colleagues as their awareness of others developed through the course of social exchange. The study indicated that the concept of colleagues was no longer bounded by district or school settings, but redefined in a global sense of community.

Moreover, developing a teacher's awareness of others was found to have a validating effect (Truscott & Truscott, 2004). In observing British teachers' use of an online forum over a two-year period, Selwyn (2000) found that the forum served as a

resource of information and empathetic exchange for "swapping experiences and comparing personal situations" (p.760-761). Other researchers found that this discernment of others served as a critical mechanism to scaffold learning effort (Ge, Chen, & Davis, 2005) and to "perturb the equilibrium of [learners'] world views" (Windschitl, 2002, p.138) in order to avoid misconceptions or naïve, intuitive presumptions.

To sum up, the studies reviewed in this section suggested that peers are a source for professional learning and growth. In the context of education, one of the primary responsibilities of teachers is to promote learning and growth of students. Thus, in the next section, the focus is placed on understanding the development of awareness of students.

Awareness of students. According to Cranton and Carusetta (2004), this dimension focused on the nature of teacher/student relationship to help teachers discerning real-world connections to students.

Dawson (2005) explored the impact of an internship program upon 30 pre-service teachers in integrating technology in classroom. The teachers' weekly reflection and synthesis paper upon their student teaching experience were collected for analysis. The researcher found evidence of the teachers developing awareness of students, and comments were found relating to students being motivated by technology and considering individual needs of students. In addition, the teachers commented on their concerns about the diverse level of technology expertise of students. The researcher noted that being aware of motivating factors, learning needs, and knowledge level of students should enable the teachers to exercise individual discretion that prioritized skills

and identified strategies accordingly, however, no evidence was found in the study with reference to the effect of technology integration influencing student learning.

In addition, Truscott and Truscott (2004) investigated the effect of a professional development (PD) project in the format of providing onsite consultation for 12 elementary teachers. The researchers conducted pretest and posttest questionnaires asking the teachers to rate statement of 11 specific literacy areas from strongly agree to strongly disagree based on their perceptions. Particular in the item that dealt with knowledge based and classroom application of struggling learners, the researcher found perceptual change of teachers as a result of the PD project. The study revealed that 63% of teachers rated themselves less confident in their knowledge about support struggling learners in posttest than they did in the pretest. However, in terms of rating the importance of the 11 literacy areas for struggling learners, the researchers found change in the ratings about importance of some literacy areas. For example, 76% of the teachers indicated a decrease of importance on these areas, which suggested that the teachers developed discernment in prioritizing important skills and strategies for struggling learners. Prior to the PD project, the teachers rated all areas important for struggling learners. This finding allowed the researchers to conclude that the PD project enabled teachers to "dismantling of previous knowledge" (p. 62) so they had come to realize a need to continually learn and develop their knowledge about struggling students.

The review of the two studies showed that situated learning in real classroom environment promoted teachers' awareness of students and developed their discernment. However, in order to transfer this awareness and devise learning activities to elicit real-

world connections for students, one needs to understand teaching contexts. Thus, in the next section, the review of studies focuses on awareness of context.

Awareness of context. Knowledge of one's teaching context including grade level and subject content to school culture and social environment in larger culture enabled individuals to consider contextual factors influencing their teaching practice (Cranton & Carusetta, 2004).

Wade, Fauske, and Thompson (2009) explored the effect of a teacher education course using peer-led, Computer-Mediated Dialogue. Particularly interested in reflective practice of problem solving, the researchers collected asynchronous discussion on the topic of instructing English Language Learners. In analyzing nine pre-service teachers' online dialogues, the study indicated that the teachers "tended to focus on the personal and academic consequences for particular students rather than social and political consequences" (p. 431). From these dialogues, the study revealed that there was a deficit in perspectives, ideologies, and policies of schools in the pre-service teachers' thinking that hindered them from critically reflecting upon the problem in a larger, social and political context.

Moreover, real-world connection in teaching context had an impact upon the volume of discussion. Lara, Howell, Dominguez, and Navarro (2001) investigated the effect of a web-based course. The researchers collected data of online dialogue through synchronous and asynchronous discussions of six bilingual Hispanic teachers including three pre-service teachers from the U.S. and three in-service teachers from international Spanish speaking countries. In counting the number of words in interactions via online chat and threaded discussions, the researchers found that in-service teachers contributed

more words than pre-service teachers. The study revealed that richness in real-world connections were attributed to enabling more experienced teachers to actively participate in online discussion.

In addition, a number of researchers found that real-world experiences help teachers to discern relevancy of content knowledge (Carr-Chellman, Dyer & Breman, 2000); to demonstrate a sophisticated level of performance in learning projects (Windschitl, 2002); to be skillful in solving ill-structured problems (Ge, Chen, & Davis, 2005); and to construct a holistic as well as the discriminative, interdisciplinary view of the profession in a larger context (Ivers, Lee, & Carter-Wells, 2005). Conversely, lacking this contextual awareness and connections to real-world experiences, the novices were found to "emulate what they were taught" (Wright & Wilson, 2005, p.2), incapable of "differentiating themselves from the collective of teachers" (Cranton & Carusetta, 2004, p. 6).

The studies reviewed above indicated that awareness of context provided a knowledge base for guiding a teacher's instructional practice. In addition, Cranton and Carusetta (2004) found that critical reflection with "open, questioning, mindful consideration" (p. 21) of context was important to help teachers to become authentic in their teaching practice. Thus, studies related to reflective approach to practice are examined in the next section.

Critical reflective approach to practice. According to Cranton and Carusetta (2004), critical reflection involved an "analytical, rational, and judgmental process" (p.18) of examining one's teaching practice.

Swaminahan, Tawick-Smith, and Barbuto (2005) explored the effectiveness of a professional development program in the topic of technology integration upon 46 teachers. The participants met monthly in forms of workshops, and workshop trainers and a technology consultant conducted school visit to provide additional support to the teachers. Data were collected through field notes of classroom visits and observations upon the change of teachers' instructional practice regarding technology implementation. The researchers found evidence of critical reflection upon practice enabling the teachers to identify needs of their students and improvise ways to incorporate newly learned technology skills into general teaching practice (e.g. creating visual aids in digital media, developing instructions for fire drill in electronic format, and expanding parent-child communication to include emails).

In analyzing weblog postings of a communal blog for 111 pre-service teachers, Dickey (2004) also found that the teachers reflected upon subject and grade level they taught and considered various instructional situations for them to implement the projects they developed during the course of learning.

The two studies revealed that engaging teachers in critical reflection enabled them to consider ways of incorporating newly learned knowledge or skills into practice.

To summarize studies reviewed in the section, constructivist approaches promoting a teacher's authentic discernment is evident. This discernment enabled a reconciliation of beliefs and values to one's professional role, thus, helping one think like a teacher. In terms of manifesting this thinking in teaching practice, empirical research revealed that constructivist approaches promoted a teacher's awareness of self, others,

students, contexts, and reflective approaches to elicit a real-world connection, so they become authentic and discerning in their practice.

Summary of Empirical Studies

The review of empirical studies provides insights into the processes as well as to the outcomes of constructivist, web-based, open environment for professional learning of teachers. These approaches including cognitive apprenticeship, project-based, problem-based, collaborative learning, and social discourse may facilitate conceptual understanding to promote the attainment of practical, contextual, and content knowledge.

In addition, constructivist approaches may serve as pedagogical strategies that develop a teacher's cognitive ability for applying (applicability) newly learned professional knowledge to practice. The reviewed studies indicate that applicability is manifested in logical reasoning, strategic thinking, and pragmatic planning when the approaches engage teachers in learning activities entailing reflective thinking and cognitive processing as well as social discourse and dialogical negotiation to solve an ill-structured problem.

Furthermore, reviewing empirical research indicates evidence of authentic discernment as an outcome of constructivist learning. Discerning of real-world connections to promote self-awareness, awareness of others, relationships with students, awareness of context and critical reflective approaches to practice, constructivist approaches may bring about a reconciliation of teachers' epistemological beliefs to instructional practice or empower the teachers to become more autonomous, thus, asserting a more discerning view to establish professional identity.

However, the majority of studies reviewed above tended to explore the effect of professional development by focusing on the change of teachers' perceptions or attitudes rather than the actual thinking process in a web-based, open learning environment. In a few studies that dealt with observing the thought processes of teachers engaged in problem solving, the researchers obtained data through asynchronous discussion or online postings. Factors such as the lag in time, interactive effect among teachers, and pressure for participation could have influenced the result of discussion, thus what was observed might not be the actual thoughts of teachers in considering solutions to solve an ill-structured problem. Thus, to add to the literature of web-based professional learning, this study employed think-aloud protocols to explore and observe the actual thoughts of teachers engaged in the process of problem solving in the Open-Ended Learning Environment.

Consequentially, this literature review serves as a conceptual base to operationally define the constructs (conceptual understanding, applicability, and authentic discernment) of the research. These concepts, discussed more fully in the next chapter, provide a framework to explore the thinking processes of teachers who are engaged in problem solving tasks prompted by web-based, OELE modules.

Chapter III: Methodology

To explore cognitive processes of teachers while performing problem solving tasks in the Open-Ended Learning Environment (OELE) lends this study to qualitative inquiry. In this methodology chapter, several topics including research design, study sample, data collection, data analysis, and study limitations are discussed.

Research Design

Answering the research questions bore a significant and personal meaning to the researcher because of her experience in teaching and her interest in instructional design. Because of this professional association, the training topic and tasks were aimed at problem-based learning for the instruction of English Language Learners (ELL). Inquiring into the thought processes of learners in web-based, OELE, think-aloud protocols provided an observational tool for understanding the professional learning of teachers.

Research questions. For the purpose of studying cognitive processes of teachers as professional, adult learners while solving authentic problems, the research includes two questions:

1. What is the nature of a teacher's thought process when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?
2. What is the nature of a teacher's thought process in the context of group learning when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?

The web-based, OELE modules. The researcher in this study designed the course, Web 2.0 Infusion for Teaching English Language Learners (see Picture One), as a mode of professional learning for teachers. Encompassing a series of learning activities, the professional learning aimed for effective classroom-based practices and required learners to incorporate media technologies into teaching English Language Learners who are national-origin-minority students with limited English proficiency (US Department of Education, 2005).

Picture One	

The course focuses on hands-on learning experiences and information technology skills related to effective classroom-based practice. Learning goals include: (a) to gain knowledge and understanding about ELL instruction through module exercises, (b) to develop teaching expertise through problem-based learning, and (c) to incorporate media technologies into teaching practice.

The course includes two learning modules, and the learning goals of each module are as follows:

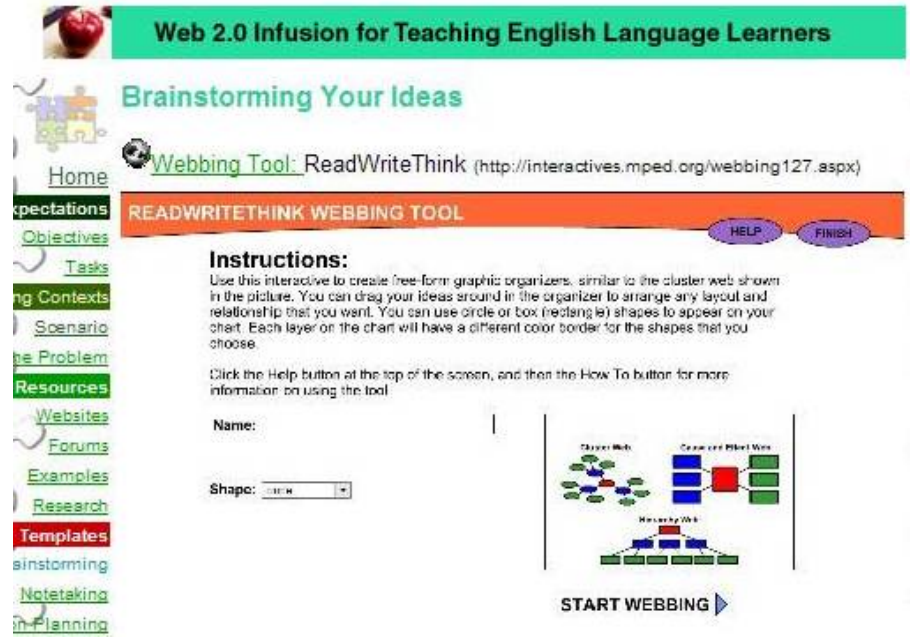
1. Understanding English Language Learners: To read and discuss related research literature about educating students with different language and cultural backgrounds and reflect upon personal experiences with ELL students.
2. Incorporating Web 2.0: To access different Web 2.0 media resources and discuss the utility, strengths and weaknesses, and implications for educating ELL students.

Learning materials are designed and structured according to four OELE components: enabling contexts, tools, resources, and scaffolds. A problem scenario (see Picture Two) is introduced to situate a learning context and to orient the teachers toward learning goals and means. The scenario features a third-grade teacher confronted by various challenges of teaching English Language Learners. This scenario serves to situate learning in a realistic context enabling teachers to reflect and connect to their own classroom situations. Using situated learning, prior knowledge is activated and supports conceptually understand of the content.

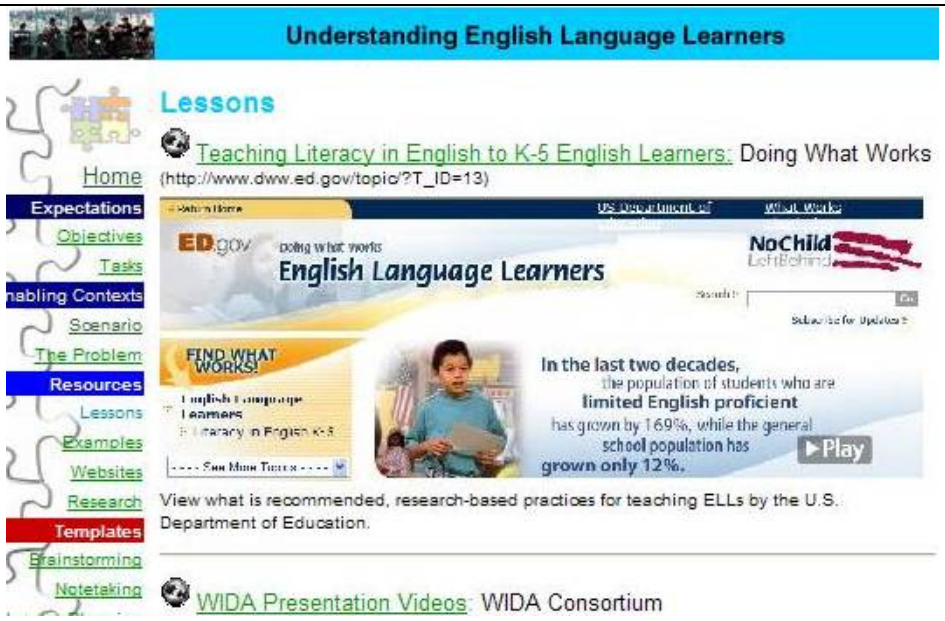
Picture Two	

Three types of tools are embedded for conceptualizing technology-infused instruction. Manipulative tools include graphic organizers (see Picture Three), integration level animation, etc. Processing tools, such as personal blogs for note-taking or recording personal thoughts, reflection, interpretation, and explanation of conceptions; lesson plan templates for organizing and planning, are for information processing. Finally, a communal blog serves as a communication tool, as a forum for general discussions, announcements, feedback, request for assistance, and concerns for the program facilitator (the researcher), and the teachers to build a professional learning community.

Additionally, these tools are incorporated into various learning activities allowing teachers to develop strategic thinking, logical reasoning, and pragmatic planning, which promote their cognitive abilities of applying (applicability) learning.

Picture Three	

Resources, including links to electronic media involving databases, websites (see Picture Four), video lessons, documents and reports, and experts in the field, can be static or dynamic. These resources contain examples of technology-infused lesson plans and learning activities, reports pertaining to ELL student learning, and experts on effective instructional model in K-12 education. Materials included in the resources provide information about key concepts, instructional methods, student data, and effective practices. These resources allow teachers to access additional information which can help them understand the key concepts and select information they identify as relevant to their needs.

Picture Four	

Scaffolding provides teachers with guidance and support for identifying appropriate tools and relevant and available resources in order to accomplish the learning tasks critical to self-directed, independent learning. For instance, conceptual scaffoldings prompt teachers regarding factors to consider when approaching the problem. Metacognitive scaffoldings such as examples and effective models demonstrate important critical thinking skills needed for solving a problem. Frequently asked questions with regard to system features are procedural scaffolds. All scaffoldings are provided via blogging (see Picture Five). These features allow teachers to ask questions and share concerns with their peers and instructors, reflect upon their own experiences and exchange ideas with peers, and monitor their understanding of learning content, which are critical in promoting teachers' conceptual understanding, applicability, and authentic discernment.

Picture Five	

Think-aloud protocols. This study employed think-aloud protocols to explore thinking processes of teachers in a web-based professional development program designed based on the OELE instructional model. According to constructivist pedagogy, learning requires egocentric, cognitive processing of an individual (Piaget, 1973; Wink & Putney, 2002) and social, dialogical negotiation among a group (Vygotsky, 1978; Daniels, 2001). Therefore, the researcher employed the research method of think-aloud protocols to observe cognitive processes of teachers both individually and collectively as a group when engaging in problem solving tasks prompted by the modules.

As a research method often used to study human thinking process, think-aloud protocols gather data by asking an individual to verbalize thoughts concurrent with focusing on solving a problem efficiently (Ericsson & Simon, 1993). Accordingly, think-aloud protocols provide a method for studying a teacher's ongoing cognitive processes in

real-time professional learning. Unlike retrospective reports relying on memory to recall information at a later time, concurrent verbal reports can capture a learner's verbalization at three levels: "oral encodings," "explication of the thought content," and "an explanation of thoughts, ideas, hypotheses or motives" (Ericsson & Simon, 1993, p.79) in real-time, on-task learning.

Think-aloud protocols are often utilized to gather direct data on human problem solving (Someren, Barnard, & Sandbert, 1994). Particularly interested in how subjects arrive at the solution, what they think, what tasks are easy or difficult, and how they reconcile conflict demands, Someren, Barnard, and Sandbert argue that think-aloud protocols can help researchers gain insight and knowledge on "two types of reasoning: constructing solutions and constructing justifications of these solutions" (p. 8) to a problem.

In the pool of empirical studies focusing on the application of the method, think-aloud protocols were utilized to explore cognitive processes of children in reading comprehension (Meyers, Gelzheiser, & Pruzek, 1989) and of undergraduate students in decision making (Lucas & Ball, 2005). Additionally, think-aloud protocols have focused on cognitive activities of adults in information processing including web navigation (Eveland & Dunwoody, 2000) and software development (Karahasanovic, Hinkel, Sjoberg, & Thomas, 2009). The method was also used to study the superior performance of an expert in memorization (Hu, Ericsson, Yang, & Lu, 2009) in order to "develop a collection of standardized laboratory tasks that capture the essential aspects of a particular type of expert performance" (Ericsson & Lehmann, 1996, p. 281).

Teachers are proponents of thinking and learning. Their daily tasks involve constantly verbalizing thoughts and modeling thinking-aloud to the students to help them solve problems in various subjects. In this study, the subjects were teachers who performed their instructional tasks through teaching aloud by modeling and scaffolding their thinking process to students. Since verbalizing thoughts was part of regular practice, with little training, the teachers were able to provide rich, explicit, and explanatory utterances of their "inner life of thought" (Vygotsky, 1987, p. 246). Thus, these concurrent verbal reports captured certain essential characteristics of expertise in teaching and learning.

Moreover, a retrospective, verbal report about the collaborative problem solving of teachers provided an understanding regarding an individual's thinking and learning in the context of group situation. Ericsson and Simon (1993) argue that post-experimental questioning engenders recognition processes, "a retrievable trace of connected episodic memory" (p.149) stored in long-term memory (LTM). Accordingly, asking the subjects to recall the group learning processes may bring together "the contents of focal attention with information accessed from LTM" to form a new memory structure (p.117). Since these new memories were indexed to the LTM content at the time of learning, the teachers were more likely to retrieve successfully to provide accurate information about their learning. Thus, the researcher conducted interviews after the training to obtain thoughts of each teacher regarding the group learning in order to explore the impact of social discourse and collaborative effort of problem solving impacting a teacher's thought processes.

Sampling Technique and Study Subjects

The researcher utilized purposive sampling techniques in selecting study subjects to "provide maximum insight and understanding" (Ary, Jacobs, & Razavieh, 1996, p.480) of a teacher's thought processes in a professional development program for new teacher induction. The subjects included six voluntary participants who were elementary teachers in an inner city school located in a southwestern state. Mcvay, Murphy, and Yoon (2008) argue that groups of three learners are an effective configuration for collaborative learning. Accordingly, these six teachers were divided into two groups for the training. All six teachers had taught in the school for less than two years, thus, participating in training oriented them to be aware of and become more familiar with effective, innovative instructional practice for ELL instruction guided by the school's strategic aims and goals. Of the six teachers, four were females, and two males. One female teacher had 26 years of teaching experience, and the other three were novice teachers in their first or second year. One male was a first year teacher, and the other had taught for four years.

Data Collection

Two research questions guided the collection of data sources and procedures of the study. To answer the first question, concurrent verbal reports are the source for obtaining data with regards to the nature of a teacher's thought processes of problem solving in a web-based, OELE module. Additionally, retrospective verbal reports serve as a data source for studying a teacher's thinking and learning processes impacted by social discourse and collaborative problem solving in the context of group learning.

Research procedures. The study was administered by the researcher in a small classroom of the elementary school in which she taught. All subjects worked in the same school with the researcher, and each individual had a laptop computer to access the training modules designed by the researcher. An introductory section was provided to the subjects prior to the training to explain the purpose of the research, the tasks entailed in the study, and the protection of data. In addition, the researcher discussed issues related to basic accessing and navigating web content, technical requirements, and how learning activities and tasks were structured in the modules.

The training involved two different learning situations: group and individual settings. According to the nature of learning tasks, the first training module, "Understanding English Language Learners," required the subjects to identify problems, reflect upon personal experiences, read literature related to effective instructional practices, and discuss implications for ELL learners. These tasks involving social discourse and collaborative problem solving of learners were suitable for small group learning. In this module, the subjects were asked to interact face to face with one another, discuss their ideas, and consider alternatives to solutions. Prompted by the module scenario, the subjects collaboratively solved an authentic problem drawn from classroom instruction. The group learning took approximately 90 minutes and was videotaped. The video recording would later serve as question prompts for interview after the subjects completed all learning modules.

On the other hand, "Module II: Incorporating Web 2.0" was a module designed for an individual learning situation. Accessing and browsing various websites to learn the utility and application of media technologies for instruction, the subjects were asked

to navigate through the sites and were engaged in independent, personal, and experiential learning activities. Before approaching the problem solving tasks prompted by the module, the researcher instructed the subject to describe everything he or she was doing or thinking when engaging in the activities. The think-aloud task was explained to the subject, and the researcher followed the guidelines suggested by Ericsson and Simon (1993) to remind the subject to "keep talking" only when he or she stopped verbalizing the thoughts, thus, maintaining minimal interruption or influence on the subject's thinking and decision-making processes (see Appendix A for think-aloud instruction). The individual learning module took about 60 minutes, and the learning processes of the subject's think-aloud was audio recorded.

After the completion of the training, the researcher conducted a 30-minute interview with each subject, which was also audio recorded in order to obtain retrospective, verbal reports about the subject's cognitive processes regarding group learning. The group learning was video-taped during the first training module, so prior to the interview, the researcher reviewed the recording and selected six excerpts of video clips based on the relevancy to the constructs (conceptual understanding, applicability, and authentic discernment) derived from the literature review of this study. Thus, these constructs served as a priori to select video excerpts for interview. The selection of video clips were based on four different group learning tasks including problem scenario, instructional theory, pedagogical strategies, and learning activities for ELL instruction. In addition, two video excerpts were selected when group members engaged in thought provoking discussions in order to explore the effect of group interaction upon thoughts of teachers. Interview questions were also developed along with these six video excerpts

serving as triggering events to further probe the subjects' thought processes in the context of group learning (see Appendices B and C for clip selections and interview questions).

The researcher collected multiple data sources including video recordings of group learning for question prompts, concurrent verbal protocols, retrospective verbal protocols, and field notes and observations for the purpose of data triangulation (Creswell, 1998). In addition, approvals from the Internal Review Boards (IRB) of both the school district and the University were also obtained for the purpose of protecting human research subjects. Immediately after the approval, informed consent forms were distributed to each subject and signed forms were obtained from all participants. After completing the study, participants were given a $20 gift card from a local restaurant as a token of appreciation for their voluntary participation in the study.

Data Analysis

According to Someren, Barnard, and Sandbert (1994), think aloud protocols are employed to "validate or construct theories of cognitive processes" (p. 9) when experts undertake a solution process to solve a problem. In the training, an authentic classroom problem was presented to the subjects to solve. In the search for solutions, each subject was asked to perform a set of standardized tasks including brainstorming various ideas, reflecting upon personal experiences, reading relevant literature, and incorporating instructional strategies as a classroom teacher. Therefore, obtaining direct data of these cognitive processes that mediated the tasks performed by the subjects in the training was structured to "uncover… generalizable aspects of cognitive processes" (Ericsson & Simon, 1993, p. 263) of a teacher in professional learning.

In public school systems, the National Board for Professional Teaching Standards (NBPTS) have set the highest professional teaching standards since 1987. These standards include an empirically scrutinized assessment to evaluate teaching performance, and National Board Certified Teachers are proven to be highly qualified professionals who contribute to improving student achievement (Goldhaber & Anthony, 2004). Accordingly, the NBPTS assessment that evaluates professional teaching performance can serve as a framework for validating teachers' cognitive processes in problem solving during a professional development activity.

According to the NBPTS (2010), professional performance of a teacher is characterized by a "rich amalgam of knowledge, skills, and dispositions and beliefs" (The five core propositions, para. 1), which guides what a proficient teacher should know and be able to do. Professional teachers may demonstrate conceptual understanding about theories of subjects, of skills, of curricular design, of teaching methods, and of students and human development. Moreover, professional teachers may exemplify the ability of applying pedagogical strategies for differentiated instruction according to the language abilities, special needs, or learning styles of students of diverse backgrounds. Furthermore, professional teachers may exhibit authentic discernment to improvise instructional activities eliciting a real-world connection. Therefore, the NBPTS provides conceptual support for three essential characteristics (conceptual understanding, applicability, and authentic discernment) of a teacher's cognitive processes that mediate problem solving exemplified in the verbal reports obtained from think-aloud protocols.

These three characteristics serve as a priori categories for developing a coding scheme (see Appendix D for codes and descriptions for each category) to analyze the

content of verbal protocols generated in this study. However, coding categories are not limited, and new categories can emerge inductively during the coding process to "identify regularities and patterns" (Ericsson & Simon, 1993, p.263) in the data of the verbal protocols.

Analyzing verbal data includes three procedures: transcribing, segmenting, and encoding (Someren, Barnard, & Sandbert, 1994). Firstly, verbal protocols were transcribed into text with the researcher's notes and observations inserted during transcription. The researcher divided the written protocols into segments by listening to the audio recording for boundaries of phrases in speech that were marked by pauses. Segments were combined into episodes in order to determine a corresponding element in the coding schema. When an episode appeared irrelevant to task performance, it was encoded into one special coding category (see Appendix E for codes and descriptions for special categories). Finally, the number of occurrences within each category was tallied and trends and patterns were identified to form themes.

Limitations

This study employs a qualitative approach to explore teachers' cognitive processes in a web-based training program, thus, several limitations need to be noted. First, the data obtained from verbal protocols came from teachers who volunteered to participate in this research, thus, the findings reported in the study might have been biased in terms of teachers who favor a web-based, technology-rich learning environment. It would therefore be useful to examine the thought process of teachers who have little knowledge about web-based learning and are intimidated by the use of technology in instruction.

Another limitation is the relatively small number of participants taking part in this study. Consequently, the conclusions regarding the development of teachers' conceptual understanding, applicability, and authentic discernment after a professional development program need to be viewed with caution as they would not be representative of all elementary teachers. Future studies with a larger sample size would be useful to verify the findings of this study.

Lastly, as a researcher and a fellow teacher, I found my personal rapport with the participants interfering with my interpretation and judgment of the findings, thus impacting the results of this study. In my attempt to present a complex, holistic picture of the teachers' learning and thinking using an interpretive, naturalistic approach, I often drew upon my own insight into the context of elementary school where I taught, including its environment, the management style of the building principals, the instructional programs impacting teaching focuses, and my friendship with some of the participating teachers. According to (Creswell, 1998), my prolonged engagement in the study context as both a teacher and a researcher can serve as a positive factor in establishing trustworthiness. Even though, my relationships might have influenced my interpretation of the way the teachers thought and made decisions while solving problems in the training, I believe that because of this proximity to the study context, my interpretation of the data collected in this study would lead to a more trustworthy portrait of a teacher's thought processes in professional learning. However, seeking collaborative effort with other researchers who have no involvement in public school settings may serve as a cross-checking of research findings. Another alternative may be to duplicate the study in a different elementary school.

Trustworthiness of the Study

Establishing trustworthiness in research processes is critical in qualitative studies. Creswell (1998) identifies seven criteria including prolonged observation, triangulation, peer review, bias clarification, in-depth description of study settings, member check, and external audit. Creswell recommends researchers select at least two of the seven criteria for the purpose of establishing trustworthiness of their studies.

The research meets four of the seven criteria as follows:

1. Prolonged engagement and persistent observation: The researcher's six years of experiences working in the research setting supported a climate of trust with participants and an understanding of the culture of the setting.
2. Triangulation: This study collected data from multiple sources including concurrent and retrospective verbal protocols, video recordings of teachers' group learning, and the researcher's notes and observations. In addition, multiple data analysis methods were incorporated including a systematic protocol analysis process and a theme-based approach informed by the literature review. Furthermore, using multiple theoretical frameworks, adult learning, constructivism, and information processing enabled the researcher to examine the complexity of the study phenomenon from different perspectives.
3. Clarifying researchers' bias: The researcher recognized and reported her experiences and personal connections to study participants that may have impacted the data interpretation processes.

4. Rich, thick description: The researcher provided a detailed portrait of the study settings, which will support the transferability of this research to other study settings.

Summary

Problem solving in the web-based, Open Ended Learning Environment (OELE) requires a learner's cognitive functioning (Land, 2000). In this chapter, six teachers were asked to perform the task of solving several problems. The teachers' cognitive processes were documented through think-aloud protocols. Consequentially, these verbal protocols were collected and the content of the protocols were analyzed using a coding scheme developed based on the literature review in order to understand the thought process of a teacher's professional learning.

Chapter IV: Findings

This study examines two research questions designed to explore thought processes of six teachers engaged in web-based modules in two different situations, individualized and group learning. These two questions generate concurrent as well as retrospective verbal reports of think-aloud protocols. Accordingly, the findings of this study are reported in two sections to answer the research questions posed in this study.

Analyzing data generated through verbal reports is conducted based on Someren, Barnard, and Sandbert's (1994) model of protocol analysis. The process includes transcribing audio recordings into written text, dividing the text into segments, labeling each segment using a researcher-developed coding schema, assigning a number in sequence to each labeled segment, and finally combining segments that have the same label in sequence to form a complete thought episode. Each thought episode serves as unit analysis of the study to examine the nature of a teacher's thought processes in solving an ill-structured problem in the Open-Ended Learning Environment (OELE). Additionally, in order to protect participants' identity, pseudonyms are used for individual teachers selected for the think-aloud experiment in this study.

Findings on Question One

Research Question: What is the nature of a teacher's thought process when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?

Answering this question involved real-time observation of individual teachers who were asked to verbalize their thoughts while engaged in learning activities prompted

by an OELE module in an independent, learning situation. The topic of the learning module focused on incorporating Web 2.0 technologies for instructing English Language Learners (ELLs). Learning tasks included identifying a problem presented in the module's scenario movie, viewing a slide presentation introducing Web 2.0 technologies, accessing various media technology websites, and browsing and navigating online resources for instruction.

The coding schema developed by the researcher includes four major categories: conceptual understanding, applicability, authentic discernment, and special codes. These categories that are derived from the literature review of this study serve as a conceptual framework for analyzing concurrent verbal reports of teachers engaged in module exercises to solve an ill-structured problem.

The protocol analysis of concurrent verbal reports resulted in a total of 1,248 thought episodes. Among these, 326 episodes (26.1%) were coded as conceptual understanding, 153 episodes (12.3%) as applicability, 304 episodes (24.4%) as authentic discernment, and 465 episodes (37.3%) as special codes (see Figure 4.1).

Figure 4.1 Distribution of Thought Episodes in Four Categories from the Analysis of Concurrent Verbal Protocols

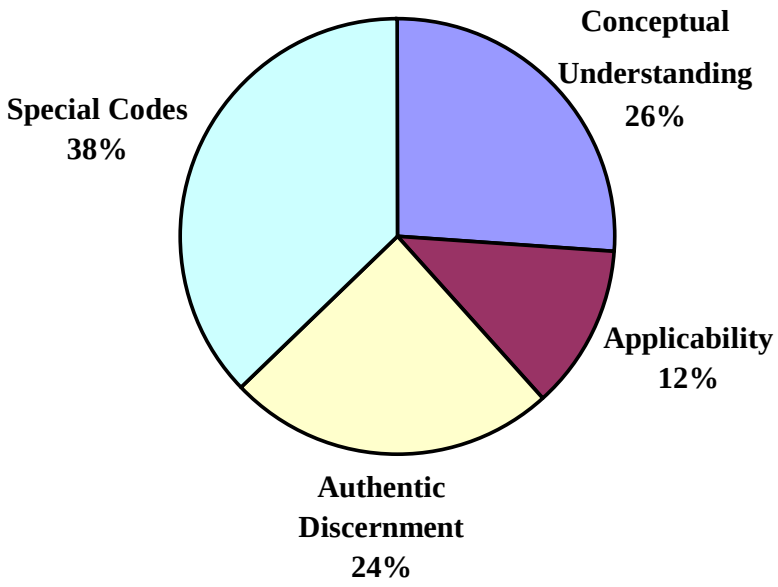


Figure 4.1 shows that twice as many thought episodes were found within the categories of conceptual understanding or authentic discernment than in the category of applicability when teachers were engaged in independent learning in the OELE module. Yet, the non-task related thinking for problem solving (special codes) accounted for the largest proportion of thought episodes shown in all categories.

The percentages present an overall distribution of thought episodes based on the four major themes listed above. However, to understand the nature of a teacher's thinking processes of problem solving in an individualized learning situation, specific

thought episodes in each category are examined in order to provide insights into the professional learning of teachers in the Open-Ended Learning Environment.

Conceptual understanding. The literature review of this study indicates that the OELE instruction should allow learners to interpret or explain their conceptualization in order to develop intuitive theory. Therefore, thought episodes that involved an interpretation or explanation of teachers' conceptualization were identified in order to illustrate a teacher's thought processes in developing conceptual understanding during the course of their professional learning.

Interpretations. Articulating one's conceptualization through interpreting concepts, meanings, and propositions can serve as evidence of conceptual understanding. Some thought episodes were found to include teachers' interpretation of different concepts about technology and instruction. For example, Andrew stated, "I guess when you're talking about Web 2.0, I guess you are talking about the Internet, different videos, different things we can use, and how we can incorporate that." Rose interpreted the concept of digital literacy to include basic knowledge and navigation skills for appropriate technology application. Debra elaborated the concept of graphic literacy as "The ability to read instruction from graphical displays and understand information presented through visual media." Travis considered technology a "supplementary use" especially when dealing with first graders.

Some thought episodes were found related to teachers articulating their conceptualization about what it meant to utilize technology for instruction. Andrew said that presenting lessons through videos provided concrete examples that helped students bridge the gap created by language barriers. Attempting to understand the meaning of the

term, “Self-Service” presented in the module’s slide presentation, Cassandra stated, “I wonder if that means you are out taking care of yourself more than working with other people.” However, Cassandra’s interpretation of the term was incorrect, which indicated a falsehood in her conceptualization about the meaning conveyed in the module content.

Some of the teachers’ conceptualization showed a lack of contextual knowledge to reflect the reality of their practice. Angel indicated that students’ participation in social networking postings could serve as a source of learning, which allowed teachers to gain understanding about students’ personal interest. Angel meant that social networking sites provided some instructional values to help teachers connect to students, however, the majority of the second graders she taught did not have sufficient knowledge to access a social networking site. Angel’s conceptualization revealed a lack of background knowledge about elementary, ELL students, so what she meant about utilizing the social networking sites to make connection with her students was therefore not feasible for the grade level she taught.

When one generates propositional interpretations to affirm the value of information provided in the module, conceptual understanding develops. Several thought episodes were found to include propositions that affirmed the value of technology instruction. In fact, three teachers, Angel, Cassandra, and Travis, provided 40 out of 52 thought episodes that were propositional in nature. Angel made a series of statement asserting the importance of incorporating technology into teaching. For example, she mentioned utilizing visual media to enhance instruction for ELL students to help them form mental images. Moreover, she argued for the use of internet resources to engage students in collaborative learning because she believed that students learned more from

their peers. Furthermore, Angel advocated that frequent exposure to technology instruction helped prepare students for today's digital learning age.

Sharing a similar view in preparing digital learners, Cassandra argued for the importance of teaching students critical skills of identifying important and relevant information as she called it, "being able to sift through things." In addition, she contended that the Internet provided rich resources and lesson ideas for cross-cultural learning, thus promoting understanding of cultural differences.

To evaluate and process information presented in the learning module, Travis asserted a critical view. He made several comments about the sequencing of the module content and information presentation. For example, he argued, "I believe the problem (statement) should be on the top" before presenting the problem scenario as a logical sequence for understanding the problem solving task. In addition, he regularly referred back to the learning objectives to determine whether each learning task he encountered helped meet those objectives specified in the module.

Explanations. In order to explain conceptualizations, one may attempt to define terminologies, restate instructional text, clarify and ask questions about learning content, verbalize new knowledge gained from learning or realize one's presumption, and summarize or specify what one has learned, which may be evidence of conceptual understanding.

Some thought episodes were found related to teachers attempting to define various terminologies listed in the module. Travis provided definitions for several terms, "Context means you can see it. Judgment means you can learn to. Create knowledge, you contribute. Organization, you figure out a way to hold on to it for quick reference."

Rose attempted to define a problem space for the scenario presented in the module movie: "So looks like her [the featured teacher in the scenario movie] problem here is she's finding a lot of different things she wants to use that would be neat to use, but she just has to figure out how to incorporate those and use the technology with it."

On another occasion, Rose restated in her own words from a paragraph of text she read: "Sometimes that [Internet search] does take out half of the time, and then you haven't really spent whole lot of time looking at what you actually need information on." In addition, Cassandra explained to herself the meaning of having a rich user experience, "If you are both a consumer and a producer, it [the use of Web 2.0 technology] would be a rich experience." Travis also reiterated the description about young people's information seeking behavior: "If it takes too long navigating, they [teenagers] skim then they butt out, so they don't really get the gist."

Offering clarifications can promote understanding of meaning conveyed in the module content. Attempting to clarify learning tasks entailed in module objectives, Travis stated, "I need to understand the utility, and I need to select from a variety of technologies. OK, so I need to find the best technology for adapting instruction for the ELL students."

Asking questions is an important technique for comprehension, which guides the search for answers to achieve conceptual understanding. Andrew was initially confused about the concept of digital natives versus digital immigrants, and he questioned what these terms were referring to, students or computer programs. Continuing to read through the module's slide presentation, he found the answer to his question. Considering the learning objectives outlined in the module, Cassandra questioned how to

differentiate technology instruction for ELLs as opposed to English-speaking students. Attempting to identify a problem space, Debra asked two questions: "How do you present it [technology] to the children? How do you get them to interact with it?" Travis also posed some challenging questions to evaluate the information presented in the module. For example, he asked for information about Web 1.0 (not included in module materials) in order to help him understand Web 2.0 applications. Additionally, both Debra and Travis wondered about the cost of utilizing online resources for instruction, and they had the impression that some sites might have a price tag attached to it, which indicated that they thought about practical aspects of incorporating these resources for instruction.

Verbalizing what one knows or realizes after reading information represents what is being conceptualized. When dealing with technology and instruction, each teacher had certain preconceived notions; however, after interacting with the learning content they became more familiar with the application of Web 2.0 for instruction. Remarks such as "Wow, 93% of teens use the internet, I didn't think it would be that high," revealed that Debra had a better understanding about the phenomenon after reading the information. Some remarks were shared to affirm an existing theory one had in mind, as Angel stated, "I know that many students do communicate with Twitter as well as text messaging and as well as instant messaging on the computer." However, her observation regarding students appeared more relevant to her previous college experiences than to her teaching of second graders.

Summarizing to provide the gist of information can also serve as evidence of what is being conceptualized. A summary statement such as "So I think her [the featured teacher in the scenario movie] problem was that she found all these different kinds of

stuff she liked but she didn't really know how to tie that in with what she was doing," gave an insight into Rose's understanding of the problem-solving task. In addition, most of the teachers offered a short summary statement after browsing a lesson example, reading a paragraph of information, or undertaking an online, interactive activity.

To filter through information and specify a particular notion one conceives is an indicator for conceptual understanding. Specifying a particular web feature that was helpful for information retrieval, Andrew stated, "It gives you a quick summary when you scroll your mouse over it." Travis considered technology a supplement to teaching subjects such as reading and math, however, he specified that the Internet be a major curriculum source for science and social studies, "because there is not a curriculum for them so you have to think outside the box and go to the internet."

In summary, thought episodes identified in this category revealed that engaging teachers in the OELE enabled them to test and build intuitive theory in order to develop conceptual understanding. Evidence of teachers interpreting or explaining their conceptualizations through the verbalization of various concepts, meanings, propositions, definitions, restatements, clarifications, questions, knowledge, realizations, and summaries learned from interacting with the learning content was found in the data, which demonstrated that most teachers achieved a fairly good conceptual understanding.

However, not all conceptualizations are a correct interpretation or explanation of learning content. For example, some thought episodes were found related to teachers misconstruing the meaning of certain concepts, while some were found about teachers lacking contextual knowledge to conceptualize the content of their professional learning. This finding suggests that in an independent, open learning environment, it is critical to

provide a mechanism of guidance and feedback that help teachers to test or examine conceptualizations in order to achieve intuitive understanding that is authentically and contextually grounded in their profession.

The OELE cultivating a teacher's conceptual understanding is found evident in the thought episodes generated in the concurrent verbal data. The next section discusses findings related to the OELE promoting a teacher's ability to apply learning.

Applicability. The literature reviewed in this study indicates that the OELE engages learners in cognitive activities to engender higher order thinking, so learners obtain the ability of applying new knowledge in everyday situations. In the context of a teacher's professional learning, the ability of applying (applicability) one's learning may be demonstrated through pedagogical strategies to include thinking strategies, logical reasoning, and pragmatic planning.

Thinking strategies. One practical aim of teacher training is to help one develop instruction that teaches students strategies of what and how to think. These thinking strategies include cause/effect, compare/contrast, classification, cluster, and brainstorming to develop students' cognitive abilities.

Some thought episodes were found related to teachers who were considering applying technology to teach thinking strategies. For example, Andrew talked about using video media to explain a cause/effect strategy. Angel mentioned several interactive, web-based activities related to the strategies of cause/effect, classification, and cluster as a way to provide scaffoldings or opportunities for student practice. Travis thought about utilizing a geographical website to demonstrate a compare/contrast strategy by showing students "aspects of China… an overview of a Chinese city, and how it might be different

than one of ours." Cassandra pointed out the fact that using online graphic organizers might be effective in teaching students about the process of brainstorming and creating thinking bubbles.

Logical reasoning. Another practical aim of teacher training is to help one develop the skill of logical reasoning that may involve presenting an argument for one's assertion, inferring or predicting from what is known, and considering relevancy of information.

Some thought episodes were found related to teachers presenting an argument to assert the effectiveness of applying technology for instruction. For example, Travis argued that using videos to present a social studies lesson would probably be more effective than using lectures to cover the same materials included in the lesson. Similarly, Angel argued that online activities providing interactive learning practices were more appealing to students than traditional pencil and paper tasks. In addition, Angel argued that incorporating these activities helped students "familiarize themselves with technology… be able to navigate themselves through websites that would be important later on in life when they have to do research on other topics." However, Cassandra questioned the feasibility of incorporating social networking sites for instructing ELL students due to their language barriers. Nevertheless, she argued that these sites could serve as a communication channel between the school and parents, and online tools could also provide opportunities for student practice at home.

Inferences and predictions were also found in the thought episodes. For instance, Rose made an inference regarding the use of online resources for her personal and professional learning, "There is a teacher community on here [a website related to

teaching resources] where I would assume you can kind of connect to other teachers and good ideas and share ideas." On the other hand, Angel seemed confident in the added value of online resources for her students, and she predicted that the students would be able to "find a lot of special things about [their own town], they never knew and they've never been introduced before."

Teachers making certain provisions in consideration of applying technology for instruction were also found in the thought episodes. When searching for relevant video media or online activities for instruction, Debra and Travis considered grade level appropriateness, while Andrew and Cassandra searched for clips or resources tailored to the needs of ELL students. In addition, Angel thought about several ways to incorporate technology considering its capability of offering visual representations for vocabulary instruction, providing curriculum resources for science and social studies, finding actual geographic locations for story settings, using various media including graphic, audio, and video to record students' ideas and writing, and incorporating interactive activities for collaborative learning of students.

Pragmatic planning. A primary responsibility of teachers is to develop lesson plans, thus, it is critical to develop the skill of pragmatic planning including identifying goals and outcomes, problems and solutions, scope and sequence to include a beginning, middle, and end, and timelines.

Some though episodes were found related to teachers considering the process of planning lessons to incorporate technology to enhance instruction. For example, Rose's thoughts revealed some practical aspects of preparing and planning for a technology-infused lesson. Depending on the goals and outcomes of a lesson, she considered several

factors including the availability of equipment (projector and computers) and possibility of collaborating with colleagues (a media specialist or computer teacher). Rose pointed out that finding "available resources to accomplish lesson ideas" was a critical step to plan a technology-infused lesson.

Considering ways of utilizing technology to aid to students' learning, Angel thought that video recording students reading and learning helped them to 'hear their thought processes and hear themselves talking out loud, so they can gain confidence in their reading as well as the work they are able to produce." In addition, she considered using online activities to provide students opportunities for independent practice and collaborative learning, so they could learn to solve problems without constantly depending on her for a quick fix.

Additionally, Angel said, "Start them with the pictures… prepare to write, to have an introduction and to have 3 body paragraphs and then a conclusion. And I think this would sort of be a great way to get them started with this whole writing process." She made plans on utilizing online graphic organizers to introduce the concept of story flow consisting of a beginning, a middle, and an end.

Pragmatic planning for an appropriate time to infuse technology for teaching and learning was also found in the data. The teachers talked about how to utilize online resources for after school activities and homework assignments (Andrew), to search video clips to prepare for the next day or week's lesson presentation (Angel), to allocate various time periods during a typical instructional day to incorporate online activities (Angel), to use an online calendar to introduce holiday celebrations in different cultures

throughout the year (Cassandra and Travis), and to archive resources online for future use (Debra).

To summarize, thought episodes identified in this category indicated that engaging teachers in problem solving in the OELE cultivated a teacher's cognitive abilities to apply learning. Some thought episodes were found related to teachers considering various technology applications to teach thinking strategies. Moreover, some thought episodes revealed that teachers developed logical reasoning to argue, infer, predict, and consider the utilities and implications for technology instruction. Furthermore, a number of thought episodes were found involving teachers developing pragmatic planning of technology-infused lessons.

When engaged in problem-based, interactive, web-based activities embedded in the OELE module, teachers appear to focus on learning for immediate application. For example, some thought episodes were found related to teachers selecting activities to deal with a particular classroom issue they encountered, to augment or enhance their current practice, or to search for instructional resources with reference to recent teaching topics. This focus of immediacy provides teachers with a practical aim for their learning and draws a great deal of personal interest that helps teachers relate to learning materials in concrete and tangible ways that are meaningful to them.

It is found evident that the OELE develops a teacher's cognitive abilities to apply learning, thus the next section details findings related to the OELE cultivating a teacher's authentic discernment.

Authentic discernment. The literature review of this study indicated that the OELE engages learners in reflective activities situated in authentic learning context in

order to develop discernment. In the context of teacher training, this discernment involves authentically examining one's perspectives, experiences, and practice to devise instructional activities that provide students with real-world learning experience.

Perspectives. Cultivating discernment involves transforming one's perspectives to promote self-referential awareness and understanding. In the context of teacher training, these newly formed perspectives may empower one to assert a more inclusive, discriminating, and integrative view that helps one develop awareness of self, peers, students, instructional contexts and approaches.

Some thought episodes were found related to teachers developing awareness of self. For example, Cassandra had poor confidence in her skills in terms of technological self-efficacy. She called herself "illiterate" while having difficulty navigating through sites. She said that she felt uncomfortable with sharing information on social networking sites for privacy reasons. She considered herself a consumer rather than a producer of online information. Not sure of her abilities of organizing information on web, Cassandra said, "Survival skills, that's what I need… I get so confused when I get too much information."

Some teachers recognized the fact that they did not have sufficient knowledge about Internet technology. For instance, Angel and Debra both mentioned that it was difficult to keep up with the constant change in the world of technology. Some teachers talked about their preferences or hobbies. For examples, Travis said that he liked the shape of a circle for creating thinking bubbles, and he chose to use the shape to create a brainstorming web required in the module. Andrew mentioned that he liked video and photography, so he searched for instructional resources of video excerpts and photo

gallery to help him demonstrate certain concepts or topics he was currently teaching in class. Apparently, these self-referential factors served as a decision base for completing learning activities or selecting instructional resources.

Some thought episodes were found related to teachers' developing awareness of peers. Being new teachers at the school, both Cassandra and Travis indicated that not being acquainted with fellow teachers was somewhat difficult because they were unsure of where to find help for troubleshooting equipment or technical problems. Cassandra mentioned that she eventually asked help from Andrew, another teacher on her grade-level team.

Before beginning the first learning task (browsing a slide presentation), Andrew commented, "This would be for people that don't know much about Internet or computers, might be like for older people or teachers that have been teaching for a long time and are stuck in the rug." Andrew appeared confident in his technology skills, and he was initially skeptical about the benefit of this learning task.

Some thought episodes were found related to teachers developing awareness of students. All six teachers verbalized their personal observations of students. Some mentioned students' preferred modes of learning, and some were aware of the diversity of students' academic skills, particular interests, and learning abilities.

Five out of six teachers mentioned that students favored video lessons. For example, Debra said, "It seems like kids respond more from watching videos than from reading information from the book." She indicated that overexposure to television at home had led the students become disinterested in learning to obtain information from textual materials at school.

In addition to video instruction, other activities such as comic books and online, interactive activities were also considered effective to draw student interest. These activities, Angel thought, could have some instructional value for promoting students' creative and artistic sense and motivating them to work to the best of their ability. However, Andrew, Travis, and Cassandra indicated that their students, especially the ELL students at the first grade level might not have the technology skills or sufficient English language proficiency to perform learning tasks required by these activities. Beyond that, Angel was also concerned about the Internet safety for her second graders, and she said, "Considering the information they give out on the website… I worry that people would see their online accounts, and they will know where they live."

Some thought episodes were found related to teachers developing awareness of instructional contexts. For example, Angel and Travis talked about the subject of math and social studies that they would like to allocate more instructional time on incorporating technology. Some mentioned that certain subjects might be more suitable for technology-infused lessons. As Debra said, "Science is so abstract. It's really hard to get the information just from the textbook." In addition, Cassandra mentioned focusing more on interactive web activities for writing and math problem solving, while Rose talked about utilizing online calendar resources for History lessons.

Some thought episodes were found related to teachers developing awareness of instructional approaches. The teachers talked about modifying their current approaches to incorporate video instruction, online activities for student practice, interactive activities for small group instruction, and games for math activities. Particularly, one thought episode was found that Travis thought blogging and instant messaging was not feasible

for student practice especially for first graders due to their limited typing and vocabulary skills.

Experiences. The literature review of this study suggests that experiences are valuable resources to guide the learning of professionals. Accordingly, cultivating a teacher's discernment may involve transforming one's past experience related to self, peers, students, instructional contexts and approaches in order to assimilate new experience.

Several thought episodes were found indicating that teachers reflected upon their experience related to self. In fact, Cassandra contributed almost 40% of all thought episodes in this category, talking about her technology experiences for instructional (Smart Board and videos) or personal (instant messaging and social networking with friends and family) purposes. Having taught for 26 years, Cassandra perhaps was enabled to speak freely and share her experiences; the others, except for Andrew, were novices in their 20's and did not have her age and experience. In fact, Angel, just fresh out of college in her early 20's, contributed only four out of 52 thought episodes in the category, and she acknowledged having limited knowledge and experience in using technology in classroom.

Only two thought episodes were found that the teachers reflected upon experiences related to peers. Cassandra talked about asking a fellow teacher for troubleshooting malfunctioning equipment, and Angel talked about soliciting advice from a fifth grade teacher. The limited number of thought episodes in the subjects' experience related to peers might be due to the fact that all six subjects were fairly new teachers at the school and had yet to build interpersonal relationships with colleagues in the school.

Some thought episodes were found that the teachers reflected upon experience related to students. Andrew gave an example, "They [students] didn't know what an island is. I drew one for them and explained it to them. They still were a little fuzzy." He indicated that the first grade students, especially the ELLs, had a very limited, geographic knowledge base. Angel shared a similar experience: "They're [students] always questioning me as to where other places around the world are."

Realizing parents who had limited awareness of academia is also evident in the teachers' experience with students' families. Andrew talked about the parents asking him to explain the concept of "phonemic awareness" shown on the children's report card. Cassandra mentioned that the rarity of technology resources in students' home environment surprised her, and she was aware of the fact that the majority of ELL students did not have an Internet connection at home.

Some thought episodes were found that the teachers reflected upon experiences related to instructional context and approaches. Almost all teachers talked about their experiences related to teaching contexts in various academic subjects such as science and social studies, in geographic topics, for instance, Mexico, volcano, and the solar system, in reading strategies, for examples, vocabulary, story sequence, and composing letters, and grade level standards. Additionally, the teachers reflected upon their past experiences related to utilizing technology as change of new teaching approach including Smart Board, a virtual reality science program, animation, video conferencing, and slide and video presentation.

Activities. Cultivating one's authentic discernment is to help one reconcile newly gained perspectives and assimilated experience to practice. In the context of teacher

training, this reconciliation requires one to discern learning activities of real-world connections to self, peers, students, and instructional contexts and approaches.

Some thought episodes were found related to the teachers discerning activities of real-world connections to self and peers. For example, Cassandra talked about the plan of spending her summer break to learn more about technology and search for online, interactive games for student center activities. Regarding the connection to peers, she indicated that Internet technology enabled information sharing via asynchronous and synchronous communication "with teachers all over the country or all over the world for that matter." On a more personal level, a geographic site enabled Andrew to find his place of origin in Mexico and also search for a colleague's home with whom he had taught together for almost two years.

Some thought episodes were found related to the teachers discerning activities of real-world connections to students. Some teachers mentioned that online activities were beneficial for their students, particularly ELL students. However, some of the learning activities Debra commented to be "a little bit over kids' head", considering some of her fourth grade students were reading on the level of a second grader.

In this category, Rose was the only teacher who made no reference to her students. Being a novice trying to meet the complex demands of the profession might be a reason for not being creative in thinking about different learning activities that utilized technology to broaden or enhance that connection.

Some thought episodes were found related to the teachers discerning activities of real-world connections to instructional context and approaches. All six teachers talked about incorporating online resources to develop lesson plans, to teach social studies and

science, and to provide visual images for vocabulary and geographic concepts in order to make learning a practical, real-world experience for their students. In addition, the teachers said that technology was a great resource augmenting their instructional approaches. Some learning activities were mentioned to enable students to virtually tour the world beyond physical boundaries. As Cassandra stated, "Doing it on the Google Earth would be a great way to do this with looking at where Africa is and what it looks like in comparison to U.S. and to Oklahoma."

In summary, thought episodes identified in this category revealed that engaging teachers in reflective activities embedded in the OELE promoted a teacher's authentic discernment. For example, thought episodes were found related to teachers developing new perspectives regarding the use of technology for instruction. Additionally, teachers were found to reflect upon personal experiences in connection to self, peers, students, instructional contexts and approaches. Furthermore, many thought episodes were found related to teachers developing discernment in considering learning activities for real-world connections.

Thought episodes identified in the category of authentic discernment also revealed that a teacher's personal as well as professional experience was associated with discerning connections of the real world. For example, Andrew's language and cultural background gave him unique perspectives in connecting with students, especially the ELL students. Cassandra's 26 years of teaching experience provided her with a solid base for reflective practice. On the other hand, still in the process adapting to their new teaching roles, the thoughts of the novices showed limited discernment in perspectives, in experiences, and in activities of real-world connections.

Conceptual understanding, applicability, and authentic discernment are three major themes identified based on the literature review of the study for analyzing concurrent verbal reports generated in the think-aloud experiment. A special coding category was also developed to identify other themes that emerged in the data to understand a teacher's thought processes when engaged in problem-solving prompted by the OELE module.

In the category of special codes, there were a total of 12 coding items identified. Among them, three noteworthy items were indentified as emerging themes to include descriptive remarks, responses to the OELE module activities, and interruptions, and these are discussed respectively as follows.

Descriptive remarks. During the entire think-aloud experiment, the teachers described their responses to reading materials, their feedback to interactive programs or websites, and their decisions entailed in the sequence of learning. Instructed to talk aloud prior to the experiment, all teachers verbalized their thoughts through the entire process of individualized learning, thus very few long, silence pauses were documented.

Among these descriptions, one teacher's comment stood out. Andrew mentioned that in this fast-clicking Internet culture, students would not have the patience to wait for the computer to completely download a large graphic file, which could be problematic. He described this frustration: "If I am having trouble, these kids are gonna have some trouble, being patient because it does take a while for it to load up all this information." Thus, he indicated a teacher's modeling and guided practice before allowing students to independently work online was the key to successful online learning.

Responses to the OELE module activities. The overwhelming number of thought episodes related to the teachers commenting positively about learning materials, interactive activities, web resources, and information presentation in the module indicated that the teachers enjoyed the OELE module to a great extent. All teachers talked about what they liked and what impressed them, and they commented that the information learned from the module exercises was intriguing and helpful.

Despite an overall positive attitude, a few negative comments were made by three teachers. Cassandra talked negatively about her technology skills in navigating through module activities. In addition, Andrew criticized a certain color used in the module design and the music selection of the module's scenario movie. Travis also expressed his dislike of pop-up windows and the district's Internet security setting that blocked the access to some information.

Interruptions. Some thought episodes were categorized as question and prompt to document two unexpected situations, technical difficulty and hazardous weather, which interrupted the think-aloud experiment. One instance was related to Andrew failing to access a geographic website due to the district's Internet security policy prohibiting teachers downloading and installing certain add-on programs. He was prompted by the researcher to proceed to subsequent learning agendas and solve the problem identified in the module. This alteration compromised his consideration of alternatives to solutions in the problem-solving task. Two weeks later, he was able to complete the missing portion; however, he seemed to have forgotten the problem and the learning purpose of the portion as a part of the solution process.

Rose's think-aloud experiment was also interrupted, this time by the weather, a tornado threat. The experiment resumed two days later to allow her to complete the problem-solving task. This delay in time and interruption in the flow of thoughts toward solving the problem is noted herein to present an authentic picture of the think-aloud experiment in a natural setting.

In addition to unexpected events, a teacher's Internet navigation and technology skills also impacted the think-aloud experiment. For example, Cassandra often stumbled when navigating websites or accessing interactive programs, so she asked the researcher for help. Being a colleague and understanding of her frustration, the researcher offered guidance, consequentially influencing Cassandra's thinking toward her problem solutions.

To summarize, the analysis of concurrent verbal reports revealed that the OELE instruction promoted a teacher's conceptual understanding, applicability, and authentic discernment. The teachers were found to construct intuitive theory through interpreting and explaining the content of their learning to develop conceptual understanding. Moreover, the teachers were found to obtain the ability of applying what they learned by developing strategic thinking, logical reasoning, and pragmatic planning. Furthermore, the teachers were found to develop authentic discernment through reflecting upon their perspectives, experiences, and practice for real-world connections.

Three emerging themes including descriptive remarks, responses to the OELE module activities, and interruptions were also found in the concurrent verbal reports. The teachers' comments were found to reflect a positive view of the OELE module. However, these themes were found to present some factors that were potentially intrusive in the thought processes of teachers in consideration of various solutions to solve the problem

featured in the module. In a natural setting, it is fairly difficult to control some factors, such as inclement weather. However, certain provisions need to be made to accommodate teachers who have limited technology skills or to consider incorporating learning tasks to avoid technical issues such as access to learning materials blocked by security settings.

Finding on Question Two

Research Question: What is the nature of a teacher's thought process in the context of group learning when attempting to solve an ill-structured problem prompted by web-based, OELE learning modules?

This research question focuses on studying an individual teacher's thinking and learning influenced by collaborative problem-solving in a group setting. Six teachers were divided into two groups. Members of Group A included Andrew, Debra, and Rose, while Group B consisted of Angel, Cassandra, and Travis. The selection of teachers for group composition was to create heterogeneous grouping based on the teachers' experience in the profession. For example, Andrew had five years of teaching experience and was assigned to lead Group A, and Cassandra had taught for 26 years and was the leader of Group B. In addition, the teachers' acquaintance with one another due to their teaching assignment was also a considering factor for grouping. For example, in Group A, Andrew and Debra worked in the same grade level team in the previous school year, and Rose's classroom was located across the hall to Debra's. In Group B, Cassandra and Travis were both in the same grade level team, and Travis and Angel had taught collaboratively to create learning projects for their students.

Subjects of each group met face to face and were engaged in collaborative problem-solving and discussion activities prompted by a web-based, OELE module. The topic of the module focused on understanding language barriers and related instructional issues in teaching English Language Learners (ELLs). Learning tasks required teachers to collaboratively identify a problem presented in the module's scenario movie, view a slide presentation introducing literacy instruction of ELLs and discuss various implications, critique a lesson example and discuss the implementation of the lesson, and examine and discuss student performance data of the subjects' school.

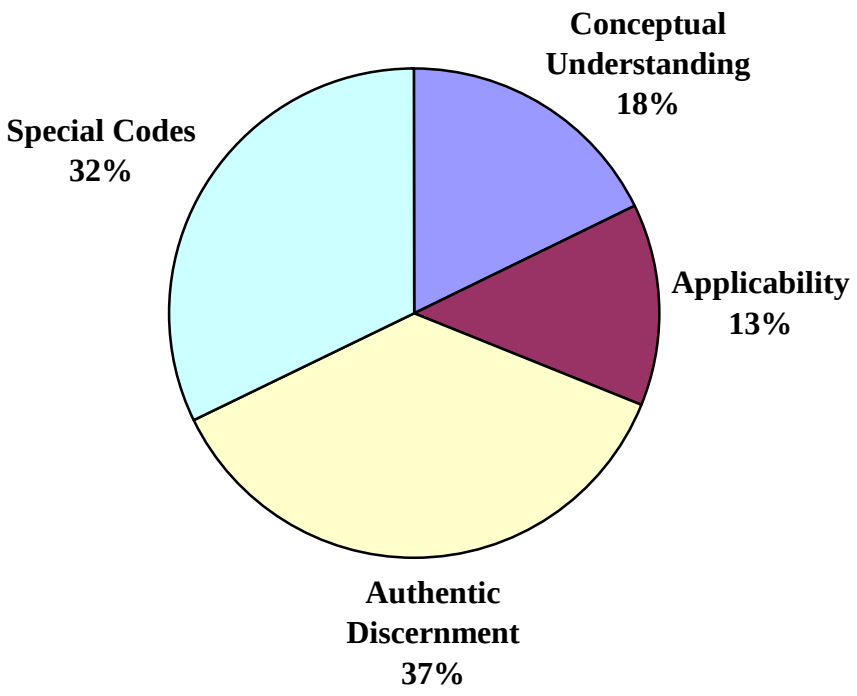
The face-to-face meetings of both groups were video recorded. The researcher reviewed the recordings and selected six video excerpts as question prompts to probe the teachers' thought processes in the group learning situation. The selection of the video excerpts was based on the relevancy to three constructs including conceptual understanding, applicability, and authentic discernment derived from the literature review of this study.

After completing all learning tasks required in the module, individual teachers were interviewed using the selected video excerpts as question prompts to obtain retrospective verbal reports focusing on the collaborative learning processes impacting their thinking of problem-solving. Thus, to analyze the retrospective data, the emphasis was place upon a teacher's verbalization that contained references to interactions and discussions of the group in collaborative problem-solving for the purpose of understanding the nature of a teacher's thought processes in the context of group learning.

The same coding categories for analyzing concurrently verbal data were also utilized to analyze retrospective verbal reports. As a result, the retrospective data yielded

684 thought episodes, of which 121 episodes (17.7%) are classified as conceptual understanding, 91 episodes (13.3%) as applicability, 251 (36.7%) episodes as authentic discernment, and 221 (32.3%) episodes into a special coding category (see Figure 4.2).

Figure 4.2 Distribution of Thought Episodes in Four Categories from the Analysis of Retrospective Verbal Protocols



As shown in Figure 4.2, comparing these four categories indicates that thought episodes found in the category of authentic discernment occupied the largest proportion in the retrospective verbal data. This suggests that the teachers' thoughts in the context of group learning oriented toward the category of authentic discernment more so than any of the two categories. In addition, the non-task related thoughts (special codes) occupied

almost one third of the total number of thought episodes generated in the retrospective data.

Details of thought episodes in each category are discussed as follows.

Collaborative problem-solving in developing conceptual understanding. The literature review of this study indicates that the OELE should engage learners in conversation and collaboration to construct collective, intuitive theory. This dialogical negotiation and collaborative learning process also enables learners to examine their existing conceptions in the context of collective practice to develop contextual understanding.

Some thought episodes were found related to teachers generating collective intuitive theory as a result of collaborative problem-solving. The teachers in Group A were found to reach a level of consensus in explaining the problem presented in the module's scenario movie. In contrast, the teachers in Group B appeared to explain the problem based on personal conceptions, and the development of collective intuitive theory was absent in this group.

Evidence of collective intuitive theory influencing individuals' conceptions is found in Group A. For example, attempting to define a problem space, Andrew thought that language barriers might be the reason that ELL students became inattentive to instruction. In addition, he specified that poor classroom management skills of the teacher featured in the movie that could play a part causing ELL students misbehaving in the classroom. Debra also commented, "It was kind of hard just to look at the ELL angle of it because you also have that classroom management issue pop up also." In addition, Rose's explanation was that the teacher's poor instructional skill failed to hold the

attention of students, so they were disruptive, which led to an issue of classroom management.

Accordingly, several thought episodes were found related to the teachers proposing different solutions to the problem based on the interpretation of the collective intuitive theory they developed as a group. Andrew suggested using visual representation to introduce vocabulary concept so students could make a personal connection to the meaning of the vocabulary. Debra said, "You have to know your students. You have to find out what they like" in order to make the lesson meaningful to them. It was evident that Rose was influenced by Andrew's propositions after reviewing the video excerpt selected for the question; she said, "Just how he (Andrew) told us to bring in more visual [aids] when you teach something new is really helpful for those kids."

Group A emphasized collective thinking in terms of identifying problems and developing solutions. On the other hand, each teacher in Group B explained the problem scenario that emphasized individualistic thinking.

For instance, in Group B, Cassandra thought that the problem was attributed to an ambiguity of focus, the teacher delivering instruction without a lesson purpose. Angel thought that it was an issue of language barriers hindering students' understanding of instruction. Without clearly identifying an issue, Travis said, "Well if I can remember right, there was a scenario where she kept getting on to the guys, the kids at the back of the room."

Even though members of Group B relied on individualistic thinking in explaining the problem scenario in the module, one thought episode was found related to group discussion facilitating individual teachers' understanding of certain concepts.

When prompted by the selected video excerpt about a scene, in which Travis was confused about the term, “graphic organizer”, and Angel immediately clarified it to him with various illustrations. Travis talked about that experience and made a propositional statement, “Yeah, after that [Angel’s clarification], I use graphic organizers. I think I made the argument later on that the fact with the ELL, just the same as first grade in general, they need to see it.”

Collaborative learning facilitating common understanding was found evident in Group A. After viewing the video excerpt to recall the learning activity involving a review of student performance data, Debra posited that ELL students should experience fewer language barriers in the subject of mathematics in comparison to other subjects, such as Reading. “I know what she’s talking about,” Andrew attempted to interpret Debra’s viewpoint after reviewing the same video excerpt, “when Math was something that was more of a universal thing [language].”

Additionally, one individual’s insight into a situation may just be a source of inspiration for another. Having heard of Andrew’s comment shown on one of the selected video excerpts, Rose indicated in the interview, “I may not have realized how much of that [a student’s disruptive behavior] was because of the fact that they might be ELL students.” Rose acknowledged that the group learning experience helped her re-examine behavior issues of her own students.

On the other hand, group learning yielded mixed results for the teachers in Group B. Cassandra, with 26 years of experience, talked about her frustration about not having a clear understanding of the academic and language gap encountered by ELL students. She elaborated on the issue of some ELL students in her class having difficulty making

appropriate progress, but she couldn't offer any explanation or to identify factors that hindered their learning. "That's my problem. I don't know where to go for help for them. I don't know what that wall is." Evidently, the dialogue exchange and collaborative, problem-solving of her group learning did not aid to Cassandra's understanding of issues she encountered in the classroom.

The collaborative problem-solving in Group B did not appear to help Angel and Travis understand the content of their learning, even though they both specified that language barriers were the root of the problem when attempting to explain the module's scenario. After reviewing the selected video excerpts, they did not offer further explanations as to interpret the concept of barriers ELL students encountered in the classroom or to propose solution to resolve the issue, thus demonstrating limited conceptual understanding of the issue. For example, Travis said, "I don't really know how big of a gap that terminology is" for the students to comprehend a teacher's vocabulary instruction.

In summary, engaging in dialogical negotiation and collaborative, problem-solving in the OELE yielded mix results in terms of promoting conceptual understanding between the two groups of teachers. For example, members of Group A were found to develop collective intuitive theory allowing individual teachers to interpret and explain the problem scenario, identify a problem space, and propose solutions accordingly. On the other hand, members of Group B were found to rely on individualistic explanation and interpretation of the problem scenario. Even though two teachers in Group B labeled language barriers as the root of the problem, they appeared to have a superficial

understanding of the issue because they had not proposed any solution that dealt with the barriers they identified in the problem scenario.

To compare the two groups, the level of a teacher's conceptual understanding is subject to group members contributing their knowledge and insights to facilitating a meaningful discussion in order to solve a problem. In other words, when group members offered constructive comments or insights into interpreting or explaining potential issues involved in a problem, the whole group thrived in conceptual understanding. Otherwise, the teachers' thought processes demonstrated limited conceptual understanding due to a lack of alternative interpretation and thorough explanation of learning content. Operating independently of one another, they were inclined to the simple solution, but that in a group they achieved a deeper understanding and could find more complex and effective solutions.

Collaborative problem-solving in developing applicability. The literature review in this study indicates that the OELE facilitates negotiation of co-constructed knowledge. This negotiation process engenders critical thinking and develops collective intelligence that calls for an incremental and holistic examination of one's thinking. In the context of teacher training, this self-examining process may stimulate one's thinking ability to apply learning by developing instructional strategies, logical reasoning for problem-solving, or pragmatic planning of instructional events including attention, objectives, materials, and feedback.

Knowledge negotiation stimulated strategic thinking, logical reasoning, and pragmatic planning was found evident in Group A. Among the selection of six video excerpts, Andrew was found to dominate most of the group discussion. To be specific,

Andrew led several discussion threads in the video, and afterwards in the interview he continued to elaborate on several brainstorming ideas to include instructional strategies of videos, demonstrations, visual aids, and relevant examples for effective ELL instruction.

In responding to Andrew's ideas shown on the video, Rose said, "You think about it [ELL instruction], but you don't think about as many ways as you can do it." Apparently, Andrew's dominance in terms of high volume in knowledge negotiation also reflected in the number of thought episodes generated in the retrospective data. Andrew produced 32 thought episodes compared to Rose with 11 and Debra with four in this category of applicability.

In Group B, personal relationships were found to encourage knowledge negotiation and stimulate an individual's thinking in the group. Since Angel and Travis were both in their 20's and were close friends on a personal level, the selected video excerpts showed that the two were engaged in several discussions without their third member, Cassandra. Interestingly, the high volume of their discussion also reflected in the number of thought episodes generated in retrospective reports. In the category of applicability, Angel and Travis each contributed 18 thought episodes; on the other hand, Cassandra contributed only 8 episodes, which indicated that the more engaged a teacher was in negotiation, the more stimulating the negotiation process was to one's thinking in terms of the ability to apply learning. .

Counting the number of thought episodes generated in retrospective data is only one of the indicators to determine whether knowledge negotiation and collaborative problem-solving of group learning promotes applicability. To further understand the

process of negotiation and collaboration impacting one's thinking and learning in the OELE, the meaning of these thought episodes needs to be extrapolated.

In Group A, Debra contributed only four thought episodes compared to Andrew's 32 and Rose's 11 episodes. However, in terms of the quality of her thoughts, Debra provided unique insight into examining student performance data. She offered several logical reasons to identify factors impacting performances of ELL students on a standardized math test:

> But in those higher grades or overall, there's a lot of reading that's involved in those math questions, so I would consider if it was just math, yes, it would be higher because they [ELLs] could do the work. It could be the way we are teaching the math vocabulary, I mean, there are a lot of vocabulary not just in reading but math too, academic vocabulary. And it could be the way that math is presented on CRT. They all story word problems, maybe the kids aren't getting the help on that. It could be that we all just putting so much focus on reading that math is suffering. It could be any of those factors.

Evidence was also found that Andrew had a similar logical thought, and he talked about language barriers being the factor that hindered ELL students from comprehending story word problems in the math test.

Knowledge negotiation appeared to enable Group A members to form group consciousness and develop collective intelligence in order to think deeper into the root of the problem and identify various academic challenges ELL students encountered. However for members of Group B, knowledge negotiation did not appear to have the similar effect in terms of the collectiveness of consciousness for problem-solving.

Aware of language barriers hindering reading comprehension, Angel's logical thinking for a solution was to ask for parental support. She said, "That [introducing language] should be something their parents have to help with this as well because we don't have enough hours in a day to completely teach them every thing in our core reading, but also build the vocabulary as well." In contrast, Travis argued, "I still felt that with ELL households, homework, anything dealing with home just becomes too difficult… And I don't think you can really have an expectation on it."

In terms of pragmatic planning, Andrew was the only one in Group A to address problem/solution during the interview. For example, he talked about specific tactics to manage a student's disruptive behavior in classroom. He also mentioned using teacher-made manipulatives to illustrate the concept of the vocabulary word "anemometer" presented in the scenario, and he said, "Maybe have a little model of it, showing and demonstrating how it works or what it is used for, and that would capture their attention more and they would know what an anemometer is."

Members of Group B were found to have divergent thinking patterns in terms of solving the problem posed in the module. For example, Cassandra recommended a warm-up activity to introduce lesson purpose before beginning vocabulary instruction to focus students' attention. Angel, however, thought that a new seating arrangement to move disruptive students to a closer proximity to the teacher and to isolate them from one another was an immediate solution to the problem. Their solutions appeared to focus on pragmatic planning of instructional events to redirect attention or classroom management tactics to correct behaviors, but these solutions failed to consider accommodating the

instructional needs of ELL students, which was the root of the problem in the context of the teachers' professional learning.

To summarize learning outcomes between the two groups, knowledge negotiation and collaborative, problem-based learning in the OELE produced mix results in terms of promoting thinking ability of teachers to apply learning.

Teachers of Group A were found to develop collective intelligence that identified several instructional strategies to accommodate needs of ELLs, developed logical reasoning to analyze student performance data, and devised pragmatic planning on different solutions to the problem posed in the learning module. Apparently, the group learning experience provided insights and scaffolds guiding and directing an individual's thinking of solutions to a problem.

In Group B, teachers were found to have divergent thinking patterns to include a strategy of refocusing student attention, solicitation of parental support as a logical reason for limited time a teacher had on vocabulary instruction, and new seating arrangement as a solution to disruptive student behaviors. The group did not form collective intelligence as a result of negotiation and collaborative problem-solving, and the divergence in the teachers' thinking arrived to different solutions that failed to address the real problem posed in the learning module.

Evidently, dialogical negotiation and collaborative problem-solving that facilitates the formation of group consciousness and the development of collective intelligence is critical in promoting a teacher's ability to apply learning. Even though teachers were interviewed individually after completing all learning tasks, the impact of collective intelligence developed as a result of group learning continued to guide the teachers'

thinking. Group A formed group consciousness and develop collective intelligence directing and guiding their strategic brainstorming, logical reasoning, and pragmatic planning of problem-solving. On the other hand, lacking in unison, Group B relying on individualistic thinking demonstrated limited ability to apply learning to solve an authentic, classroom-based problem.

Collaborative problem-solving in developing authentic discernment. The literature review in this study indicates that the OELE facilitates validation of collective intuitive theory by engaging learners in critical discourse and collaboration. This validation process promotes authentic discernment allowing learners to not only become aware of individual differences in one's personal, professional, and cultural backgrounds, but also to accept and even embrace these differences. In the context of teacher training, the differences in backgrounds may include a teacher's perspectives, experiences, and practice for real-world connections. Thus, the goal of professional learning is to cultivate a teacher's discernment to obtain truth and knowledge that is contextually and authentically validated.

In analyzing retrospective data, the number of thought episodes generated in authentic discernment accounted for almost 37%, the largest proportion of all, compared to conceptual understanding at 18% and applicability at 13% of total thought episodes. This indicates that engaging teachers in critical discourse and collaborative problem solving can be thought provoking, thus helping individuals to validate and discern true knowledge gained from professional learning.

Even though the number of thought episodes generated in this category appears convincing that collaborative, problem-based learning promotes a teacher's authentic

discernment, it is also critical to examine the nature of these thought episodes with respect to a teacher's perspectives, experiences, and instructional activities in developing the awareness of self, peers, students, context, and approaches to real-world connections.

Some thought episodes were found related to teachers developing awareness of self in connection to students. For example, as the only Hispanic teacher in Group A, Andrew was interviewed and asked to review the video excerpt, in which he shared his perspectives about Hispanic culture, his experiences of growing up as an ELL student, and his expertise as a bilingual teacher. When asked about this unique background in connection with ELL students, Andrew said, "there's a lot of kids in my class personally that have called me Dad in Spanish just because there is some kind of connection there." He further commented that not just ELLs but also native English speaking students viewed him as a father figure, thus he pointed out that a teacher's ethnic background was not and should not be an issue for a teacher making an effort to connect with students.

Interestingly, after Rose reviewed the video involving the discussion of Group A about the issue of ethnicity and culture, Rose talked about her personal background, "Well, it's assumed that I know a lot of Hispanic culture and stuff like that just because of my last name. I do have family members that are Hispanic but they don't live here, and I am not around them constantly, and I wasn't around them consistently growing up." Being a first year teacher in a predominantly ELL school, she talked about her students. "I am comfortable with them," she said, "but I think I still have a lot to learn about how to teach them."

Critical discourse and collaborative problem solving allowing for sharing of multiple perspectives were found in the retrospective data. For example, in Group A,

Rose indicated that she gained some perspectives about understanding ELL students from Andrew's sharing of personal experiences.

In addition, a change of teaching contexts enabled Debra to become more knowledgeable about standardize testing comparing to her peers in Group A. When prompted by the video excerpt, which showed her providing a keen insight into interpreting student performance data, Debra said, "I think from my transition from first to fourth. In first grade, testing's really not that big of a deal. Once I got to fourth grade, I start to really feeling the pressure." After reviewing the same video excerpt, Andrew recalled that Debra's insight helped him to see the data in a new way. He said, "I was just trying to figure out more of what the graph meant or the percentages." Evidently, Debra's unique contribution in this respect promoted an awareness of testing and performance data, which was a critical element of reality in the context of teaching.

Awareness of teaching contexts due to a change of grade level may promote discernment requiring a teacher to make appropriate adjustments in order to meet the needs of students. In reviewing the video excerpt about the discussion of Group B, in which Travis talked about that he was confronted by "double language barriers", he further explained that he taught mostly African American high school students prior to becoming a teacher at a predominantly ELL, elementary school. In addition, he addressed the issue of confronting the double language barriers and adjusting his teaching approach: "I usually draw it and then do movement if it's something involves movement… I drew everything on the board even flowcharts… [With first graders] we'll do color and we'll do linear progression." In the previous year, he said, "I taught a political science… an AP political science… And I didn't color code or anything."

Apparently, this big transition allowed him to rethink his teaching approaches and to make adjustments according to the grade level and language abilities of students.

After reviewing the video excerpt about the concept of double language barriers discussed in Group B, Angel discovered her naïve idea about students. "I think a lot of words I expect some of them [students] to understand, like when we were reading that I understand." She quickly realized that her second graders lacked the basic "comprehension words" they needed to understand the text. Also identifying with Travis's experience in adjusting teaching context based on grade levels, Angel talked about future goals of her instructional practice: "Giving them the foundation to start to build upon some of the language and academic vocabulary that they'll be needing in order to be successful."

Also aware of the ELL students' deficiency in academic language, Cassandra said, "This is my first year in a real ELL school, and I am amazed at the words these kids don't know… and how it affects their learning." Language barriers were not only an issue for the students but also for their parents, and Cassandra recognized this reality. She said, "The parents do as much as they can, but a lot of times with them being only Spanish speaking, there are a lot of things they don't do because they don't have the language to be able to function and move around within those settings." Making an effort to bridge the communication gap with the parents, she told about her recent engagement in taking a Spanish class. She said, "Definitely, I know how it feels to be in a new language now."

In summary, it is evident that engaging in dialogical negotiation and collaborative problem solving in the OELE promotes the development of a teacher's authentic discernment. Both groups of teachers were found to develop awareness of self, peers,

students, contexts, and approaches as a result of reflecting upon their perspectives, experiences, and practice to discern the reality they encountered in classroom.

The negotiation and collaborative learning process in the OELE also has an effect of validation. In Group A, the teachers were found to develop mutual understanding and appreciation despite of individual differences in cultural, social, and professional backgrounds. In Group B, the teachers were found to share a commonality of struggles, such as confronted by the so called "double language barriers" and required to adjust instructional focus due to a change of teaching assignment. Evidently, the OELE enables one to contribute his or her unique perspectives and experiences to group learning, and in turn group learning experience validates the discernment one develops as a result of learning.

In addition to conceptual understanding, applicability, and authentic discernment, a special coding category allows for flexibility of additional themes to inductively emerge from the retrospective data. As a result, two themes, social interaction among learners and subject-researcher interaction, are particularly noteworthy and then discussed respectively as follows.

Social interaction among learners. The interaction among group members is found to influence a teacher's attitude toward his or her professional learning in collaborative problem solving. In Group A, Rose was open and receptive toward Andrew's viewpoint. Commenting on the video that showed Andrew sharing his experience as an ELL student who lacked contextual knowledge necessary to understand reading materials of the mainstream culture, Rose said, "I never really thought about that, but, I guess that would be true." Moreover, after reviewing the video showing Debra's

unique perspectives about the standardized testing, and Andrew said, “I was thinking that she was really looking into that data.” Recalling the group learning experience, Debra commented that having a representation of different grade levels in her group enriched the discussion and enabled an exchange of multiple perspectives.

On the other hand, a very different pattern of social exchange and interaction was observed in Group B. All three teachers were well acquainted with one another. Angel and Travis were close friends; they collaborated and taught their second and first graders to work together on projects. Travis and Cassandra were both on the same first grade team and worked closely together; they seemed to be very familiar with each other’s personality traits. However, this casualness and familiarity in ways the teachers associated with one another did not bring about a positive effect in helping the group to become more cohesive and unified in terms of constructing collective knowledge or developing solutions to solve a problem.

For example, Angel referred to Travis as her buddy, but after reviewing the video about Travis who was confused about graphic organizers, she said, “I am glad that somebody has to keep him on track.” After reviewing the video excerpt about her group discussion, Cassandra made a comment about Travis being stubborn and argumentative, and she quickly dismissed his ideas without giving him the benefit of doubt. However, Travis insisted that he was right, so in responding to his peers’ differences in opinion shown on the video, he said, “This is where it’s me versus the world.” It appeared to be that members of Group B held on to their own perceptions after the group learning, indicating that the social discourse of the group provided little contribution to redirect or guide individual thinking in problem solving.

Subject-researcher interaction. The issue of trust and mutual understanding between study subjects and researchers may influence the process of collecting retrospective, think-aloud data through interviews. As a researcher asking questions and providing feedback for probing purposes, I found my professional relationships with some of the teachers and my personal interest in ELL instruction impacting the teacher's thought processes. A close work relationship with three of the study subjects including Andrew (in Group A), Cassandra, and Travis (both in Group B) enabled me to probe deeper into various interview topics. This sense of acquaintance fostered a safe and trusting researcher/subject relationship that was inviting for conversation. As a result, these three teachers were enthusiastic about interview topics and appeared eager to share their thoughts, reflections, and even personal concerns. For instance, when discussing the topic of race, Andrew and I also talked about our shared experience as a minority teacher in bringing a diversity of language and culture to our school. Cassandra mentioned asking her husband to help translate notes to a student's parent. She also shared with me long conversations about her family. On a more professional level, Travis and I had a lengthy discussion about the pros and cons of our existing reading and ELL programs and the current intervention practice for his students.

However, having yet to build a rapport with the other three teachers in the workplace, I felt apprehensive in probing for deeper thoughts and reflections. Without routine, professional contact, there was a lack of common interest between the teacher and me to stimulate or extend our discussion. The teachers appeared tired or uninterested in most of the interview topics. For instance, Angel answered the majority of the questions in a straightforward, as a matter of fact manner just to get through the process.

Debra was always brief about her responses, but several of her physical cues indicating disinterest and tiredness. Lastly, Rose replied, "I'm not quite sure or I don't really know" in several occasions even after two or three more prompts were given. I suspected that this could be a factor that the interview ended sooner than expected, and several discussion topics did not reach a desired outcome to provide a more balanced view of all six teachers.

In summary, the analysis of retrospective reports revealed that group learning impacting individual teachers' thinking in problem solving was found evident. Group difference in terms of developing collective intuitive theory versus individualistic interpretation and explanation in problem solving was found to impact teachers' conceptual understanding of learning content. In addition, developing collective intelligence as a result of group learning was found to promote teachers' thinking ability to apply learning. On the other hand, the group of teachers who failed to consolidate their divergent thinking patterns into a collaborative effort for problem-solving was found to demonstrate limited ability to apply learning. Furthermore, group learning was found to promote authentic discernment of teachers, which elicited the effect of validation on their perspectives, experiences, and practice and allowed them to develop mutual understanding and appreciation and to share a commonality of struggles and triumphs.

Findings from the analysis retrospective reports also revealed that social interaction among learners can impact the outcome of collaborative, problem-based learning, and social relationships between a researcher and study subjects can also influence the outcome of research. Using the approach of interview to understand the nature of a teacher's thought processes in the context of group learning, these influential

factors need to be noted in order to present an authentic picture of studying this phenomenon in a natural setting.

Summary of Findings

Two research questions posed in this study are devised to explore the nature of a teacher's thought processes for problem-solving in the Open-Ended Learning Environment (OELE). The think-aloud experiment conducted in this study is designed to explore a teacher's independent, professional learning. In addition, individual interviews conducted after teachers completing the OELE learning modules are designed to explore the impact of collaborative learning influencing teachers' thinking.

The analysis of think-aloud protocols resulted in a total of 1,248 thought episodes that include 26.1% of conceptual understanding, 12.3% of applicability, 24.4% of authentic discernment, and 37.3% of special codes. These percentages suggested that among the three major categories, the OELE instruction was not as thought provoking in the teachers' thinking ability related to applicability when compared with their thoughts in conceptual understanding and authentic discernment. In other words, in terms of the number of thought episodes, the independent learning in the OELE elicited more thoughts of teachers in understanding the learning content and discerning the learning for real-world connections than promoting their thinking ability of applying the learning.

In addition, the think-aloud experiment yields several findings and are discussed as follow:

The OELE instruction is found to promote a teacher's conceptual understanding of learning content. Engaging a teacher in experiential and independent learning allows for knowledge construction to develop intuitive understanding. In addition, the findings

also reveal the importance of providing a mechanism of guidance and feedback that allows for the testing of a teacher's conceptualization in independent, web-based learning for developing contextual knowledge in the profession.

The OELE instruction is also found to promote a teacher's cognitive abilities to apply learning. Engaging a teacher in problem-solving develops strategic thinking, logical reasoning, and pragmatic planning. In addition, immediate application is found to be the central focus of a teacher's thought processes to problem-solving.

The OELE instruction promoting a teacher's authentic discernment is found evident in this study. Engaging a teacher in critical reflection develops new perspectives and new experiences of learning for real-world connections. Moreover, a teacher's personal and professional experience is found relevant to the development of authentic discernment.

The result of think-aloud experiment reveals that teachers enjoy the independent, web-based mode of professional learning. However, a teacher's technical knowledge and skills of web-based learning can be a determining factor for achieving goals of professional learning in the Open-Ended Learning Environment.

Individual interviews were also conducted in this study to explore the process of collaborative problem-solving in the OELE impacting a teacher's thinking and learning. The analysis of interview transcripts resulted in a total of 684 thought episodes that include 17.7% of conceptual understanding, 13.3% of applicability, 36.7% of authentic discernment, and 32.3% of special codes. In reviewing the distribution of thought episodes among the three major categories, authentic discernment had twice as many thought episodes as conceptual understanding or applicability. This indicated that

collaborative problem-solving in the OELE was more thought provoking for individual teachers in the category of authentic discernment than the other two categories.

The findings of collaborative problem-solving in the OELE impacting individual teachers' thoughts are summarized as follows:

First, the OELE instruction allowing for dialogical negotiation and collaborative, problem-solving is found to promote a teacher's conceptual understanding. The study reveals that engaging teachers in knowledge negotiation and collaboration enables the development of collective intuitive theory that helps individuals achieve a deeper understanding of learning content.

Second, engaging in knowledge negotiation and collaboration in the OELE also promotes thinking ability of teachers to apply learning (applicability). The study reveals that an individual's applicability is associated with teachers forming group consciousness and develop collective intelligence as the result of collaborative problem-solving.

Third, the negotiation and collaboration in the OELE is found to have a validating effect that promotes individual teachers' authentic discernment. Collaborative, problem-solving engenders critical reflection that helps teachers develop awareness of self, students, peers, instructional contexts and approaches to discern knowledge for real-world connections.

Fourth, the social interaction among teachers is found to impact the outcome of collaborative, problem-solving in the OELE, allowing one group of teachers to develop mutual understanding and appreciation of individual differences in thought processes, which contributes to group learning. In addition, social relationships between a researcher and study subjects that allow one to probe deeper into subjects' thinking is

found to impact the outcome of research when using the research technique of interview to study teachers' thought processes in this study.

Conclusion

Overall, a teacher's active involvement and participation in learning activities, whether through an individualized or group situation, is a determinant for the impact of web-based, professional learning. In this study, six teachers' thought processes of interactive, experiential learning and collaborative problem solving are observed. The result of the study reveals that the OELE can elicit the type of learning that is imperative for professional learning of teachers. In addition, several individual, group, or even environmental factors may impact a teacher's thinking processes in problem-based learning. With these influential factors identified, the next step involves a thorough discussion to compare these findings with literature and to outline practical implications for web-based, professional learning of teachers.

Chapter V: Discussion, Implication, and Recommendations

This study explores the thought processes of teachers while engaged in the Open-Ended Learning Environment (OELE). The teachers demonstrated various degrees of conceptual understanding, applicability, and authentic discernment in their thinking regarding various solutions to a problem. The study indicated that the development of conceptual understanding in the OELE was associated with a teacher's contextual knowledge to conceptualize the content of professional learning. Moreover, the development of a teacher's cognitive ability to apply learning (applicability) in the OELE was related to learning tasks that provided practical aims and means for immediate application. Furthermore, teachers' development of authentic discernment in the OELE varied based upon their personal and professional experiences.

Several influential factors were also found to impact individual teachers' thinking in problem solving in the context of group learning. The study revealed that collaborative learning in the OELE enabled the construction of collective, intuitive theory, which helped individual teachers achieve deeper conceptual understanding. Collaborative learning in the OELE was also found to promote thinking ability of teachers to apply learning (applicability) through the formation of group consciousness and the development of collective intelligence. In addition, collaborative learning in the OELE cultivated individual teachers' authentic discernment, which allowed for the validation of one's perspectives, experiences, and practice for real-world connections.

To conclude this study, this chapter includes discussions to compare these findings with current literature, to consider various implications for theory and research,

and to outline recommendations for future studies and practice regarding web-based, professional learning.

Discussion

Six teachers were selected as study subjects to perform problem-solving tasks prompted by web-based, OELE modules in two situations, individualized and group learning. The individualized learning required teachers to work independently, while the group learning involved collaborative problem-solving by teachers. To discuss the results of this study with respect to the independent and collaborative learning in the OELE, this section includes a summary of the findings and a comparison of findings with theory and empirical literature.

Independent learning in the OELE. Six teachers were engaged in independent problem-solving tasks prompted by a web-based, OELE learning module designed by the researcher. During their learning processes, the teachers were asked to verbalize their thoughts concurrently with solving the problem. Consequentially, these concurrent verbal reports were collected for data analysis and the summary of findings is as follows:

Conceptual understanding. The OELE instruction was found to enable the teachers to interpret and explain their conceptualization in order to develop intuitive theory, thus promoted the development of conceptual understanding.

The teachers who verbalized their conceptualizations through interpreting various concepts, meanings, and propositions were found evident in this study. For example, some teachers examined the learning materials and explored various applications of technology from the viewpoint of utilizing technology to improve student learning. Some viewed technology as an empowering tool to enhance instruction. Some

considered technology as providing rich resources for personal as well as student learning to promote cross-cultural understanding.

Most of the teachers were found to develop conceptualizations and construct personal, intuitive theory that embraced the idea of utilizing technology to enhance learning and teaching. This finding concurs with constructivist theory that the OELE allows the learners to explain initial, naïve conceptions (Land, 2000) in order to build intuitive theory (Land & Hannifin, 1996).

However, one teacher's interpretation was different. Travis perceived a certain limitation on technology-infused instruction. The finding corresponds to constructivist theory that there exist multiple perspectives to examine a phenomenon (Duffy & Cunningham, 1996).

Moreover, Travis's thoughts appeared to follow a logical sequence that guided his learning and thinking in order to meet the goals of the professional learning. This logical sequence, according to Piaget (1980), a constructivist theorist, serves as an "operational model" (p.85) that enables the learners to hypothesize, experiment, and test their intuitive theories. In addition, Travis's goal-driven thought process concurs with adult learning literature that professionals are goal-oriented learners who have a strong sense of self-direction in determining learning projects (Tough, 1979).

Furthermore, the teachers' verbalization of their conceptualizations in the OELE appear to be consistent with constructivist theory that individuals often examine facts by considering them in the light of one theory or another; thus different theorists may present different dimensions of viewpoint in interpreting facts (Vygotsky, 1987). This

finding also concurs with the literature that the OELE enables learners to interpret multi-faceted perspectives in order to develop intuitive understanding (Land & Hannafin, 2000).

Evidence of the teachers verbalizing their conceptualizations by offering explanations to define terminologies, clarify content, and summarize learning were found related to the development of intuitive theory. In conceptualizing the content of their learning through defining, clarifying, and summarizing Web 2.0 applications for instruction, the teachers were found to develop intuitive theory based upon their prior knowledge and experiences. A teacher relying on personal knowledge and experience to develop conceptual understanding concurs with adult learning literature that experience is a valuable resource (Lindeman, 1961) that guides adult learning, thinking, and meaning-making (Dewey, 1984; Knowles, 1990).

However, a teacher's conception based on prior knowledge or experience can be misguided, rendering a false assumption for understanding. For example, a novice teacher like Angel has prior knowledge of web applications based upon her college experience rather than teaching experience, so her understanding of these applications for instruction of elementary students seems limited. This insufficient knowledge in practical, contextual understanding of elementary school settings is also found in the studies of pre-service and novice teachers (Pierson, 2005; Dawson, 2005). These studies indicated that teachers who lacked practical, contextual knowledge were found to develop limited or superficial understanding about learning content. Therefore, in the OELE, Land and Hannafin (2000) argue for the importance of engaging learners in activities that allow them to test the validity of prior intuitive theory in order to develop conceptual understanding.

Applicability. The OELE instruction was found to enable the teachers to develop pedagogical strategies to include thinking strategies, logical reasoning, and pragmatic planning, thus promoted the development of cognitive ability of applying learning.

For example, the teachers were found to consider incorporating media resources as instructional strategies or utilizing online, interactive activities to demonstrate comprehension strategies. In addition, the teachers' thinking in problem-solving involved logical reasoning to consider ways of infusing technology for instruction and pragmatic planning to devise logistics and flows of a technology-infused lesson.

In this study, the teachers' thoughts were found to involve solutions that deal with a particular classroom problem or augment or enhance current practice. Adult learning theorist, Perdue (2003), argues that practical solutions and immediate application are especially useful for the professional knowledge workers who analyze relevant information to apply knowledge creatively. In adult learning literature, Kegan (1994) and Merriam (1994) also suggest that professionals often play complex, social roles in life, thus the driving force for their learning is to solve problems in life and fulfill family and career-related demands. Apparently, the teachers' thinking about focusing on practice and application is found to be problem oriented, socially related, and application focused, as suggested in the literature.

Authentic discernment. The OELE instruction was found to enable teachers to examine perspectives, experiences, and practice for real-world connections and develop awareness of self, others, students, and instructional contexts and approaches, thus promoted the development of authentic discernment.

Evidence was found related to the teachers developing discernment and awareness of self. In the OELE, technology self-efficacy appears to have an impact upon a teacher's confidence in navigating through web-based learning activities. For example, Cassandra commented about her need for basic technology skills, and she appeared to have low confidence in her competence at using computer technology. However, her low self-confidence seemed not to deter this veteran teacher of 26 years from sharing her experience of using technology in the classroom. She also mentioned several technology resources that she had utilized for instruction.

This finding does not appear to be entirely consistent with the literature. Self-efficacy, according to Bandura's (1986) definition, refers to "people's judgments of their capabilities to organize or execute courses of action required to attain designated types of performances" (p. 391). Bandura argues that self-efficacy deals with one's judgment of a particular skill rather than one's actual competency of that skill. In addition, some studies (Delcourt & Kinzie, 1993; Ertmer, Addison, Lane, Ross, & Wood, 1999) found that self-efficacy was associated with teachers integrating technology into instruction. Their findings suggest that the more confident teachers feel about using technology, the more likely they are to incorporate it in the classroom. On the contrary, in Cassandra's case, her low self-efficacy does not limit her engagement with technology infusion in instruction; rather it was dependent upon the accessibility and availability of technology in classroom that provided opportunities for her adoption of technology in instruction.

Moreover, developing discernment and awareness of self in assessing one's technology competency or in identifying one's interests and preferences is found to serve as a referential factor influencing a teacher's decision-making process in the OELE

instruction. This finding concurs with adult learning (Knowles, 1990) and distance learning (Moore, 1973) literature that teachers are self-directed, independent learners capable of organizing learning events, identifying learning means and goals, and evaluating learning outcomes. .

Evidence was also found related to teachers developing discernment and awareness of others, students, and instructional contexts and approaches. For example, the teachers were found to verbalize their needs for collegial, social support, their perspectives of students' academic skills and computer literacy skills, and their concerns about school-related contextual and environmental factors impacting the integration of technology into teaching. This finding is consistent with Bandura's (1986) assertion from a social-cognitive perspective, which emphasizes reciprocal causation through the interplay of cognitive, behavioral, and environmental factors for technology integration in learning and teaching.

In addition to the development of conceptual understanding, applicability, and authentic discernment, three themes that characterize the nature of the teachers' thought processes in the OELE emerge from the concurrent verbal data, and these themes are discussed as follows:

Descriptive remarks. The teachers were found to describe their responses and actions in the OELE during the think-aloud experiment. The researcher found that her presence during the experiment enabled a communicative process in which the teachers were not merely speaking aloud what they thought, they were also attempting to communicate with the researcher. For example, they seemed to justify their responses or actions throughout the entire processes in the OELE, independent learning.

Ericsson and Simon (1998) suggest that researchers explicitly instruct participants to "focus on the task while thinking aloud and merely to verbalize their thoughts rather than describe or explain them to anyone else" (p. 139). Ericsson and Simon argue that this level of verbalization may generate incomplete sentences and phrases, which they explain by citing Vygotsky's comment about inner speech characterized as "disconnected and incomplete" (p.181). Prior to conducting the think-aloud experiment, the teachers were instructed to simply verbalize their thoughts. However, the finding of teachers' describing and explaining their thoughts to the researcher coincides with Smagorinsky (1998) assertion that "a concurrent verbal protocol has the appearance of being a solitary act, yet from cultural-historical activity theory (CHAT) perspective can only be understood as a social act" (p. 161). Smagorinsky argues that in addition to information-processing (IP) theory that grounds Ericsson and Simon's work in protocol analysis, CHAT theory may offer an alternative perspective to study cognition and verbalization.

Using Vygotsky's (1987) framework in understanding thinking and speech, Smagorinsky argues that the theoretical lens that a researcher uses to study a phenomenon impacts his or her data collection and interpretation. Thus, the researcher suspected that her presence as a colleague of the study subjects might have engendered a process of communicative, social speech from the teachers when verbalizing their thoughts, so what was captured in the think-aloud experiment did not entirely mirror teachers' thought processes if they were truly engaged in independent, solitary, web-based professional learning.

In addition, the findings of this study indicated that the teachers' thoughts include both egocentric and social speech that is dialogical in nature. Constructivists assert that

learning involves one's cognitive (Piaget, 1973) and dialogical processing (Vygotsky, 1987), which requires an individual to interact with learning content, peer learners, and instructors (Duffy & Cunningham, 1996). In addition, Duffy and Cunningham argue that these interactions include mindful, negotiated processes, and "the activity of mind is always dialogic, connected to another" (p.176) to create intrapersonal and interpersonal speech. In this study, teachers were engaged in independent, interactive learning activities in the OELE while verbalizing their thoughts. The teachers' verbalizations, which were found to involve intrapersonal and interpersonal speech, are consistent with these constructivists' assertions that learning is a social process.

Response to the OELE module activities. The teachers were found to respond positively to the experiential and interactive learning in the OELE module. This finding concurs with the literature that teachers describe web-based, professional development as favorable (Cole & Styron, 2005; Chuang, 2002).

Moreover, Knowles (1990) argues that adult learning is driven by an intrinsic reward such as enjoyment. The finding of teachers' enjoying the learning activities in the web-based, OELE module may indicate that the OELE instruction can be a motivating mode for professional learning of teachers.

Interruptions. Employing think-aloud protocols to study a teacher's thinking in a quasi-experimental research environment was found to involve some challenges. Ericsson and Simon (1998) suggest conducting the think-aloud experiment in a controlled environment, in which "individuals could verbalize their thoughts without any, or at worst with minimal, reactive influences on their thinking" (p.139). However, perfect control of the circumstances in which a teacher's thought process in a technology-

mediated learning environment can be observed without reactive influence is virtually unattainable.

For example, two teachers' think-aloud experiments were interrupted due to technical difficulty and inclement weather. In addition, the teachers asked for guidance from the researcher when experiencing a technical or navigational glitch. Evidently in the OELE, a teacher's web learning quest relies on a mechanism to provide technical assistance and an instructor to provide guidance. This finding concurs with constructivist learning literature.

Constructivists suggest that technology enables an interactive, media-rich learning environment that is engaging and challenging (Jonassen, Peck, & Wilson, 1999). In addition, Hannafin, Land, and Oliver (1999) point out that the OELE relies heavily on technology to mediate and support a learner's cognitive effort, thus it is critical to provide adequate technical assistance and procedural scaffoldings in web-based professional learning of teachers.

In summary, the above section discusses findings and relevant literature with regard to studying individual teachers' thought processes in the OELE professional learning. The next section focuses on the discussion of findings of collaborative problem solving impacting a teacher's thinking and learning in reference to the theory and empirical literature of web-based learning.

Collaborative learning in the OELE. Six teachers were divided into two groups that met face-to-face to collaboratively solve a problem prompted by the OELE module. In addition, the entire group learning processes were video recorded. After the completion of all learning modules, the teachers were interviewed individually using

selected excerpts of the video recordings as question prompts in order to probe their thoughts in retrospect about the collaborative problem-solving processes. These retrospective verbal reports were gathered for analysis, and the summary of findings includes:

Collaborative problem solving to develop conceptual understanding. Engaging in collaborative problem solving in the OELE was found to enable the teachers to construct collective, intuitive knowledge and allow them to examine existing conceptions in the context of collective practice to develop conceptual understanding.

One group was found to have a common understanding about the problem, and this collective thinking appears to be the common thread that helped each individual of the group examined the problem in a new light. In this group, knowledge negotiation and collaborative problem-solving was found to promote teachers' collected intelligence (Gunawardena & Anderson, 1997). The collectiveness in thinking and understanding, according to Carabajal, LaPointe, and Gunawardena (2003), helps learners co-constructing collective knowledge, which facilitates the formation of a community of "networked minds" (p. 217). In addition, this collective knowledge and consciousness allow an individual to test his or her intuitive theory against group theory to confirm or refute the validity of prior intuitive theory in order to develop understanding (Land & Hannafin, 2000).

However, group learning in the OELE was found to yield different results in the two groups of teachers-- the development of collective consciousness was present in one group but absent in the other. The absence of collective intelligence was found in the group of teachers who developed individualistic thinking and understanding of the

problem to be solved. To further examine this phenomenon, professional dialogue and exchange among teachers in group learning were not found to lead to a reach of common understanding or to promote collective consciousness. This group of teachers relied upon their own intuitive theory to interpret and explain the problem space. Thus, limited understanding of the context of the problem was found in this group for the teachers failed to develop alternative solutions to the problem.

This finding appears to correspond to the results of two studies (Pierson, 2005; Dawson, 2005). In these studies, pre-service teachers were engaged in an internship program and were asked to journal and reflect on their practice in an actual classroom setting. The analysis of reflective journals indicated that the teachers demonstrated superficial content knowledge and limited contextual knowledge.

Constructivist theorists argued for the importance of engaging learners in social and dialogical negotiation (Vygotsgy, 1987; Daniels, 2001) in an authentic learning context (Hannafin, Hill, Oliver, & Glazer, 2003) to evoke intuitive reasoning in everyday practice (Brown Collins, & Duguid, 1989). However, the similarity in these study findings of teachers demonstrating limited understanding points out that, in addition to engaging teachers in dialogical negotiation and collaboration in an authentic learning context, there may exist other influential factors. These factors that may promote meaningful group learning experiences and the development of collective intelligence for problem solving need to be identified.

Collaborative problem solving to develop applicability. Engaging in group learning in the OELE was found to enable the teachers to develop strategic thinking and

reasoning for problem-solving and promote the development of their cognitive ability to apply learning.

The teachers in the two groups were found to have divergent thinking patterns. Group learning was found to enable one group of teachers to consolidate their divergent thinking efforts, thus generating into unified and holistic, strategic thinking and reasoning about a problem and solution process. On the other hand, for the other, group learning was not found to elicit the same effect of consolidation and unification in terms of the impact on individual teachers' problem-solving processes, and the teachers continued to rely on their individualistic thinking and reasoning to solve the problem.

In the first group described above, knowledge negotiation and collaborative problem-solving had a transformative effect on the teachers' mental functions. This finding is consistent with adult learning literature that learning involves transforming one's meaning perspectives (Mezirow, 1984), expanding one's consciousness (Weiser, 1987), and developing one's mental complexity to increase one's intellectual strength (Kegan, 1994) or to obtain wisdom (Sinnott, 1994). This transformation, constructivist theorists suggest, may be achieved in a "social, communicative, and discursive process" (Duffy & Cunningham, 1999, p. 181). Evidently, the findings on the collaborative learning in the OELE impacting individual teachers' cognitive functioning are consistent with adult learning and constructivist learning literature.

However, in the second group described above, knowledge negotiation and collaborative problem-solving did not yield similar results claimed by these constructivist and adult learning theorists. Thus the effect of social, communicative, and discursive

process needs further investigation in order to understand what factors truly contribute to effective, social discourse for collaborative professional learning.

Collaborative problem solving to develop authentic discernment. Engaging in group learning in the OELE was found to enable the teachers to share multiple perspectives and promote the development of authentic discernment for real-world connections.

For example, Andrew's unique cultural background and experience as a Hispanic bilingual teacher not only enabled him to contribute to group discussion in the context of learning but also allowed other teachers in the group to gain perspectives for problem solving. In addition, Debra's unique insight in analyzing student performance data provided scaffolding for group learning and stimulated learning interest of other teachers in the same group. Travis's view about confronting a double language barrier was shared by other teachers in his group, which inspired the teachers of reflecting on their prior experience, discerning the reality of teaching English Language Learners, and considering about making adjustments accordingly.

These findings are consistent with adult and constructivist learning literature. Duffy and Cunningham (1996) suggest that learning is navigating knowledge through one's local, social-cultural communication. This locality, adult learning theorists argue, means individual differences in social and cultural backgrounds (Merriam, 1994), in intelligence (Wagner & Sternberg, 1986), in prior knowledge and experiences (Dewey, 1984; Knowles, 1990), and in meaning perspectives (Mezirow, 1984), which can impact a teacher's professional learning. Evidently, engaging teachers in knowledge negotiation and collaborative problem-solving—to share professional knowledge including academic

and practical knowledge, language and cultural backgrounds, prior learning and teaching experiences, and mental schemata in interpreting a particular phenomenon-- develops a teacher's authentic discernment of real-world connections.

Group learning that facilitated the development of the teachers' conceptual understanding, applicability, and authentic discernment was found evident in the retrospective data. Two additional themes, social interaction among learners and subject-researcher interaction, are also observed in the interview data and are identified as factors impacting the teachers' thought processes for collaborative problem solving in the OELE professional learning.

Social interaction among learners. Different patterns of social interactions and distinct traits of group dynamics were found in the two groups of teachers, which influenced their thought processes for collaborative problem-solving in the OELE, professional learning.

For example, one group was found to have a positive and cooperative learning attitude. Members of this group were found to demonstrate openness, acceptance, and willingness to learn from one another, which had a validating effect upon individual teachers' thinking in problem-solving. This finding is consistent with the results of some empirical studies (e.g. Truscott & Truscott, 2004; Selwyn, 2000; Ge, Chen, & Davis, 2005; Windschitl, 2002). These studies indicated this validation serves as a vital mechanism to scaffold learning effort and to provide the equilibrium of world views.

Moreover, Land and Hannafin (2000) argue that the OELE allows learners to test personal, intuitive theory in order to avoid misconceptions or naïve, intuitive

presumptions. Grabove (1997) also suggests that engaging learners in critical discourse can serve as a reality check to avoid distortion or misunderstanding.

Apparently, teachers of the other group who demonstrated individualistic thinking, oblivious to alternative perspectives, and sometimes even rejecting others' propositions were engaged in social discourse, however, were not found to be engaged in critical discourse. Therefore, merely engaging teachers in social discourse does not necessarily lead to the formation of a community of networked minds (Carabajal, LaPointe, & Gunawardena, 2003). It is the kind of social discourse that promotes open communication of different perspectives and beliefs and enables teachers to share interests and experiences (Jonnassen, 1999), can truly serve the freedom rather than the oppression of truth and knowledge (Tennant & Pogson, 1995).

Researcher-subject interaction. The researcher conducted interviews with individual teachers and asked them to provide retrospective verbal reports of their thought processes in the collaborative problem solving in the OELE, professional learning. Unlike concurrent reports, retrospective verbalization has the potential to be influenced by reactive questioning and prompting of a researcher who asks the subjects to describe and explain their thoughts so that their covert thinking becomes available for study.

The researcher's personal rapport and relationships with study subjects engendered a researcher-subject interaction, which were found to be a factor for reactive influences upon the teachers' retrospective verbalizations. In other words, the stronger the relationship the researcher has with her subject, the more influence she has on the verbalization. This relationship can help the subject generate richer, more in-depth,

retrospective verbalization, as compared to subjects with whom the researcher has a weaker connection.

Ericsson and Simon's (1998) assert that asking participants "to describe and explain their thinking, their performance is often changed—mostly it is improved" (p. 182). Thus, personal relationships between a researcher and study subjects may be a positive factor that influences the subjects' retrospective verbalization.

To summarize, comparing the findings of this study with theory reveals several factors of professional learning of teachers, which may shed light upon web-based, adult learning literature.

First, the characteristics of teachers as learners including self-direction, richness in experiences, complexity of one's social roles, and problem-oriented and application-focused thinking, which are important constructs in studying adult learning, are also found related to the development teachers' conceptual understanding, applicability, and authentic discernment in professional learning.

Second, constructivist pedagogy that epitomizes the Open-Ended Learning Environment (OELE) that is designed to situate in authentic learning context and to engage learners in cognitive and dialogical processing is found to promote a teacher's conceptual understanding, applicability, and authentic discernment in web-based, professional learning.

Third, the OELE components including enabling context, resources, tools, and scaffoldings are found to provide a critical mechanism to support both independent and collaborative problem-solving for professional learning of teachers.

Fourth, the use of think-aloud protocols to explore a teacher's cognitive processing in the OELE instruction reveals that in addition to information-processing theory, examining the phenomena of a teacher's cognitive functioning in the process of professional learning may be viewed from cultural-historical activity theory.

Enlightened by these different strands of theory, the research efforts to understand the inner working of a teacher's mind may have several implications for research and practice in web-based, professional learning. Accordingly, the following section discusses these implications.

Implication

The findings of this study point toward three implications for research and practice. First, the results of this study suggest that think-aloud protocols can be a useful method to study cognitive functioning of teachers in web-based, professional learning. In Ericsson and Lehmann's (1996) review of literature, think-aloud protocols have been utilized to study expert performance in various domains including chess, medicine, auditing, music, and sports, etc. In this study, think-aloud protocols were specifically designed to include concurrent and retrospective verbalizations to study individual teachers' thoughts in problem-solving in the domain of teaching.

Second, the findings of this study suggest that the examination of a teacher's cognitive processes for thinking, learning, and problem-solving can provide insights into two strands of theory, adult learning and constructivist learning. These two theoretical strands served as a lens to examine a teacher's professional learning in a web-based environment; in turn the results of this study also inform the theoretical assumptions originated from the two strands. In this process, this study may help researchers

conceptualize a model for the development of effective, web-based learning environment for continuing professional education through merging key concepts from these two theoretical perspectives.

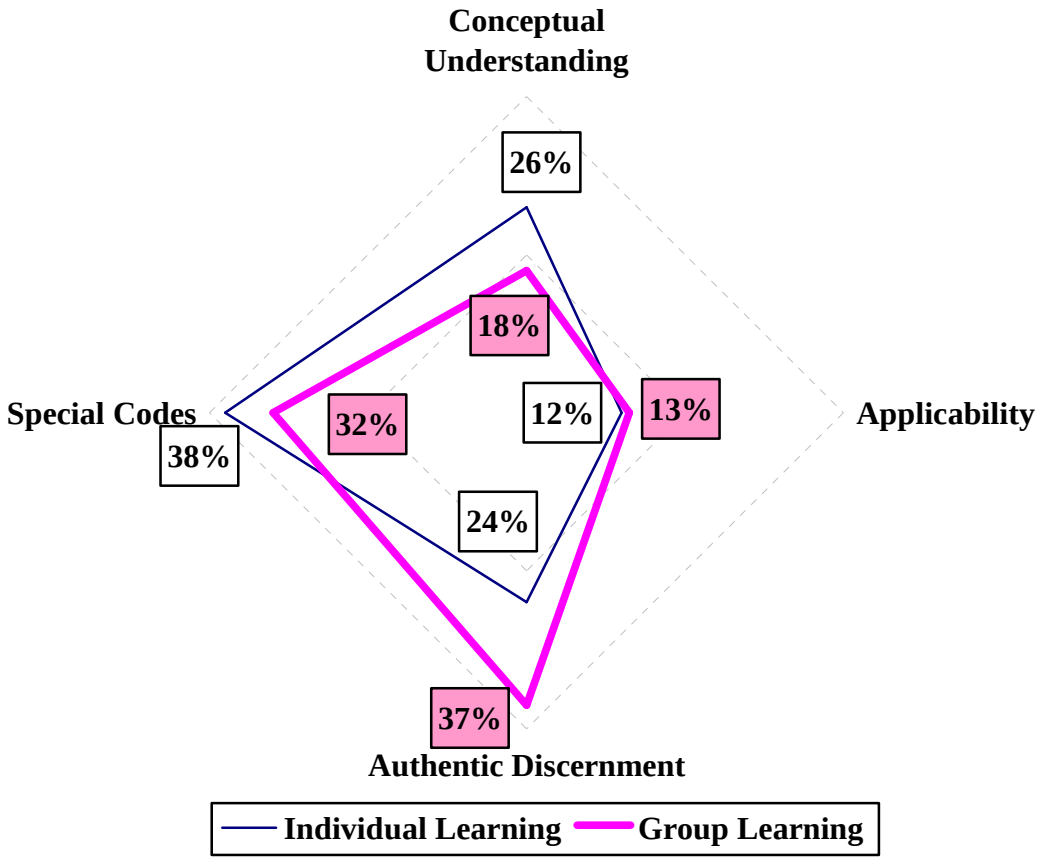
Third, the OELE instruction can be an effective approach to professional learning of teachers. The study reveals that the OELE instruction cultivates a teacher's conceptual understanding, applicability, and authentic discernment including knowledge, skills, and dispositions and professional judgment required to become a professional teacher based on National Board Professional Teaching Standards (2010).

In examining the distribution of thought episodes among the four categories between individual and group learning in the OELE instruction (see Figure 5.1), the study reveals that differences in terms of learning outcomes exist between independent and collaborative problem solving. When engaged in independent learning in the OELE instruction, teachers elicited more thoughts related to understanding the learning content and discerning the learning for real-world connections and fewer thoughts promoting their thinking ability pertaining to applying the learning. However, when learning in a group context, the OELE instruction appears to promote authentic discernment that validates one's thoughts and develops one's discernment for real-world connections.

In comparing independent and group learning, the OELE instruction did not have as much impact upon thinking about applicability (12% in individual learning and 13% in group learning) as upon the teachers' conceptual understanding and authentic discernment. The relatively low rate of thought episodes in a teacher's thinking about application of learning may have implications such that instructional designers should

develop learning activities, which require teachers to think more deeply about applying their professional learning for instructional practice.

Figure 5.1 A Comparison of the Distribution of Thought Episodes among the Four Categories between Individual Learning and Group Learning



Based on these three implications, several recommendations for research, conceptualizing theory, and the design of the OELE instruction for teachers' professional learning are outlined as follows:

Recommendations

Research. In this study, think-aloud protocols were employed to examine a teacher's covert thinking through verbalization in a natural, professional learning situation. As a result, the researcher recommends several adjustments to be made during the data collection and analysis processes of individual verbal reports.

First, in a quasi-experimental design, the selection of study settings may become a factor impacting the data collection process. In consideration of convenience and limited time available to teachers, the think-aloud experiment in this study took place at the participants' work place. Several interruptions occurred during the data collection processes, which impacted the results of this study. Further studies interested in this line of research may consider a neutral or exclusive research setting outside of professional work environments to control miscellaneous interruptions of study subjects during problem solving.

Second, this study endeavors to understand a teacher's inner life of thought through the means of think-aloud protocols, which requires a researcher to control reactive influence upon study subjects. Due to the difficulty of soliciting research subjects, the researcher recruited only teachers with whom she had built a rapport. This personal relationship between the researcher and subjects, however, may pose an inevitable threat for controlling the influence of researchers upon study subjects. In order to control for reactive influence, researchers may consider the involvement of a third party to conduct a think-aloud experiment.

The need to involve a third party in research processes is also desirable for the purpose of achieving interrater reliability of data encoding and interpretation. In this case,

the researcher worked alone and collected all verbal reports, transcribed these reports into research data, and coded and interpreted the data for emergent themes. Given the relevancy and proximity of her study context, the researcher had the advantage of utilizing her expertise in the profession for data interpretation. However, this familiarity with study context may lead to assumptions and error in the absence of cross-checking. Thus, this study suggests that involving multiple coders to achieve intercoder reliability and incorporating multiple perspectives from skilled, introspective experts in data interpretations would assist researchers to obtain accuracy and objectivity of analyzing think-aloud protocols.

Third, interviews were conducted in this study to obtain retrospective verbal reports from subjects regarding group learning impacting individual teachers' cognitive processing of problem solving. Having a particular interest in understanding a teacher's thoughts in the context of group learning, the researcher asked individual teachers to describe and explain their thinking processes in the conclusion of their professional learning. Unlike concurrent verbalization, the teachers gave retrospective reports on account of what they remembered and learned during the group learning and discussion process.

Retrospective verbal reports may provide a data source to understand a subject's cognitive processing impacted by group learning experiences. In order to present a more complete portrait, multiple data sources to include transcripts of group discussion and other artifacts produced as results of learning may provide a better understanding of the research phenomenon being studied.

Fourth, in addition to exploring teachers' cognitive functioning while engaged in problem-solving tasks, future research may involve investigating the impact of the OELE instruction upon changing teaching practice. Furthermore, the OELE four components (enabling contexts, tools, resources, and scaffoldings) may also be explored to determine how these factors contribute to a teacher's learning and thinking in problem-solving. Finally, researchers may consider exploring the impact of the OELE instruction upon learner differences, for example, by comparing veteran to novice teachers or comparing a homogenous to a heterogeneous group of teachers for collaborative learning.

Fifth, in the analysis of data, the study was designed to assess the cognitive processes of teachers using three major constructs based on National Board Professional Teaching Standards. These constructs serve as a priori categories for data analysis. As a result, the findings of this study support the validity of the OELE instruction, such in that it demonstrates that this design supports conceptual understanding, applicability, and authentic discernment that constitute and identify a professional teacher. Future studies should explore the cognitive processes of adult learners in different professional fields. In addition, future data analysis should include both a priori analysis and open coding to determine if additional themes emerge.

In summary, think-aloud protocols employed in this study can be a useful to tool to understand a teacher's cognitive development in professional learning. The study results also reveal some suggestions for conceptualizing theory for web-based, professional learning, and these suggestions are discussed further in the next section.

Conceptualizing theory for web-based, professional learning. The assumptions of adult learning and constructivist learning provided a theoretical framework to examine

cognitive processes of professionals in web-based learning environments. The findings of this study suggest that the activity of a human mind is a complex process, thus to conceptualize the complexity of the phenomenon, the researcher recommends the convergence of adult learning and constructivist learning theory. This convergence explains why the thinking and learning of professionals are self directed, experience based, personally and socially related, problem oriented, and application focused, and how to engage professionals in cognitive processing and dialogical negotiation through interactive, experiential, and collaborative learning to promote higher order thinking and make learning more applicable and meaningful.

The design of the OELE instruction for professional learning of teacher. The study results also reveal some practical directions for designing the Open-Ended Learning Environment (OELE) for professional learning of teachers.

A web-based, technology-rich, open learning environment creates unlimited possibilities for professional learning; however, the enormous amount of information may become overwhelming for teachers to discern relevancy and importance of information pertaining to their professional growth and development. Web-based learning modules designed according to the instructional principle of the OELE provide interactive, experiential, problem-based learning activities that target a teacher's learning needs and goals for immediate application. However, the results of this study reveal that technology efficacy in terms of a teacher's ability of navigating and accessing learning content can become a deterrent of learning. Thus, the study recommends that certain provisions need to be made to accommodate teachers who have limited technology skills by offering additional technology training programs or to consider incorporating learning

tasks to avoid technical issues such as access to learning materials blocked by security settings. In addition, it is critical to design a mechanism to provide technical support and guidance to help teachers successfully accomplish required learning tasks.

Moreover, several factors need to be considered when engaging teachers in learning tasks that involve group discussion and collaboration. In this study, group composition, dynamics, and interactions are found to impact each individual teacher's professional learning and development. For example, one group of teachers was more open to suggestions and guidance of group members than the other group. This may have been a result of the fact that one teacher in the more interactive group has an ELL background relevant to the topics and context of discussion required in the OELE instruction. Additionally, personality traits of group members may also impact group interaction. For instance, the teachers in one group were less engaging and open, with respect to accepting opinions and suggestions of the group members. Thus, making group assignments for collaborative learning should consider personal preferences and a diversity of backgrounds along with the flexibility to modify group assignments as needed. In addition, facilitators should encourage openness and mutual acceptance and respect among teachers in a learning community and work toward moderating meaningful discussion and critical reflection necessary for collaborative learning and problem-solving.

Furthermore, the study reveals that conceptual and manipulative tools are particularly effective in stimulating teachers' cognitive ability to include applying thinking strategies, using logical reasoning, and engaging in pragmatic planning. As such, the results of this study suggest that the design of the OELE four components including

enabling context, tools, resources, and scaffoldings may contribute to promoting teachers' conceptual understanding, applicability, and authentic discernment.

Finally, the study provides evidence that the OELE instruction is an effective approach for the professional learning of teachers. Traditional approaches such as lecture-based, in-service training and conferences, which focus primarily upon information dissemination, often fail to demonstrate effective change in teaching practice. These traditional approaches often include learning events that lack continuity and relevance to practice necessary for long-term learning and transfer of learning to practice. Furthermore, conferences can be a very costly approach to gather a large group of teachers for professional development.

The results of this study provide evidence that the OELE instruction is effective in promoting conceptual understanding, applicability, and authentic discernment as identified by the National Board Professional Standards as important constructs in the continuing professional education of teachers. In addition, the OELE instruction is designed to situate learning in an authentic context. The OELE instruction provides immediacy of access to learning materials using independent, individualized methods providing for time and place independence. Additionally, the OELE uses collaborative learning so that the teachers can learn from each other and develop a virtual, professional learning community.

Conclusion

Problem-Based Learning (PBL) has become a prevalent instructional method to cultivate practical experience and skill in professional domains (Boshuizen, 2009). In addition, web-based learning appears to open up unique training and development

opportunities for professionals. This study explores the role of web-based learning, specifically the Open-Ended Learning Environment (OELE) in promoting higher order cognitive functioning of teachers in continuing professional development, and the study reveals that teachers may achieve positive learning outcomes through the OELE instruction.

Studying teachers' cognitive functioning in problem-based, OELE professional development through think-aloud protocols relies on their overt verbalization as "the means through which cognition develops, in terms of both cultural history and the individuals who are situated in specific... social, cultural, and historical contexts" (Smagorinsky, 1998, p. 163).

The inner working of a human mind is complex. This study endeavors to examine a teacher's thinking processes while engaged in professional learning. The endeavor to provide insight into understanding the complexity of a teacher's inner life of thought is a worthwhile investment.

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Appendix A: Think-Aloud Instruction

You will in a moment begin a problem-based, learning module. You will be prompted with a classroom problem. Please solve the problem and while you do so, try to say everything that goes through your mind.

Keep on talking.

(Avoid unnecessary interference).

Appendix B: Interview Questions for Group A

1. What were you thinking when…(problem scenario)?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:01:39	00:01:39	00:01:39
Screen Shot Out	00:03:17	00:03:17	00:03:17

2. What instructional theory were you considering when…(Doing what works)?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:10:50	00:10:50	00:10:50
Screen Shot Out	00:11:58	00:11:58	00:11:58

3. What instructional strategies did you have in mind when …(Note taking)?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:18:10	00:18:10	00:18:10
Screen Shot Out	00:19:04	00:19:04	00:19:04

4. What learning activities were you thinking about for real world connections

….(Examples)?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:34:50	00:34:50	00:34:50
Screen Shot Out	00:36:09	00:36:09	00:36:09

5. What were you thinking when "Teacher X" said…?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:44:00	00:37:00	00:37:00
Screen Shot Out	00:45:02	00:39:00	00:39:00

6. What were your thoughts when you said that?

Teacher	Andrew	Debra	Rose
Screen Shot In	00:46:00	00:46:00	00:48:00
Screen Shot Out	00:47:00	00:47:00	00:48:39

Appendix C: Interview Questions for Group B

1. What were you thinking when…(problem scenario)?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:04:25	00:04:25	00:04:25
Screen Shot Out	00:06:24	00:06:24	00:06:24

2. What instructional theory were you considering when…(Doing what works)?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:14:25	00:14:25	00:14:25
Screen Shot Out	00:17:48	00:17:48	00:17:48

3. What instructional strategies did you have in mind when …(Notaker)?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:34:00	00:34:00	00:34:00
Screen Shot Out	00:35:22	00:35:22	00:35:22

4. What learning activities were you thinking about for real world connections

   ….(Examples)?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:46:00	00:46:00	00:46:00
Screen Shot Out	00:48:30	00:48:30	00:48:30

5. What were you thinking when “Teacher X” said…?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:11:00	00:11:00	00:29:00
Screen Shot Out	00:11:45	00:11:45	00:29:40

6. When you said…what were your thoughts on that?

Teacher	Angel	Cassandra	Travis
Screen Shot In	00:42:20	00:38:30	00:40:05
Screen Shot Out	00:43:27	00:39:04	00:41:35

Appendix D: Coding Scheme

Code	Description		
CIC	Conceptual understanding	Interpretative	concepts
CIM	Conceptual understanding	Interpretative	meanings
CIP	Conceptual understanding	Interpretative	propositions
CED	Conceptual understanding	Explanatory	A statement that defines
CER	Conceptual understanding	Explanatory	A statement that restates
CEC	Conceptual understanding	Explanatory	A statement that clarifies
CEQ	Conceptual understanding	Explanatory	A statement that questions
CEKR	Conceptual understanding	Explanatory	A statement that knows/realizes
CES1	Conceptual understanding	Explanatory	A statement that summarizes
CES2	Conceptual understanding	Explanatory	A statement that specifies

ASCE	Applicability	Strategies	cause/effect
ASCC	Applicability	Strategies	compare/contrast
ASCF	Applicability	Strategies	classification
ASCL	Applicability	Strategies	cluster
ASB	Applicability	Strategies	brainstorming
ALA	Applicability	Logical Reasoning	argument
ALI	Applicability	Logical Reasoning	inference
ALP	Applicability	Logical Reasoning	prediction
ALC	Applicability	Logical Reasoning	consideration
APG	Applicability	Pragmatic planning	goal-and-outcome
APP	Applicability	Pragmatic planning	problem/solution
APB	Applicability	Pragmatic planning	beginning/middle/end
APT	Applicability	Pragmatic planning	timeline

DPF	Authentic Discernment	Perspectives	view of self
DPP	Authentic Discernment	Perspectives	view of peers
DPS	Authentic Discernment	Perspectives	view of students
DPC	Authentic Discernment	Perspectives	view of teaching context
DPA	Authentic Discernment	Perspectives	view of teaching approach
DEF	Authentic Discernment	Experiences	about self
DEP	Authentic Discernment	Experiences	about peers
DES	Authentic Discernment	Experiences	about students
DEC	Authentic Discernment	Experiences	about teaching context
DEA	Authentic Discernment	Experiences	about teaching approach
DAF	Authentic Discernment	Activities	real-world connection of self
DAP	Authentic Discernment	Activities	real-world connection of peers
DAS	Authentic Discernment	Activities	real-world connection of students
DAC	Authentic Discernment	Activities	real-world connection of context
DAA	Authentic Discernment	Activities	real-world connection of approach

Appendix E: Special Coding Categories

Code	Description		
SN	Special	Not-task related issues	Are you going to the staff party?
SE	Special	Evaluation of task	Let me think, determine what to do
SEM	Special	Evaluation of task-situation at a meta level	I don't like to work on this kind of problems (Evaluation in general)
SCN	Special	Comments (Negative)	I don't like this.
SCP	Special	Comments (Positive)	It's neat. I like this.
SS	Special	Silent periods	Relatively long pauses
SAW	Special	Actions	Write a note
SAM	Special	Actions	Manipulates a device
SR	Special	Reading materials	Websites or instruction
SPA	Special	Prompt for answer	Remind to continue to talk, ask for directions, prompt to move on
SPB	Special	Procedure of browsing	Steps related to website browsing
SD	Special	Description	Describing what he or she does or sees
SRN	Special	Researcher's note	Providing feedback and notes
GR	Special	Group learning	Referring to group learning experiences