University of Northern Colorado
Scholarship & Creative Works @ Digital UNC

Dissertations | Student Research

8-2011

Students' knowledge construction and attitudes toward synchronous videoconferencing in an online collaborative problem-based learning environment

Chatchada Akarasriworn

UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

STUDENTS' KNOWLEDGE CONSTRUCTION AND ATTITUDES TOWARD SYNCHRONOUS VIDEOCONFERENCING IN AN ONLINE COLLABORATIVE PROBLEM-BASED LEARNING ENVIRONMENT

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

Chatchada Akarasriworn

College of Education and Behavioral Sciences
Department of Educational Technology

August, 2011

This Dissertation by: Chatchada Akarasriworn

Entitled: *Students' Knowledge Construction and Attitudes toward Synchronous Videoconferencing in an Online Collaborative Problem-Based Learning Environment*

has been approved as meeting the requirement for the Degree of Doctor of Psychology in College of Education and Behavioral Sciences in Department of Educational Technology

Accepted by the Doctoral Committee

____

Heng-Yu Ku, Ph.D., Chair

____

Jeffrey W. Bauer, Ph.D., Committee Member

____

Mia K. Williams, Ph.D., Committee Member

____

Katrina Rodriguez, Ph.D., Faculty Representative

Date of Dissertation Defense June 30th, 2011

Accepted by the Graduate School

____

Robbyn R. Wacker, Ph.D.
Assistant Vice President for Research
Dean of the Graduate School & International Admissions

ABSTRACT

Akarasriworn, Chatchada. *Students' Knowledge Construction and Attitudes toward Synchronous Videoconferencing in an Online Collaborative Problem-Based Learning Environment*. Published Doctor of Philosophy dissertation. University of Northern Colorado, 2011.

The purpose of this study was to investigate students' cognitive learning process during problem-based discussions in an online synchronous collaborative learning environment via videoconferencing. In addition, students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing as well as recommendations on how to improve their online synchronous collaborative small-group discussions with videoconferencing were investigated.

The participants were 28 graduate students who took a graduate-level online Mathematical Modeling course at a western university. They were assigned into eight groups of three (or four) students to work on nine collaborative projects throughout the semester. They were instructed to utilize the Elluminate *Live!*® for the synchronous small-group discussions each week. A triangulation mixed methods design was used to analyze and interpret four data sources including (1) twelve synchronous small-group discussion transcriptions; (2) three teamwork attitude surveys; (3) a learning environment attitude survey; and (4) seven individual interviews.

The main findings of this study revealed that students performed more messages at Phase I than at Phase IV or Phase V based on the Gunawardena, Lowe, and Anderson's Interaction Analysis Model (1997) in the online synchronous collaborative small-group

discussions with videoconferencing integrated. The results of the findings might be due to students' sharing preferences, preparedness of the group members, and the nature of the Mathematical Modeling course. Nevertheless, videoconferencing can be a potential tool to help facilitate participants to perform more messages at Phase V than synchronous chat.

Additionally, students had positive attitudes toward the online synchronous collaborative learning environment and their most favorable experiences included the sense of community, learning facilitation, and significance of the synchronous small-group discussions via videoconferencing sessions. Conversely, technology problems and unprepared group members were students' unfavorable experiences when participating in the synchronous small-group discussions via videoconferencing.

Furthermore, recommendations such as technical assistance, group rotation, clear course expectations, greater preparation time, and increased learner-instructor interaction were provided to improve students' online synchronous collaborative small-group discussions with videoconferencing. Finally, implications for educational practices and recommendations for future studies were discussed.

AKNOWLEDGEMENTS

It can be evidently understood that this dissertation could not be accomplished by one person. Without the assistance and encouragement of many people, this dissertation would not be completed. I would like to express my gratefulness to those who have supported me throughout this process.

First and foremost, to Dr. Heng-Yu Ku, a man with an infinite amount of patience and faith. As my faculty and dissertation chair, he went above and beyond to keep me going to complete this journey. I would also like to thank him for providing me great opportunities to work and earn skillful experiences as a graduate research assistance as well as a teaching assistance throughout years that I was a doctoral student at University of Northern Colorado. He encouraged me more than he will ever know.

To my committee members, Dr. Katrina Rodriguez, Dr. Jeffrey W. Bauer, and Dr. Mia K. Williams, for providing me noteworthy information to improve my dissertation and supporting me through to the end.

To Dr. Berlinda Saenz for providing me feedback emphasized details and strengthened the quality of this dissertation. I am indebted to her who always generous with her time and expertise.

To Dr. Jodie Novak and Dr. Shandy Hauk for providing me the great opportunity to be a part of the National Science Foundation grant (NSF Award # DUE-0832026). To Dr. Nathaniel Miller for allowing me to conduct my research in his class.

To my parent and families, from Thailand, Japan, and USA (North Carolina), for encouraging me to pursue my doctorate, for believing in my abilities to succeed, and for ever-ending love and support.

To my brother, Chatchai, for taking care of our dad and grandparents when I was away from home and unable to look after them. To my cousins, Nuttanich and Jukkrit, for assisting me in the initial proofreading throughout my dissertation.

To friends at University of Northern Colorado, for their ongoing support, friendship, and encouragement. To the students who participated in this study, for providing ultimate responses.

Last and more than any other individual, to my husband, Hiroaki Nagaoka, for his devoted encouragement, infinite support, and generous love that made it possible for me to achieve my academic goals and succeed this journey. I am truly blessed to have him by my side.

TABLE OF CONTENTS

CHAPTER

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURE

CHAPTER I

INTRODUCTION

Over the past decade, distance education has become a fast-growing delivery method in the United States (Dunlap, Sobel, & Sands, 2007). In addition, online enrollments have been increasing more rapidly than on campus enrollment (Allen & Seaman, 2010). A survey conducted by Allen and Seaman (2010) found that "17 percent growth rate for online enrollments far exceeds the 1.2 percent growth of the overall higher education student population" (p. 1). There were over 4.6 million students taking at least one online course in Fall 2008, an increase from 1.6 million students in Fall 2002, which represented a compound annual growth rate of 19 percent. In addition, 14 percent of the 4.6 million students were taking graduate level courses (Allen & Seaman, 2010).

The growth of distance education has created new opportunities and challenges for both the learners and the instructors. Learners can benefit from the independence online classes since they are able to learn at convenient times and in preferred locations (Goodyear, 2006). However, such benefits also produce associated challenges in that the distance accompanying online classes often generates feelings of isolation and loneliness in various learners (Rovai, 2002). For instance, learners who are social by nature may often dislike online learning due to the social distance created between instructors and learners. Instructors also experience both benefits and challenges of distance education. For example, instructors' teaching schedules are more flexible. At the same time, instructors must bridge the gap created by their physical absences as instructors' tone of voice, questions, and things that learners can hear and see in the context of a lesson are absent (Lahaie, 2007).

The interaction among instructors and learners is an essential component of the educational process for meaningful learning (Garrison & Anderson, 2003) and is central to the expectations of instructors and learners in distance education (Berge, 2002). The interaction serves a variety of functions in the educational transaction, such as providing various forms of participation and communication, allowing for learning control, and facilitating learning acquisition (Sims, 1999). According to Moore (2001) and Vrasidas and McIsaac (1999), the lack of interactions in designing and developing instructional tools and activities can cause ineffective distance education.

There are four types of interactions in distance education: learner-interface interaction (Hillman, Willis, & Gunawardena, 1994; Iverson, 2004), learner-content interaction, learner-instructor interaction, and learner-learner interaction (Moore, 1993; Iverson, 2004).

First, the learner-interface interaction is a process of manipulating tools to accomplish a task (Hillman, Willis, & Gunawarena, 1994). An example of good learner-interface interaction is having concise and clear instruction which would allow learners to concentrate on learning and communication, instead of being anxious about accessing the instructional content and communicating with others. This interaction provides learners' access to the instruction and allows learners to participate in other course activities (Iverson, 2004). Second, the learner-content interaction is the interaction between the individual learner and the course content and materials that facilitate the personal knowledge construction of the learner (Moore, 1993; Iverson, 2004).

Third, the learner-instructor interaction is the communication between the learner and instructor who prepared the course materials (Moore, 1993). For instance, instructors can use the announcement section to update all information regarding the class and give prompt feedback to learners to encourage them to participate in the class. Fourth, the learner-learner interaction is the communication among learners in group settings with or without real-time presence of an instructor (Moore, 1993; Iverson, 2004). The interaction is primarily group discussions promoted through project questions where learners exchange ideas and engagement with all group members. This interaction promotes groups' and individuals' construction and use of knowledge (Moore & Kearsley, 1996). In contrast, the lack of communication among learners can have a negative effect on the online learning experience (Moore, 2001) because learners may experience feelings of isolation and loneliness. Therefore, increasing the interaction is critical for effective online learning (Roblyer & Ekhaml, 2000; Vrasidas & McIsaac, 1999).

According to Schrage (1990), the collaborative learning method allows learners to work in groups and encourages them to share ideas to promote learner-learner interaction and cultivate a positive online learning experience. Furthermore, the use of collaborative learning in higher education courses was also found to cultivate higher level reasoning, help to generate more ideas and solutions, and produce greater transfer of learning than individual or competitive learning strategies (Johnson et al., 1991). In addition, Vygotsky (1978) addressed the issue that peer collaboration or assistance from others can help learners to solve a problem which could not be solved alone. Moreover, several researchers (Johnson & Chung, 1999; Mergendoller et al., 2000) examining the effect of collaboration on problem solving found that collaboration improved learner performance regarding complex or higher-order thinking activities when learners discussed the problem, brainstormed potential solutions, and arrived at final solutions.

In addition, the nature of the workplace and the requirements of employees have changed over the past decade. Problem-solving skills are essential in our personal and professional lives because everyone has to encounter and solve problems endlessly (Jonassen, 2000). Today's working conditions have required learners to come to a job equipped with skills to think critically and make clever decisions (National Research Council, 1996; Uden & Beaumont, 2006). Therefore, an important challenge for today's higher education is to implement instructional practices that will assist students to cultivate higher order thinking and problem-solving skills along with the ability to work effectively within a group (Halpern, 1999; Uden & Beaumont, 2006).

The use of a problem-based approach for learning has been discussed over the years (DeGrave, Boshuizen, & Schmidt, 1996; Şendağ & Odabaşi, 2009; Valaitis, Sword, Jones, & Hodges, 2005). Problem-based learning (PBL) is an instructional practice in which a problem is used as a starting point for students to discuss and share ideas with each other (Bridges, 1992). Through PBL, learners can address real-life problems, gather resources, discuss options with peers, propose resolutions, and share results (Hou, Chang, & Sung, 2008; Jonassen, 1997).

The PBL process helps support students' knowledge construction as they are guided through their learning and problem-solving processes (Greeno, Collins, & Resnick, 1996; Schmidt, DeVolder, De Grave, Moust, & Patel, 1989). The process of new information or knowledge construction is facilitated by the discussion of a relevant problem among students when they are working in small groups (Hmelo-Silver, 2004; Schmidt et al., 1989). According to Cercone (2008) and Kim (2009), students have higher motivation to learn when they participate in authentic learning activities, in which they apply what they have learned into real-world situations.

Problem-Based Learning in Online Environment

As distance education is changing the face of traditional classrooms with the integration of new technology, synchronous and asynchronous communication tools have appeared as optional forms of online communication in teaching, learning, and supplements to traditional teaching (Chen & Shaw, 2006). In asynchronous online classes, students can access and work on their assignments by communicating with their instructors or other students via e-mail, newsgroup, or discussion board as students are not required to log onto the online class at the same time (Jolliffe, Ritter, & Stevens, 2001; Tallent-Runnels et al., 2006). Rovai and Grooms (2004) stated that asynchronous communication is a great tool for group discussion that promotes the level of interaction in the online classroom. The asynchronous discussion board allows students to have sufficient time to read, to reflect, and to reply to other students' postings as well as to participate whenever students wish to do so (Poole, 2000).

Conversely, in synchronous online classes, students are communicating at the same time but not necessarily in the same place (Jolliffe et al., 2001). Students can communicate by using text chat, audio-conferencing, videoconferencing, or white boards online (Chen, Chen, & Tsai, 2009; Romiszowski & Mason, 2004). A synchronous environment allows students to adjust their paces continuously, to address their concerns immediately, and to immerse themselves in problem-solving and decision-making processes deeply (Murphy & Collins, 1997). Additionally, Pattillo (2007) discovered that the synchronous audio conferencing could boost the communications between the instructor and students.

In response to the expansion of online learning, educators have been exploring the use of the PBL approach in online environments (Hou et al., 2008; Koh, Herring, & Hew, 2010; Orrill, 2002; Şendağ & Odabaşi, 2009). The online environment has features that are favorable for PBL. For example, students have more time to analyze and reflect on the content before composing ideas and responding to other people (Althaus, 1997). In addition, students can take control of their own learning pace (Vrasidas & McIsaac, 2000). The online learning environment also promotes interactions and collaboration among the instructor and students (Relan & Gillani, 1997) as well as engages students in higher level thinking through active and interactive learning (Harasim, Calvert, & Groeneboer, 1997; Şendağ & Odabaşi, 2009). Further, the online learning environment provides students access to valuable learning resources as they receive advice from experts, practitioners, and peers (Bonk & King, 1998; Valaitis et al., 2005). According to Ozdemir (2005) and Uribe, Klein, and Sullivan (2003), students who worked collaboratively performed better than students who worked individually in online PBL environments.

However, some aspects of the online environment might not be suitable for PBL. For example, the asynchronous computer-mediated communication (CMC) in online environments lacks audio and visual cues (Vrasidas & McIsaac, 2000). It would seem that students may take more time to complete communications or tasks when using asynchronous CMC when compared with students who worked in real-time communication situations (Bordia, 1992). Moreover, using text-based asynchronous CMC could be overwhelming to students because of the large number of messages students need to read and respond to (Wooley, 1998). At the same time, Davidson-Shivers, Muilenburg, and Tanner (2001) asserted that although students found it was difficult to follow the messages or dialogue in the chat box, they enjoyed the interaction with other friends. It appeared that the synchronous chat is easy to respond to because it is interactive and immediate so that students can respond directly without losing their train of thought or becoming confused. On the other hand, asynchronous CMC, due to its multitude of random-timed messages can be more confusing since students may lose the train of (previous) thought in a non-immediate (time) format. Therefore, since online PBL depends on discussion and communication, understanding the features of an online environment and finding proper communication tools and ways to make online PBL effective and efficient is critical.

The Use of Videoconferencing

In education, the videoconferencing feature enhances communication, collaboration, and interaction between the learner and the educator (Cavanaugh, 2001; Saw et al., 2008). Simonson, Smaldino, Albright, & Zvacek (2009) stated that there are three different types of video tools that learners can experience in distance education. These tools include the following: 1) one-way live video, 2) two-way audio, one-way video, and 3) two-way audio/video or compressed videoconferencing system.

Videoconferencing is synchronous communication in real time via audio, video, and data between two or more distant locations (Chandler & Hanrahan, 2000; Simonson et al., 2009). Since videoconferencing utilizes similar characteristics as real-time conferencing, (i.e., face-to-face communication) featured in synchronous verbal exchanges with the ability to see a collaborative partner live (McGrath & Hollingshead, 1994; Dennis & Valacich, 1999), it also has a potential for facilitating online collaborative learning arrangements successfully.

The videoconference has been implemented in various educational settings in recent years. For distance education, synchronous videoconferencing requires real time physical presence allowing students to communicate with their instructors or other students at distance sites (Anastasiades, 2009; Newman, 2008). Allen, Sargeant, Mann, Fleming, and Premi (2003) applied videoconferencing as a potential tool to facilitate small-group, practice-based learning to physicians in the medical education field. Riley (2009) utilized videoconferencing to deliver music classes from pre-service music teachers in the USA to students in Mexico. Saw et al. (2008) implemented the graphics display mode involved in a real-time interaction of the teacher, students, and course materials in a Mathematics and Physics program using videoconferencing. According to Ertl, Reiserer, and Mandl (2005), the collaboration among students through the medium of videoconferencing has been found to be as effective as the collaboration among students in face-to-face interactions.

Statement of the Problem

Due to the increase in online learning and the decrease in educational face-to-face communication, distance learning technologies have become paramount to an online learner's success. However, the lack of nonverbal information reduces social cues and interaction in an online asynchronous learning environment (Sproull & Kiesler, 1986).

Although several studies explored using videoconferencing to support collaborative synchronous distance learning activities (Anastasiades, 2009; Newman, 2008) and classroom interaction (Cavanaugh, 2001), the advantage of applying an online synchronous videoconferencing tool in the PBL environment has not been explored.

In addition, many studies have focused on the content analysis of asynchronous threaded discussion and synchronous chat room discussion (Hewitt, 2005; Hou, 2011; Hou et al., 2008; Gunawardena et al., 1997; Koh, Herring, & Hew, 2010; Luebeck & Bice, 2005; Sing & Khine, 2006) but they have not focused on the content analysis of synchronous videoconferencing discussion. The content analysis of these studies applied the Interaction Analysis Model developed by Gunawardena et al. (1997) which contains five different phases: 1) Sharing/comparing of information; 2) Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements; 3) Negotiation of meaning/co-construction of knowledge; 4) Testing and modification of proposed synthesis or co-construction; 5) Agreement statement(s) and applications of newly constructed meaning.

The Interaction Analysis Model (Gunawardena et al., 1997) has been applied to analyze the students' knowledge construction during problem-based discussions in many studies (Hou et al., 2008; Koh, Herring, & Hew, 2010; Luebeck & Bice, 2005; Sing & Khine, 2006). For example, the conceptual change of mathematics and science educators (Luebeck & Bice, 2005), the pattern of participation and discourse of in-service teachers in a teacher training institute in Singapore (Sing & Khine, 2006), and the learner's level of knowledge construction during asynchronous discussion activities (Hou et al., 2008; Koh et al., 2010) are some such studies. To the researcher's knowledge, there are no research attempts to analyze transcripts of students' discussions in synchronous videoconferencing in online collaborative educational settings. Hence, it is essential to explore how synchronous videoconferencing influences students' knowledge construction and critical thinking skills in an online problem-based learning environment as well as explore students' attitudes toward the learning environment.

Purpose of the Study

This study investigated to understand a learner's cognitive learning process during problem-based discussion integrated with a synchronous videoconferencing tool. The researcher intended to apply the Interaction Analysis Model developed by Gunawardena et al. (1997) to evaluate the level of knowledge construction during synchronous online discussions. Consequently, the purpose of this study was to investigate how problem-based learning (PBL) influenced graduate students' knowledge construction in an online synchronous collaborative learning environment via videoconferencing. Furthermore, students' attitudes toward the online synchronous collaborative learning environment were studied. Finally, recommendations for best practices in an online synchronous collaborative learning environment were provided.

Research Questions

The following three research questions derived from the purpose of the study are:

Q1 How did students perform in the online synchronous collaborative small group discussions with videoconferencing integrated based on the Interaction Analysis Model?

Q2 What were students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated?

Q3 What recommendations can be provided to improve the online synchronous collaborative small-group discussions with videoconferencing integrated?

Significance of the Study

The results of this study not only provided examples regarding how to design and implement an online collaborative context using videoconferencing to educators or course designers but also provide recommendations for best practices, which involve synchronous videoconferencing communication tools in an online learning environment. The results of this study also were added to the empirical research base regarding the quality of synchronous online discussion with videoconferencing as well as to the application of the Interaction Analysis Model in analyzing problem-solving discussions in the context of graduate-level coursework of mathematics educators. In addition, the findings were useful for promoting students' higher-level of thinking or knowledge construction via synchronous videoconferencing tools. Finally, the proper course design could be established as a key to increase students' satisfaction in online courses.

Definition of Terms

Several technical terms in the distance education field are used throughout this chapter. To clarify the discussion in this chapter and in subsequent chapters, definitions of those terms are included as follows:

Asynchronous: Communication in which the interaction is time-independent. The asynchronous communication environment is one where communication between learners and the facilitator does not take place simultaneously (Spector, Merrill, Merriënboer, & Driscoll, 2008). This mode of communication is done via a computer forum of some discussions at different times. Examples of the online asynchronous media are web pages, file download, e-mail, newsgroup, forum, and response pad (Chen & Shaw, 2006).

Blackboard's Discussion Board: A type of Learning Management System (LMS). The asynchronous threaded discussions on Blackboard are used to facilitate online students' asynchronous discussions.

Collaborative learning: Collaborative learning takes place when "students working together to maximize their own and each other's learning" or to achieve shared learning goals (Spector et al., 2008, p. 818).

Computer-mediated communication (CMC): Specific application of technology designed to facilitate communication between two or more individuals who are connected by a computer network with text-based tools. Examples of such tools include e-mail, computer-based conferencing systems, and instant messaging (Spector et al., 2008).

Computer supported collaborative learning (CSCL): The instructional use of technology combined with the use of collaborative learning. CSCL implies that learners communicate with each other based on the written discourse of learners discussing their perspectives on a problem with the goal to acquire knowledge via text-based tools (Weinberger & Fischer, 2006).

Distance education: The "teaching through the use of telecommunications technologies to transmit and receive various materials through voice, video and data" when an educator and learner(s) are physically separated (Bielefield & Cheeseman, 2007, p. 141).

Elluminate Live!®: The main product of Elluminate Learning Suite, a synchronous platform, which is used to facilitate online students' real time interactions and communications from remote areas. Sample Elluminate *Live!*® components consist of two-way audio, multipoint video, chat, and shared whiteboards to application sharing, interactive recording, and breakout rooms.

Face-to-face learning: Learning conducted in a traditional manner with all participants in the same place at the same time. In this environment, learning can be characterized by oral exchanges and visual contact among the participants.

Higher order thinking: Higher order thinking arises when a person obtains new information which is stored in memory. A person then correlates, reorganizes, and elaborates this information to accomplish a purpose or find possible answers in confounding situations. Illustrations of this might include, deciding what to do, creating a new idea, making a prediction, or solving a non-routine problem.

Ill-defined problem: Ill-defined problems have no specific givens, goals, or problem-solving operators (Eastman, 1969). The problem descriptions lack a solid goal-state statement (Eastman, 1969). Problem solvers have to plan the direction or method towards a solution.

Interaction: Interaction refers to the relationship between learners and instructors, back and forth within the learning environment. Interaction serves a variety of functions in the educational transaction, such as providing various forms of participation and communication, allowing for learning control, and facilitating learning acquisition (Sims, 1999). There are four types of interactions in distance education: learner-interface (Hillman, Willis, & Gunawardena, 1994; Iverson, 2004), learner-content, learner-learner, and learner-instructor (Moore, 1993; Iverson, 2004).

Knowledge-construction (Knowledge-building): Knowledge is constructed within the community as Scardamalia and Bereiter (2006) described as “the production and continual improvement of idea of value to a community… results in the creation and modification of public knowledge – knowledge that lives 'in the world' and is available to be worked on and used by other people" (p. 1370).

Problem-based learning (PBL): Acquiring knowledge as part of a learner group by analyzing a problem, studying privately, using various learning resources, and collectively synthesizing knowledge. It is an instructional method that initiates students' learning by creating a need to solve an authentic problem. During the problem-solving process, students construct content knowledge and develop problem-solving skills as well as self-directed learning skills while working toward the solution to a problem (Spector et al., 2008, p. 824-825).

Problem-solving: A process of understanding the discrepancy between current and goal states of a problem, generating and testing hypotheses for the causes of the problem, devising solutions to the problem, and executing the solution to satisfy the goal state of the problem (Spector et al., 2008, p. 825).

Sense of community: "A feeling that members belong to each other, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" (McMillan & Chavis, 1986, p. 9).

Synchronous: A communication environment that "takes place in real time where those involved in the communication process are all present at the same time, but not necessarily in the same place" (Jolliffe et al., 2001, p. 9). Examples of the online synchronous communication tools are text chat, audio-conferencing, videoconferencing, or white boards online (Chen, Chen, & Tsai, 2009; Romiszowski & Mason, 2004).

Videoconferencing: Audio-video and in some cases text data transmit over the Internet to the conference participants using personal computers equipped with microphones, small video cameras, and videoconferencing application (Holfelder, 1998). Examples of the videoconferencing tools are Elluminate *Live!*®, Wimba, Skype, MSN messenger, Google Talk.

Limitations of the Study

The findings of this study were limited in the extent to three characteristics represented as the following:

First, the subjects used for the study were students from two sections of a graduate-level online course in mathematics education. The sample could not be considered as a representative of the general population or even of all college students. Due to the similarities between the population and students in the study, the result produced from the study provided the insight on how it affected the general population.

Second, the researcher focused on the use of Elluminate *Live!*® during the study, which might not be applicable to other videoconferencing tools such as Wimba, Skype, MSN messenger, Yahoo messenger, or Google talk.

Third, the researcher also focused on the use of Elluminate *Live!*® during the class schedule time. The researcher was not able to observe and record participants' discussions when they had meetings outside of classes via Elluminate *Live!*® or other tools. Participants would be able to accomplish their assignments during those meetings which might involve more discussions indicated in Phase IV and Phase V.

Fourth, the researcher concentrated on verbal communication of participants during the synchronous small-group discussions. Due to the large number of messages generated in the synchronous small-group discussion sessions, the researcher was unable to record and collect all discussions from all groups. Therefore, it was necessary to filter the data by randomly selecting groups to record students' discussions during their synchronous small-group discussion. Instead of recording and analyzing discussions for all 16 weeks, the synchronous small-group discussions were collected four separate times in weeks 8, 10, and 12 for the purpose of investigating participants' knowledge construction.

Summary

An important challenge in today's higher education environments is the development and implementation of instructional practices that will promote students' higher order thinking and problem solving skills along with the ability to work collaboratively and effectively in a group setting. Moreover, in the past few years, educators have been exploring the use of technology to support PBL. Therefore, this study seeks to understand a learner's knowledge construction process during problem-based discussions integrated with synchronous videoconferencing tool. The Interaction Analysis Model developed by Gunawardena et al. (1997) was applied to evaluate students' level of knowledge construction during their synchronous online discussions. In addition, students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing as well as recommendations on how to improve students' online synchronous collaborative small-group discussions with videoconferencing were investigated.

CHAPTER II

LITERATURE REVIEW

The review of literature covers important components of problem-based learning (PBL) as well as research findings and issues related to PBL. This chapter is organized in the following sections: (1) essential concepts of problem-based learning - including definition, characteristics, and goals; (2) theoretical framework - including constructivism and collaborative learning; (3) research related to online PBL - including research on online collaborative PBL, pedagogies and technologies to facilitate PBL, and students' attitudes toward PBL; (4) communication modes and content analysis - including asynchronous and synchronous discussions; and (5) videoconferencing - including background and definition, the importance of visual, text, audio, and video, effectiveness of videoconferencing in education, research on videoconferencing in mathematics and sciences education, and students' attitudes toward videoconferencing. The primary topics of importance to this study are presented in Figure 1.

A thorough review of the literature is conducted to find research that investigates how the synchronous videoconferencing influences students' knowledge construction and attitudes in an online collaborative PBL learning environment.

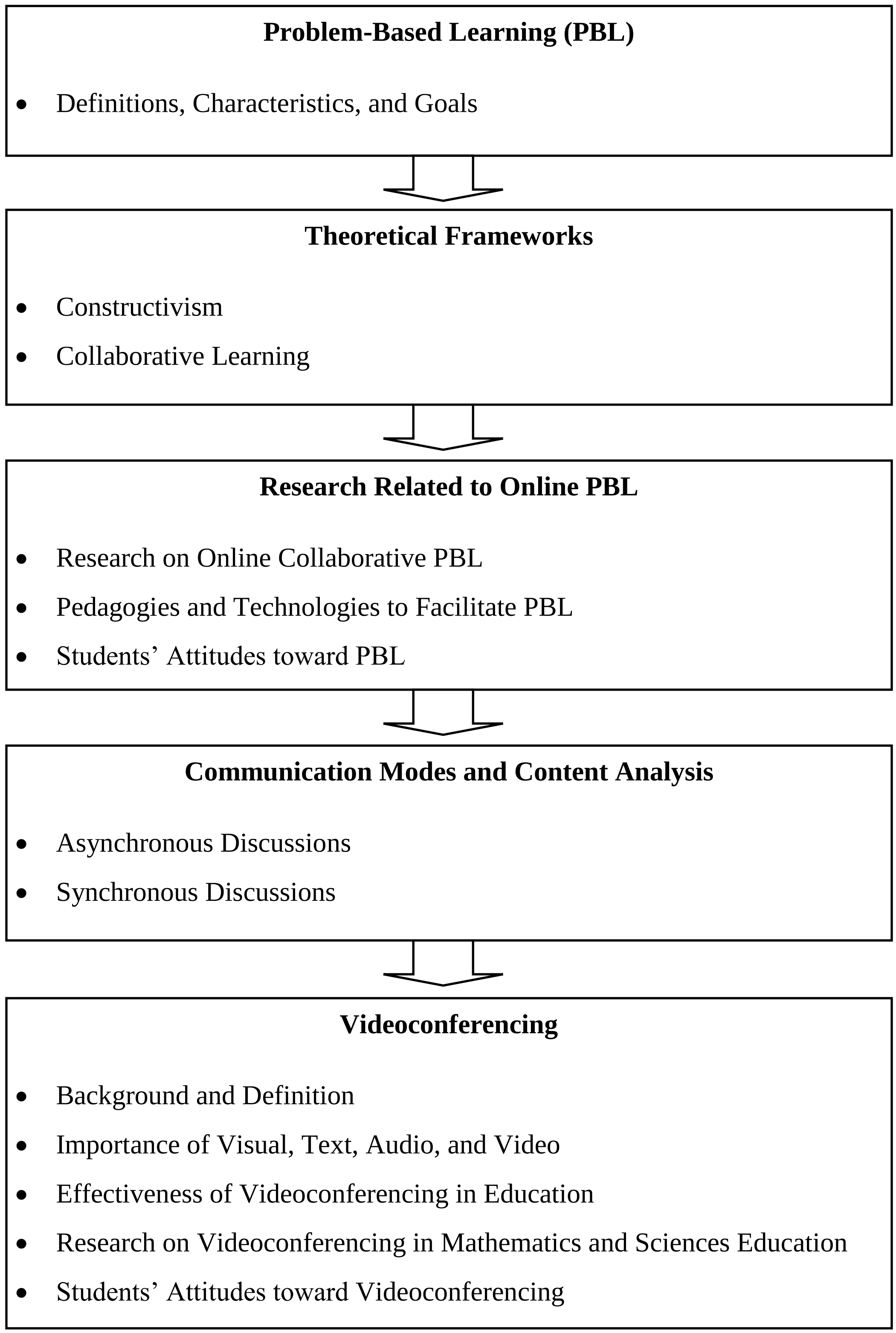


Figure 1. Primary Topics of Importance to this Study.

Problem-Based Learning (PBL)

Problem-based learning (PBL) is an instructional method that focuses on a learner-centered instructional approach (Aspy, Apsy, & Quinby, 1993; Valaitis et al., 2005; Hung, Jonassen, & Liu, 2008). PBL was originally developed in the medical school at McMaster University, Canada, in the early 1970s (Barrows, 2000; Hung et al., 2008). Today, problem-based learning is becoming more widespread around the world. A number of medical schools throughout the world (e.g., North America, the Netherlands, England, Germany, Australia, New Zealand, and India) have implemented PBL as their primary instructional method (Barrows, 1994). In addition, PBL has also increased its popularity across disciplines in various educational settings (Barrows, 2000; Hmelo-Silver, 2004; Torp & Sage, 2002), such as in business administration, economics, architecture, leadership education, teacher education, post-secondary (Hung et al., 2008), and K-12 education (Barrows & Kelson, 1993).

Definitions, Characteristics, and Goals

According to Butler, Inrnan, and Lobb (2005) and Hung et al. (2008), problem-based learning (PBL) embeds the learning process of students with real-world circumstances or problems instead of studying only the content knowledge and practicing context-free problems. In PBL, the learning is bounded by problems in which students are required to learn through facilitated problem solving and then reflect on their experiences (Barrows & Tamblyn, 1980; Hmelo-Silver, 2004). In this respect, the problem seems to play an important role in the PBL as Bridges (1992) described in the following:

> Problem-based learning is an instructional strategy that uses a problem as a starting point for learning. The problem is one that students are apt to face as future professionals. The knowledge students are expected to gain during their training is organized around problems rather than the disciplines. Students work in project teams on these problems and assume a major responsibility for their own instruction and learning. (p. 17)

Similarly, Hung et al. (2008) defined PBL as:

> [A]n instructional method that initiates students' learning by creating a need to solve an authentic problem. During the problem solving process, students construct content knowledge and develop problem-solving skill as well as self-directed learning skill while working toward solution to the problem. (p. 486)

In addition, Hmelo-Silver (2004) explained that in PBL, learners work collaboratively in groups to identify what they have to learn in order to solve a problem. Learners engage in self-directed learning, apply their new knowledge to the problem, and reflect on what they learned as well as the effectiveness of the strategies employed. Learners become responsible for their learning through developing strategies and constructing knowledge (Hmelo & Ferrari, 1997).

According to Hung et al. (2008), the characteristics of PBL can be summarized as follows:

1. PBL is problem focused. The content and skills to be learned are organized around problems. Learners are given insufficient information, and they identify what they need to learn in order to solve the problem and search for required information. Learners begin learning by focusing on simulations of an authentic, ill-structured problem, such as heuristic tasks (Savery & Duffy, 1995), developing abstract understandings and cognitive strategies, and then applying them to the problem (Nelson, 1999).

2. PBL is a student-centered instructional approach because instructors cannot control the learning. As the result, learners have to take responsibility for their own learning (Coombs & Elden, 2004).
3. PBL is self-directed (Hmelo & Lin, 2000). Learners individually assume responsibility for generating learning issues processes through self- and peer-assessments as well as access their own learning materials (Hung et al. 2008).
4. PBL is self-reflective. Learners monitor their understanding and learn to adjust strategies for learning. Learners are encouraged to reflect on the problem-solving process or what they have learned (Hmelo-Silver, 2004; Hung et al., 2008).
5. The role of instructor is facilitator who scaffolds learners to learn through modeling and supporting analysis processes, facilitates group processes and interpersonal dynamics, probes students' knowledge deeply, and never interjects content nor provides direct answers to questions.

Therefore, PBL is a learner-centered approach which intends to facilitate learners to obtain a variety of skills, such as problem-solving, self-directed learning, self-reflective learning, and teamwork skills, by employing a problem as the initial point for encouraging students to learn in a collaborative learning environment (An, 2006; Bridges, 1992; Dunlop, 2005; Knowlton, 2003; Hmelo-Silver, 2004; Hung et al., 2008; Savery, 2006).

According to Barrows and Kelson (1993) and Hmelo-Silver (2004), five important goals have been established when designing PBL. The first goal of PBL is to assist learners to construct a broad and flexible knowledge in which they learn beyond the facts (Hmelo-Silver, 2004) as well as apply their knowledge in a variety of problem situations (Cognition and Technology Group at Vanderbilt, 1997). The second goal of PBL is to assist learners to develop effective problem-solving skills. These skills include the ability to apply appropriate metacognitive skills, such as planning one's problem solving process, monitoring one's progress, and assessing one's achievement (Hmelo-Silver, 2004; Schoenfeld, 1985). The third goal of PBL is to assist learners to develop self-directed, lifelong learning skills. Metacognitive strategies are also important for the third goal (Hmelo-Silver, 2004). The fourth goal of PBL is to assist learners to develop effective collaboration skills to work as a group. These tasks require learners to establish a common goal, resolve disagreement, exchange ideas and engagement with all group members, and come to an agreement (Barron, 2002; Cohen, 1994; Wenger, 1998). Finally, the fifth goal of PBL is to assist learners to become intrinsically motivated to learn. Intrinsic motivation occurs when learners work on a task and are motivated by their own interests, challenges, or sense of satisfaction.

During discussing problems in a PBL group, a process of discussion stimulates relevant previous knowledge and facilitates the processing of new information (Schmidt et al., 1989). Learners can construct new knowledge when they can relate new information to what they already know (Bransford & McCarrell, 1977). Moreover, learners can be more motivated to learn when they participate in authentic learning activities, in which they apply and integrate what they have learned into real-world situations (Cercone, 2008; Kim, 2009).

Theoretical Framework

This review synthesizes Constructivism and Collaborative learning theories and provides the foundation for understanding the online collaborative problem-based learning. The background information of constructivism and collaborative learning are presented below.

Constructivism

Constructivism is a theoretical view that knowledge and meanings are constructed by individuals "attempt[ing] to make sense of their experiences" (Driscoll, 2005, p. 387). The most important premise of the constructivism framework is that individuals actively construct knowledge or perspective of the world through experiences based on their own existing knowledge (Duffy & Jonassen, 1991; Fox, 2008). In other words, knowledge is constructed individually by each learner through his/her experiences in the world. Thus, constructivism pays attention to preparing and providing learning environments that can optimize the learner's experience in knowledge construction. Dewey (1916) stated that the constructivism approach influences education by cultivating the learner's problem-solving skills in the real world.

Vygotsky (1978) put more emphasis on learning in a social context based on the assumption that social factors influence cognitive development of the learners. Thus, he proposed a theory called "social constructivism," which focuses on the socio-cultural context in the learning environment (Maddux, Johnson, & Willis, 1997). Vygotsky (1978) also proposed the idea of "zones of proximal development," which presumed that some problems can be solved by learners only when they receive support or help from others. The social environment is important to the development of an individual understanding as well as to the development of the body of knowledge. By providing a collaborative problem solving situation, learners are encouraged to interact and complement each other. According to von Glaserfeld (1989), other people can provide alternative views and additional information to challenge learners' current views or understanding. Subsequently, learners can succeed in constructing knowledge that could not be obtained without the social-cultural context. Constructivist theorists who are influenced by Vygotsky posit that knowledge is co-constructed with peers or experts and through the immersion in a social context (Bonk & Cunningham, 1998).

Jonassen (1994) stated that due to the predictable learning outcomes of constructivism, an instruction should promote learning rather than control learning. There are six characteristics of constructivist learning environments as Jonassen (1994) proposed: (1) emphasis authentic tasks in a meaningful context, (2) representations of reality, without oversimplifying the real case, (3) emphasis on knowledge construction over knowledge reproduction, (4) real-world setting or case based learning, (5) emphasis on reflection on experience, and (6) supporting collaborative and interactive knowledge sharing.

In recent decades, the term "communal constructivism" was first defined by Holmes, Tangney, FitzGibbon, Savage, and Mehan (2001) as "an approach to learning in which students not only construct their own knowledge (constructivism) as a result of interacting with their environment (social constructivism), but are also actively engaged in the process of constructing knowledge for their learning community" (p.1). This approach reveals that instructors and learners are not only involved in creating their own understanding but also involved in constructing new knowledge that will help other learners (Holmes et al., 2001).

Younie and Leask (2001) further argued that the communal constructivism is different from Vygotsky's social constructivism as it has been derived from the following essential ways:

- Rather than the individual, it is a communal knowledge construction;
- Rather than theoretical situations, it represents on real situations through communicating with knowledge experts in community;
- It is involved with the use of Information and Communication Technologies (ICTs) as new ways of learning. The technology allows learners "to build on, add to, and republish this knowledge for their own purposes or in conjunction with the other creators of the knowledge" (p. 119).

Collaborative Learning

Collaborative learning developed from the psychologists' works of Johnson and Johnson (1975) and Slavin (1987). In collaborative learning, the students construct knowledge actively by formulating ideas or thoughts from social process occurring through communication with others (Hiltz, 1998) and work together as a group to reach a conclusion or complete an academic problem-solving task (Alavi, 1994). According to Brandon and Hollingshead (1999), collaborative learning is defined as "an activity that is undertaken by equal partners who work jointly on the same problem rather than on different components of the problem" (p. 111).

Alavi (1994) stated that collaborative learning encompassed with three attributes of effective learning: (1) active learning and construction of knowledge, (2) cooperation and teamwork in learning, and (3) learning via problem solving. Moreover, Olivares (2007) further summarized important key points of collaborative learning as the following essential ways:

- The central concern of collaborative learning is that activities of mutual group generate problem-solving or knowledge acquisition that is greater to individual efforts.
- Collaborative learning is involved with nurturing independence of thought through the collaborative process.
- Interpersonal skills and small group are not trained as part of the collaborative process since this might restrict the flow of ideas and information.

In collaborative learning process, instruction shifts away the focus from teacher-centered to learner-centered, where knowledge can be regarded as a social construct helped by peer interaction (Hiltz, 1998). Hence, the instructor role in collaborative learning is a facilitator or "guide who promotes independence of thought, the free flow of information, focuses on group—not individual—learning, is concerned with successful completion of the task at hand" (Olivares, 2007, p. 31). Additionally, the instructor can be involved in the discussion matter and consequently guide or facilitate the student's process of collaborative knowledge construction from the sidewalk (Veerman & Veldhuis-Diermanse, 2006).

In short, each of the theoretical perspectives has its focal point on learning but they are not mutually exclusive. Both theoretical perspectives, constructivism and collaborative learning, overlap in three general areas: (a) construction of knowledge, (b) social interaction, and (c) collaboration. Both emphasize that knowledge construction through interaction and collaboration in a social context can contribute to successful learning experiences.

Research Related to Online Problem-Based Learning

Due to the increase in online learning and the decrease in educational face-to-face communication, distance learning technologies have become paramount to an online learner's success. Online learning practices generally follow constructivist perspectives to facilitate personalized learning regardless of time and locations. In addition, as online learning environments are becoming flexible and interactive, it is more convenient to implement constructivist and PBL practices through online learning tools (Brown & King, 2000). Therefore, several studies have been attempted to implement a PBL approach in an online environment (Mattheos, Nattestad, Schittek, & Attstrom, 2001) and online PBL techniques into a face-to-face setting (Donnelly, 2006).

Mattheos et al. (2001) conducted a study from a virtual classroom, which applied a PBL approach. Participants engaged in this study were 28 international dental students. This web-based course implemented synchronous and asynchronous communication, online libraries, and multimedia material. The authors found that real time communication programs were superior for problem discussions and hypothesis formulation. The authors indicated that web boards and email were too slow to allow group work in the virtual classroom. Their findings showed that an international group of dentistry students highly rated multimedia resources, such as video clips and images for learning of clinical procedures. They recommended that distance learning should be organized with a mixture of different media, allowing communication of knowledge and skills between the resources and the students, and cooperation between the students.

Moreover, the goal of a case study done by Donnelly (2006) was to integrate online PBL techniques into a face-to-face setting. Participants were instructors, librarians, and technical support staff taking a graduate course for ten weeks from different universities in Ireland. Social interaction in online PBL was sustained through both face-to-face and online discussion groups. The findings showed that group activities contribute to the process success. It was also revealed that supporting the student–content and student–student interactions were the most important.

Research on Online Collaborative Problem-Based Learning

In the online collaborative PBL setting, learners have a common goal and strive to solve problems collaboratively and reflect on their experiences through interaction (Yeh & She, 2010). This collaborative PBL process assists learners to develop problem-solving abilities, collaborative skills (Ram, Ram, & Sprague, 2004), and knowledge construction (Vye, Goldman, Voss, Hmelo, & Williams, 1997).

Several studies exploring the performance of learners who worked in the online collaborative problem-based learning environments found that this environment would be more effective than ones in the online individual problem-based learning environments (Lou, 2004; Ozdemir, 2005; Uribe et al., 2003). Uribe et al. (2003) examined how the computer-mediated collaboration affected solving ill-defined problems. The authors discovered that participants who worked in computer-mediated collaborative dyads performed significantly better than participants who worked individually. Additionally, the authors found that the benefit of collaboration for problem-solving in face-to-face learning environments also carried over to online environments.

The same result also has been confirmed by the study conducted by Ozdemir (2005), which revealed that students in a collaborative PBL environment outperformed those who were in an individual PBL environment in terms of critical thinking scores. Furthermore, Lou (2004) discovered that between-group collaboration working on projects online also enhanced group processes, group project performance, individual student achievement, and confidence in complex problem solving.

A few peer-reviewed studies of online collaborative PBL compared the achievements of online PBL students with face-to- face PBL students and found that there were no differences (Carr-Chellman, Dyer, & Breman, 2000; Dennis, 2003). Carr-Chellman et al. (2000) investigated the feasibility of utilizing authentic problem-based collaboration in a distance instructional design course compared to a traditional delivery mode. Students from a traditional university and a distance education institution were given a similar Instructional Design project with similar authentic context and Subject Matter Experts with whom to work. The authors found that both groups met the course objectives with equal success. Similarly, the research by Dennis (2003) compared the achievement between face-to-face and online PBL classrooms. The author discovered that the achievements of both groups were not significantly different.

Moreover, the study conducted by McConnell (2002) examined the collaborative problem solving process of learners in an online PBL course. All learners were professional educators interested in distance learning, and the course was loosely structured. However, the loose structure appeared to work well in the course. It may have been because the learners, as professionals, were highly motivated and committed to the project, which was directly related to their professional work. The results of the study revealed that there were phases, which were not planned beforehand but created by the learners in the collaborative problem solving process: negotiation, division of work and research activity, and production. These phases were not completely discrete. Rather, they tended to occur partly simultaneously with iterations of some activities.

Pedagogies and Technologies to Facilitate PBL

In addition to implementing PBL in education, several researchers tended to integrate various activities and technologies to facilitate effective PBL environments (Cho & Jonassen, 2002; Reznich & Werner, 2001; Chan et al., 1999; Kamin, Deterding, Wilson, Armacost, & Breedon, 1999). For instance, the use of scripted collaboration and the use of student roles have been applied to support effective collaborative learning with K–16 students in the PBL setting (O'Donnell, 1999; Palincsar & Herrenkohl, 1999). The following paragraphs represent how pedagogies and technologies facilitated PBL in higher education.

A study conducted by Cho and Jonassen (2002) showed that the problem solving process can be facilitated by supporting the generation of coherent arguments. The authors examined how online argumentation scaffolds affected ill-structured problem solving. The authors compared the groups who used only an asynchronous bulletin board system to collaboratively solve their problems and the groups who used a constraint-based argumentation scaffold tool, called Belvedere, to structure their arguments and discussions in the problem-solving process. In this study, "the constraints were the predetermined message types that modeled a form of argumentation" among learners in an online discussion forum (p. 6). The authors found that groups who used the argumentation scaffold tool resulted in significantly more problem-solving actions and generated more coherent arguments than the groups who used an asynchronous bulletin board. In addition, the effects of the argument scaffold appeared to transfer to the creation of arguments during individual problem solving. Students successfully transferred what they had learned from online discussions to their actual discussions during problem solving.

Additionally, Reznich and Werner (2001) examined how Internet technology affected students' learning in PBL. The authors found a general positive effect on the discussion process, in which the preceptors or tutors played an important role in ensuring the group sessions' success and guiding the use of electronic resources to students.

Another study conducted by Kamin et al. (1999) conducted a formative evaluation of case videos implemented in the virtual PBL program. Teams of four to five medical students and a faculty member collaborated asynchronously through a digital video patient case in this virtual PBL program. The authors revealed that video cases in combination with PBL and collaborative conferencing provide a rich environment for active learning. Such cases also formed appropriate professional behavior and allowed students to solve clinical problems in authentic clinical situations.

Students' Attitudes toward Problem-Based Learning

According to the growth of the PBL approach in education, there were studies exploring students' attitudes toward the problem-based learning (PBL) approach in an online environment (Hong, Lai, & Holton, 2003; Valaitis et al., 2005). The finding of these studies indicated that students had positive experiences in the PBL environment and they appreciated its characteristic learning flexibility.

PBL encouraged students to process content intensely. A study by Valaitis et al. (2005) explored the perception of health sciences students regarding their experiences in online problem-based learning, focusing on their views concerning learning and group processes in the online environment. The authors discovered that students felt PBL increased their flexibility for learning, enhanced their ability to deeply process content, and provided access to valuable learning resources.

Similar to the result of Valaitis et al.'s (2005) study, Hong et al. (2003) explored students' responses and reactions to a Web-based tertiary statistics course supporting problem-based learning. The authors discovered that the majority of the students were satisfied with their learning experience and achieved comparable learning outcomes when compared to students in the face-to-face version of the course. Students appreciated the flexibility of anytime, anywhere learning. The majority of students was motivated to learn and had adequate technical support to complete the course. The recommendation from this study was that an organizing strategy in the asynchronous Web-based conferences using the PBL approach should be clearly designed to aid students in completing the PBL process.

Additionally, Alper (2003) examined how the cognitive flexibility in online PBL affected student achievement levels and attitudes. Participants were divided into three different categories based on their cognitive flexibility: low-level, medium-level, and high-level. The author found that online PBL application increased students' achievement levels and retention scores.

Communication Modes and Content Analysis

It is evident that the integration of technology in distance education is changing the face of classrooms. The communication which occurs between individuals and among groups via computer network is called the computer-mediated communication (CMC) (Naidu & Järvelä, 2006). Asynchronous and synchronous in the CMC have appeared as optional communication forms of online communication in teaching and learning and as a supplement to traditional teaching (Chen & Shaw, 2006; Naidu & Järvelä, 2006).

An asynchronous communication environment is "one where communication between learners and the facilitator is done via a computer forum of some description at different times" whereas a synchronous communication environment "takes place in real time where those involved in the communication process are present all at the same time, but not necessarily in the same place" (Jolliffe et al., 2001, p. 9). Both asynchronous and synchronous communication types have their unique features and values to fit certain instructional and learning situations.

Asynchronous Discussions

For online problem-based learning, teachers' request for students' asynchronous online discussions has been applied in actual learning scenarios. The benefits of asynchronous communication tools for students have been confirmed by several literature sources (Hara, Bonk, & Angeli, 2000; Johnson & Green, 2007; Kanuka, 2005).

Johnson and Green (2007) applied the online discussions to promote mathematical discourse. They revealed that asynchronous dialogues facilitated the students' knowledge construction. The authors recommended assessment criteria should be created around the learning process rather than factual knowledge because students learned differently. Moreover, Kanuka (2005) investigated various instructional strategies by implementing a text-based Internet learning environment into a class via WebCT in order to promote higher levels of learning. She reported that asynchronous communication tools can support effective learning environments through the use of brainstorming, debates, and WebQuests, by encouraging students to achieve higher levels of learning or to learn in deeper ways.

Many researchers have analyzed the messages of asynchronous discussions (Gunawardena et al., 1997; Hou et al., 2008; Luebeck & Bice, 2005). Two coding schemes, the Interaction Analysis Model by Gunawardena et al. (1997) and the Practical Inquiry Model by Garrison, Anderson, and Archer (2001) have been developed for online discussion content analysis.

In their study, Gunawardena et al. (1997) introduced the Interaction Analysis Model used to identify and categorize levels of conceptual change and knowledge construction from discussions. The discussions were obtained from a six-day international online debate in collaborative learning environments facilitated by computer conferencing. The Interaction Analysis Model focused more on social interaction student-to-student and student-to-instructor and social knowledge construction. Moreover, the study by Luebeck and Rice (2005) also applied the Interaction Analysis Model to further investigate the potential for promoting and supporting conceptual change via online asynchronous discussions in the context of graduate-level coursework among mathematics and science educators. They found that fewer indicators of reflection, metacognitive activity, and higher-order cognitive processes (Phases 3-5) were evident. Forty-three of the 484 messages (8.9%) showed that participants were engaged in negotiating meaning and constructing knowledge (Phase 3). Six of the 484 messages (roughly 1.2%) revealed testing and modification of proposed synthesis (Phase 4) and only one of the 484 messages (0.2%) presented agreement and application of new meaning (Phase 5).

Furthermore, the study conducted by Hou et al. (2008) explored the process of asynchronous problem-solving-based discussion activities as well as recognized limitations, which occurred during the learners' problem-solving discussions. To explore the level of knowledge construction that took place in the discussions, the authors utilized the coding scheme of the Interaction Analysis Model proposed by Gunawardena et al. (1997). They found that the sequential pattern derived from students' discussions in which problems were initiated, solutions were then proposed, and comparisons or conclusions were given to the proposed solutions. Another study by Sing and Khine (2006) presented findings from the pattern of participation and discourse analysis of the online interaction among in-service teachers in the teacher training institute in Singapore. To code the online interaction among in-service teachers, Gunawardena et al.'s (1997) Interaction Analysis Model was also applied. The authors found that the teachers formed a knowledge-building community and jointly discussed issues related to integrating information technology into the classroom.

In addition, in Garrison, Anderson, and Archer (2001), they introduced the Practical Inquiry Model to operationalize cognitive presence. According to Garrison et al. (2001), ''cognitive presence reflects higher-order knowledge acquisition and application and is most associated with the literature and research related to critical thinking'' (Garrison et al., 2001, p. 7). They operationalized cognitive presence through the practical inquiry process, which consisted of four phases: (a) an initiation phase, considered as a triggering event, (b) an exploration phase, characterized by brainstorming, questioning, and exchange of information, (c) an integration phase, characterized by constructing meaning and (d) a resolution phase, characterized by the resolution of the problem created by the triggering event. A total of 51 complete online asynchronous messages were chosen as the unit of analysis.

Synchronous Discussions

According to the National Center for Accessible Media (2005), synchronous communication and collaboration tools, for example, synchronous text chat, audio-conferencing, videoconferencing, and white boards, are becoming important components in online learning.

The advantages of synchronous communication tools have been established by several literature sources (Davidson-Shivers et al., 2001; Murphy & Collins, 1997; Pattillo, 2007). According to Murphy and Collins (1997), a synchronous environment allows students to adjust their paces continuously, to address their concerns immediately, and to immerse in problem-solving and decision-making processes. Similarly, Pattillo (2007) discovered synchronous audio conferencing could boost the communications between instructor and students.

In the study of Davidson-Shivers et al. (2001), the authors found that students responded to more messages, which directly related to the topic in the chats than one in the threaded discussions. However, students felt that although they enjoyed the interaction with their peers in the synchronous portion of the course, it was difficult for them to follow the messages or dialogue within the chat box.

Moreover, Osman and Herring (2007) assessed the potential usefulness of synchronous chat for conceptual learning in a distance education program between two universities in different cultural settings as well as investigated the factors that influence the quantity and quality of interaction and facilitation. The chat was designed to be the primary communication tool for learning-oriented interaction between students and instructors. The authors utilized the Gunawardena et al.'s (1997) Interaction Analysis Model to analyze the social construction of knowledge in a content analysis of chat sessions between four adult learners in Azerbaijan and their two facilitators in the United States. The authors indicated that conceptual change activity or knowledge construction increased over time, although the quality of the interaction was limited by the nature of the task, language difficulties, and different cultural expectations about instruction.

Videoconferencing

Background and Definition

A clear definition of the technology under investigation is considered necessary as there exists a variety of video types used in education. According to Simonson et al. (2009), there are three different types of video tools in which learners experienced in distance education: (1) one-way live video, (2) two-way, one-way video, and (3) two-way audio/video or compressed videoconferencing system.

First, the one-way live video referred to as "broadcast distance education" (Simonson et al., 2009, p. 100) was broadcast over a commercial television station in the 1950s. Learners would watch the program on television and complete the course assignment. The course would be mailed along with the packet of printed materials and readings after learners had registered for those classes (Simonson et al., 2009). The benefits of this type of video are that 1) programs are broadcast with the high quality of the video and 2) learners can watch the program as many times they want to because each television program is often being broadcasted several times.

Second, the two-way audio, one-way video approach of communication has begun to be used in the last few decades. The microwave transmission systems, instructional television fixed service, or community cable television networks used this approach (Simonson et al., 2009). The courses are offered synchronously to students in many locations. Students can ask instructors questions during or after classes via phone. The concept of the teleconference, short course on special topics offered by an organization to individuals in different locations, has become well known in the last decade (Simonson et al., 2009).

Third, the two-way audio/video or compressed videoconferencing system used regular telephone lines to send and receive audio and video signals. According to Mullins-Dove (2006), this videoconferencing system allows the sharing of audio and video from the remote site's computer to the viewer's computer via the Internet. Videoconferencing can be described as a synchronous real-time audio and video communication through computers between two or more different places (Anderson, 2008).

In this part of literature review, the focus will be on videoconferencing and will concentrate on two-way audio/video or a compressed videoconferencing system, which is more user-friendly and location dependent since many individuals can use it on their personal computers at home or at a workplace to participate in a conference (Lawson, Comber, Gage, & Cullum-Hanshaw, 2010; Plonczak, 2010). Videoconferencing allows individuals who are working with people in different locations to have a visual connection. While videoconferencing is well known in the media, television venues, and the business community, it is becoming more broadly used not only in traditional classrooms but also in distance education (Lawson et al., 2010).

Importance of Visual, Text, Audio, and Video

With the advent of advanced technology, there is a debate over whether using videoconferencing or only audio mediated interaction itself is sufficient for learning. Many studies have explored how body language and verbal cues are important in communication (Hampel & Hauck, 2004; O'Malley, Langton, Anderson, Doherty-Sneddon, & Bruce, 1996; Sproull & Kiesler, 1986). The importance of visual, text, and video are discussed in the following studies.

The study conducted by Sproull and Kiesler (1986) indicated that lack of nonverbal information reduces social cues and impairs interaction. Boyle, Anderson, and Newlands (1994) stated that when performing a collaborative task, subjects produced shorter exchanges of speech and less problematical dialogues when they could see each other, than when they could only hear each other. Chun and Plass (2000) revealed that the visual, audio, and textual nature were important to transfer meaning in the CMC setting.

The issue of lack of body language and of depersonalization of communication in text-based and audio-based CMC has been recognized by Hampel and Hauck (2004). They stated that when visual clues and body language were not recognized, students were unsure of what was happening and were less likely to participate in the class. Moreover, the impact of video in helping to build a learning community, increase confidence, and reduce isolation for distance learners was also documented in the literature (Hampel & Hauck, 2004; Stacey, 1999).

On the other hand, O'Malley et al. (1996) conducted experiments in which pairs of participants performed collaborative tasks at a distance via video and audio links or audio links only. They found that “users of video links produced longer and more interrupted dialogues than those who had audio links only, although there were no differences in performance” and that “performance was affected when the video links were of low bandwidth, resulting in transmission delays” (p. 177).

Effectiveness of Videoconferencing in Education

Several studies have described the effectiveness of the use of videoconferencing in education (Ertl, Fischer, & Mandl, 2006; Falconer & Lignugaris-Kraft, 2002; Li, Moorman, & Dyjur, 2010; Squire & Johnson, 2000; Yamada, 2009). In addition to developing better critical thinking and problem-solving skills, researchers revealed that the benefits of teaching through videoconferencing in the following studies.

In their study, Falconer and Lignugaris-Kraft (2002), discovered the benefits and limitations of using two-way audio/video conferencing technology to assist in a preservice teacher training program located in remote university distance education sites. The finding of the perceived benefits included increased contact with on-campus personnel, opportunities for face-to-face interactions, and the chance to provide immediate feedback to field-based students. They further described the benefits of interactive video conferencing as an instructional medium: (1) modeling the effective use of technology in the classroom, (2) providing opportunities for hands-on learning, (3) establishing a just-in-time learning context, (4) developing higher-level thinking skills, (5) presenting real-life situations, (6) increasing the meaningful knowledge transferred, (7) developing skills and tools for use in the real world, and (8) adding fun to the learning experience.

Similarly, Squire and Johnson (2000) examined three distance learning programs conducted over Vision Athena, an interactive television distance learning system to engage learners in communities of practice in designed learning environments. They indicated the potential of videoconferencing technologies in communication for collaborative learning through distributed communities of practice. The results revealed that interactive television was a useful tool for providing learners access to authentic resources and affording learners opportunities to participate in authentic communities of practice.

Moreover, Yamada's (2009) study also proved that videoconferencing helped develop participants' practical skills in speaking other languages, such as when to laugh or nod, as well as increasing the motivation of learners. The purpose of this study was to identify the relationship between media, learners' perception of social presence, and output in communicative learning using synchronous computer-mediated communication. The author developed four types of synchronous computer-mediated communication: videoconferencing (image and voice), audio conferencing (voice but no image), text chat with image (image but no voice), and plain text chat (no image and no voice). The results show that image and voice promote consciousness of natural communication and relief, while a text-mediated system enhances confidence in grammatical accuracy. The existence of a partner's image also enhances the consciousness of natural communication, which leads to a number of self-corrections, an aspect of learning performance.

Furthermore, as videoconferencing demonstrated its helpful impact to the characteristics common to communication, it also demonstrated a high potential for enabling virtual collaborative learning arrangements. Ertl, Fischer, and Mandl (2006) examined how to foster collaborative learning through videoconferencing. They indicated that collaborative learning through videoconferencing was most successful when there was additional support included, such as shared applications across conference members or through the use of scripts, which structured the activities carried out in the conference.

Similarly, another study conducted by the Alberta Ministry of Education (2006) reported successful outcomes while using an inquiry based approach through videoconferencing. Videoconferencing technology was observed to enhance regular classroom delivery by allowing students to engage in learning activities with peers, experts, and other educational resources outside of their traditional classroom. Students enjoyed these enrichment activities and seemed eager to expand their learning opportunities using the technology. The technology also fit with some inquiry-based learning designs and allowed students to interact firsthand with experts and remote students with particular skills and interests. The findings indicated that students were more engaged when an inquiry-based approach was employed.

Research on Videoconferencing in Mathematics and Science Education

The educational use of videoconferencing was first employed in higher education institutions (Lawson et al., 2010). Videoconferencing also has great potential for developing mathematical communication skills within the classroom. The study conducted by Gage (2003) explored how teachers and students in two schools on the south coast of England viewed videoconferencing and whether videoconferencing a math lesson would help students develop their mathematical communication skills. The results indicated students were motivated and eager to interact with students in the other school, although the act of communicating presented more difficulties than they had anticipated.

Additionally, Plonczak's (2010) study confirmed that the articulate and formulate skills of a learner could be improved through videoconferencing. The author investigated how videoconferencing impacted preservice teachers' understanding and implementation of inquiry-based approaches to teaching and learning math and science. Plonczak also explored benefits and challenges of teaching through videoconferencing in the context of students' field placement experiences. The context of mathematics and science methods courses was taught via video conferencing to 5th grade classes in a major urban public school. The author found that teaching through videoconferencing highlights strengths and weaknesses in questioning skill techniques, which are important to an inquiry-based approach. The main strengths were that preservice teachers were required to have good questioning skills as well as a good knowledge of the content matter to teach math and science through videoconferencing. The videoconferencing also helped students develop their questioning skills. On the other hand, the main challenge referred to was the difficulty of teaching in an environment where there is no direct face-to-face interaction with the learners, and where interaction is based on the intellectual dialogue generated by the questions and answers between the preservice teachers and the learners.

Furthermore, Saw et al. (2008) examined the interaction patterns of distance learners enrolled in the Mathematics and Physics program of the University Sains Malaysia in the videoconferencing learning environment. The authors contended that there were more interactions in the graphics display mode than the video display mode. The graphics display mode involved the real-time interaction of the teacher, students, and course materials, and revealed greater student engagement in the videoconferencing learning environment. The higher number of teacher-initiated interactions also inferred that the teacher plays an important role in creating and maintaining a community of inquiry focused on exploring and developing content as well as giving feedback pertaining to concepts, ideas, or solutions. The author found that teachers were much more likely to initiate interactions in the videoconference events than students.

In addition, Li et al. (2010) developed a model of inquiry-based learning, referred to as PBL in this study, with e-mentoring (IBLE) based on Community Informatics Initiative's inquiry model. The authors investigated a practicable development and implementation of the IBLE model by using videoconferencing as well as applying the model to examine its effectiveness and impact on rural secondary students' mathematics and science learning. The authors focused on affective and achievement scores. The findings presented confirmed that IBLE had enhanced students' learning, most significantly in reference to their affective development, including increased motivation, broadened understanding of the relevancy of math and science in students' lives, and augmented career awareness in math and science.

Additionally, Andrews and Klease (2002) implemented a student-centered group work approach via videoconferencing in a chemistry program. Staff from a number of

Australian Universities participated in the project to explore the viability of establishing a virtual faculty using videoconferencing as the medium of delivery. The findings showed that smaller group sizes and close collaboration better supported the redesign of curriculum, which was necessary for effective use of technologies such as videoconferencing. Moreover, the opportunity for small group tutoring and interaction with the remote lecturer provided in-depth exploration of topics in this environment.

Students' Attitudes toward Videoconferencing

Students' attitudes toward videoconferencing focus on students' experiences when employing the videoconferencing as a tool to facilitate class activities. Several studies showed that learners had positive experiences and attitudes toward videoconferencing (Allen, Sargeant, Mann, Fleming, & Premi, 2003; Bello, Knowton, & Chaffin, 2007; Choi & Johnson, 2007; Gillies, 2008; Li et al., 2010). However, some technical issues, personality issues, and feelings of isolation could negatively influence students' experiences and attitudes toward videoconferencing (Allen et al., 2003; Gage, 2003; Gillies, 2008). The following studies presented both positive and negative experiences that students encountered toward the videoconferencing implemented in the classroom.

Li et al. (2010) explored students' experiences when applying videoconferencing to facilitate the model of inquiry-based learning with e-mentoring (IBLE) in secondary students' mathematics and science learning. The results showed that students enjoyed learning using videoconferencing in classes since using videoconferencing provided students with a new perspective, one different from their traditional classrooms.

Additionally, videoconferencing offered an opportunity for students not only to hear but also to be heard from e-mentors as well.

Bello, Knowton, and Chaffin (2007) found that the use of videoconferences widened the exposure of teacher trainees to educational situations that would be otherwise out of their reach. These 15 respondents endorsed interactive video conference as a useful medium for teaching and learning in higher education teacher preparation programs. Teacher trainees overwhelmingly favored the technology.

In addition, Choi and Johnson (2007) discovered how two main components (e.g., video and group discussions) of problem-based video instruction (PBVI) affected college students' learning. The authors examined whether learner satisfaction, comprehension, and retention can be improved by PBVI. According to the findings, the use of video (PBVI) is more effective for learner satisfaction, comprehension, and delayed retention than the use of text (PBTI) in problem-based instruction. Students also were highly satisfied with the video-based instruction and reported that the video-based anchored instruction made the class more enjoyable.

Another study conducted by Allen, Sargeant, Mann, Fleming, and Premi, (2003) assessed the feasibility, acceptability, effectiveness, and cost of conducting practice-based, small-group continuing medical education learning by videoconference. Through a videoconferencing link, 10 learners in three communities were guided through four practice-based learning modules by a facilitator at a fourth site. The videoconferencing was well accepted by learners.

In contrast, students' attitudes could be negative as Gage (2003) discovered when applying videoconferencing to deliver a math lesson in two schools on the south coast of

England. Some students felt shy and uncomfortable talking about math during the videoconference. Additionally, students felt a lot of pressure when they had to speak in front of a camera to communicate their mathematical ideas clearly, efficiently, and effectively. From the teachers' point of view, students would be forced to think about how they were going to communicate mathematically in a videoconferencing environment. It was difficult to estimate whether students had understood teachers or other students said.

Another study conducted by Gillies (2008) explored students' views of the videoconference as a teaching and learning tool in teacher education at a distance. The videoconferencing was primarily utilized in the distance education course. The author felt that there was little interaction between different sites, which militated against any sense of common purpose between them and could lead to disengagement when students at another site were giving feedback to the tutor.

Likewise, Falconer and Lignugaris-Kraft (2002) explored the limitations of using two-way audio/video conferencing technology to assist in a preservice teacher training program located in remote university distance education sites. The limitations included concerns about conferencing via modem, overcoming the initial fear of being on camera, and problems with the microphones. Similar to Falconer and Lignugaris-Kraft's (2002) results, Allen et al. (2003) indicated that muting microphones, video quality, audio quality, and audio lag all somewhat hindered discussions.

Summary

This chapter described in detail the important components of problem-based learning (PBL) as well as research findings and issues related to PBL. The PBL is bounded by problems in which students are required to learn through facilitated problem solving and then reflect on their experiences. The foundation of PBL is constructivism and collaborative learning theories. Because of the flexible and interactive characteristics of online learning environments, it is more convenient to implement constructivist and PBL practices through online learning tools. Some studies reported that students indicated positive experiences in the online PBL environment and appreciated the flexibility of learning.

For online communication, asynchronous and synchronous discussions in the CMC have been implemented in teaching and learning. Many researchers have analyzed the messages of asynchronous discussions and coding schemes have been developed for analyzing the content of online discussions. On the other hand, only a few studies have analyzed the messages of a synchronous discussion.

With the advent of advanced technology, several studies have found the effectiveness of using videoconferencing in education, for example, developing higher-level thinking skills, presenting real-life situations, increasing the meaningful knowledge transferred, and adding fun to the learning experience. In addition, many studies showed that learners had both positive and negative attitudes toward the videoconferencing implemented in the classroom.

CHAPTER III

METHODOLOGY

The purpose of this study was to investigate how an online problem-based learning (PBL) approach influenced graduate students' knowledge construction in an online synchronous collaborative learning environment. Furthermore, this study was an exploration of students' attitudes toward the online synchronous collaborative learning environment. Finally, recommendations for best practices in an online synchronous collaborative learning environment were provided.

This chapter discusses how the study was conducted and how the methodology was implemented to answer the research questions. This chapter is organized into four sections: (1) Research Design, (2) Materials, (3) Procedures, and (4) Data Analysis.

Research Design

This research used a mixed methods research design, in which qualitative and quantitative methods were employed sequentially in order to analyze and describe the data (Hanson, Creswell, Plano-Clark, Petska, & Creswell, 2005). According to Creswell and Plano Clark (2007) and Sieber (1973), a mixed methods research design is the combination of both qualitative data (e.g., interviews, observing reports, and responses to open-ended question) and quantitative data (i.e., survey or questionnaire) in one study to understand the research problem.

Creswell (2008) stated three reasons for applying a mixed methods design to conduct a research study are as follows: 1) both quantitative and qualitative data present a better understanding of the research problem than either design by itself; 2) a quantitative research design alone or a qualitative research design alone may not prove adequate to thoroughly answer research questions; and 3) a qualitative component can be incorporated into an otherwise quantitative dominant study to provide more overall depth of understanding of findings. Based on these three reasons, this study was conducted utilizing both qualitative and quantitative approaches.

The study was a "triangulation" (QUAL + QUAN) mixed methods design with equal priority given to both qualitative and quantitative methods. For the triangulation design analysis, the researcher collected both quantitative and qualitative data simultaneously during the study. Afterwards, the researcher used the results from both forms to understand the students' knowledge construction, collaborative interactions and discourse in the synchronous small-group discussion environment, and the students' attitudes toward the online synchronous collaborative learning environment.

Three different quantitative data sources including the synchronous small-group discussion transcriptions, teamwork attitude survey, and learning environment attitude survey were used. In addition, qualitative data sources including interviews and responses to open-ended questions in the teamwork attitude survey and the learning environment attitude survey were also collected. The triangulation mixed methods design was presented in Figure 2.

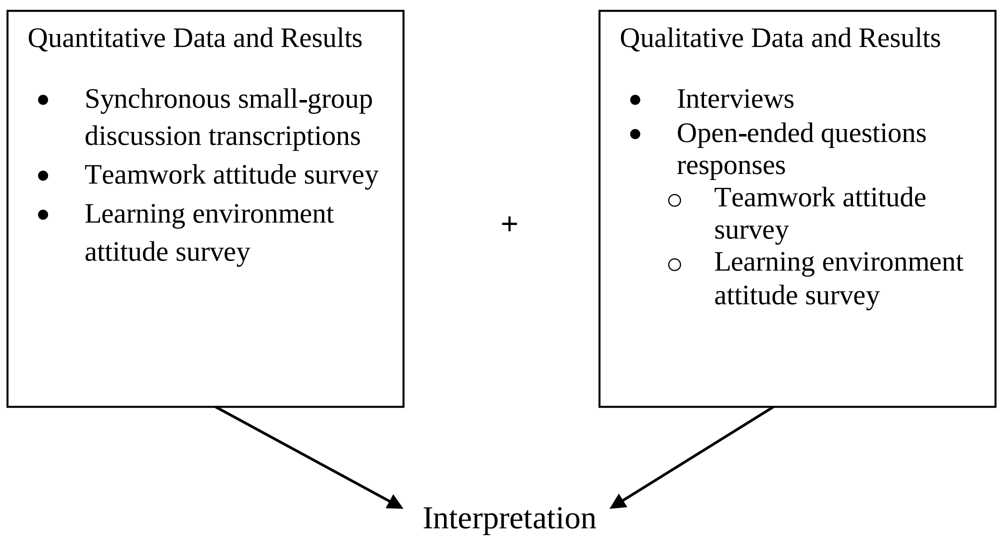


Figure 2. Triangulation mixed method design.

Participants

Twenty-eight in-service mathematics teachers participated in this study. Additionally, these 28 participants were working toward their Master's Degrees. These participants represented a purposeful and convenient sample from two online *Mathematical Modeling* (Math 537) classes, sections 970 and 971 that were taught by the same instructor. There were 15 participants from section 970 and 13 participants from section 971. Among these 28 participants, 13 were females and 15 were males. Age range of participants was approximately 25 to 55 years. Participants' teaching experiences ranged from less than 5 years to more than 16 years. Participants were taking the graduate-level online mathematical modeling course held at the University of Northern Colorado.

Online Course Format

The *Mathematical Modeling* class (Math 537) is a three-credit required course offered to graduate students in the Mathematics Teacher Leadership (Math TLC) program. Two sections of the mathematical modeling online course were offered in the Spring of 2011 by the Mathematics Teacher Leadership Center (Math TLC) over the period of 16 weeks. These classes integrated the use of synchronous and asynchronous online learning tools. These two math sections were offered via Blackboard, a learning management system. An asynchronous threaded discussion board on Blackboard was used to facilitate online students' discussions. In addition, Elluminate *Live!*® version 10, a synchronous virtual platform, which includes text-based chat discussions and videoconferencing, was used independent of Blackboard to facilitate online students' interactions and communications.

Elluminate *Live!*® combines the text-based synchronous distance learning and the face-to-face interaction of a physical classroom. According to Elluminate *Live!*® (2010), students are able to collaborate, share, and present ideas, as well as develop new projects in their local areas. Elluminate *Live!*® enables students, including some from remote areas, to present their findings and explain their plans to other classmates in real time. Sample components of Elluminate *Live!*® consist of two-way audio, multipoint video, chat, shared whiteboards with application sharing, interactive recording, and breakout rooms. This virtual environment can be integrated with learning management systems such Blackboard to provide the ultimate interactive learning environment in the online course.

The audio function of Elluminate *Live!*® allows an instructor and students to participate in conversations during real-time chat sessions by using a microphone and speakers (or headset) via Voice over Internet Protocol (VoIP). The video feature of Elluminate *Live!*® enables an instructor and students to transmit video broadcasts to others in an Elluminate *Live!*® session. The chat tool allows an instructor and students to send text messages to everyone or to selected participants within a session. The whiteboard displays the main presentation window in Elluminate *Live!*® which is used as a working area by an instructor and students to write or draw images as shown in Figure 3.

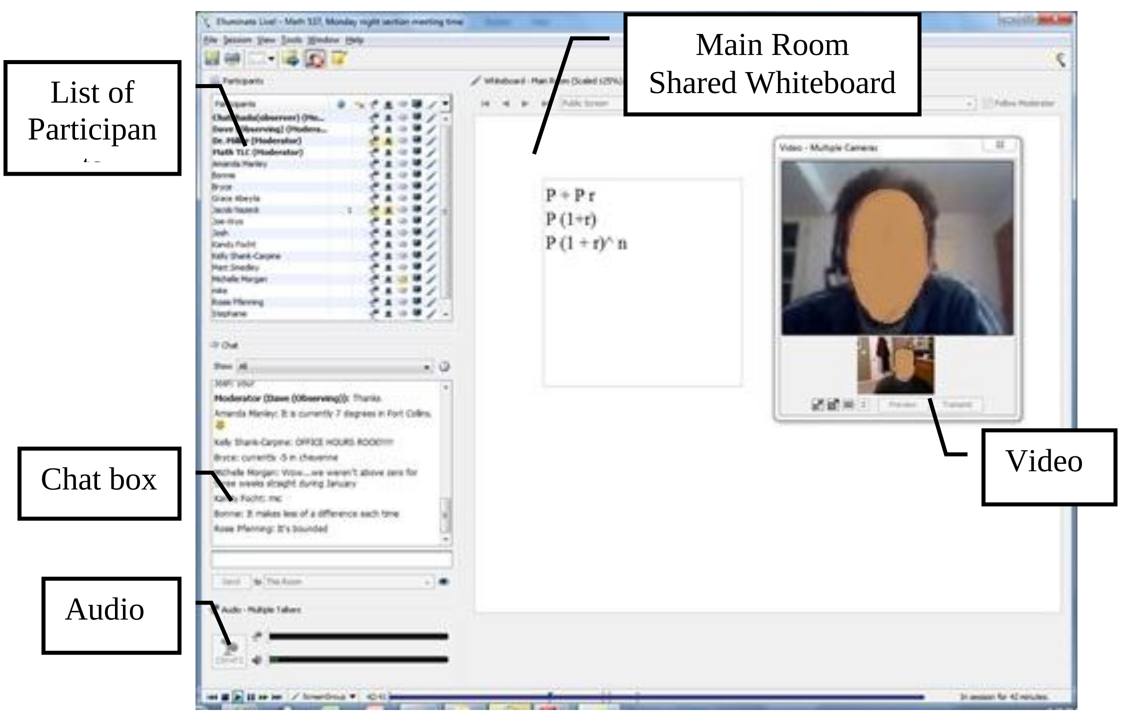


Figure 3. Elluminate *Live!*® shared whiteboard function.

In addition, the application sharing function of Elluminate *Live!*® allows an instructor and students to share multiple applications and windows with others in the class simultaneously as presented in Figure 4. Moreover, all activities that occur in the main room of the session can be recorded by Elluminate *Live!*®, except for private chat messages. Students can view or pause the recording at any time during the recorded session.

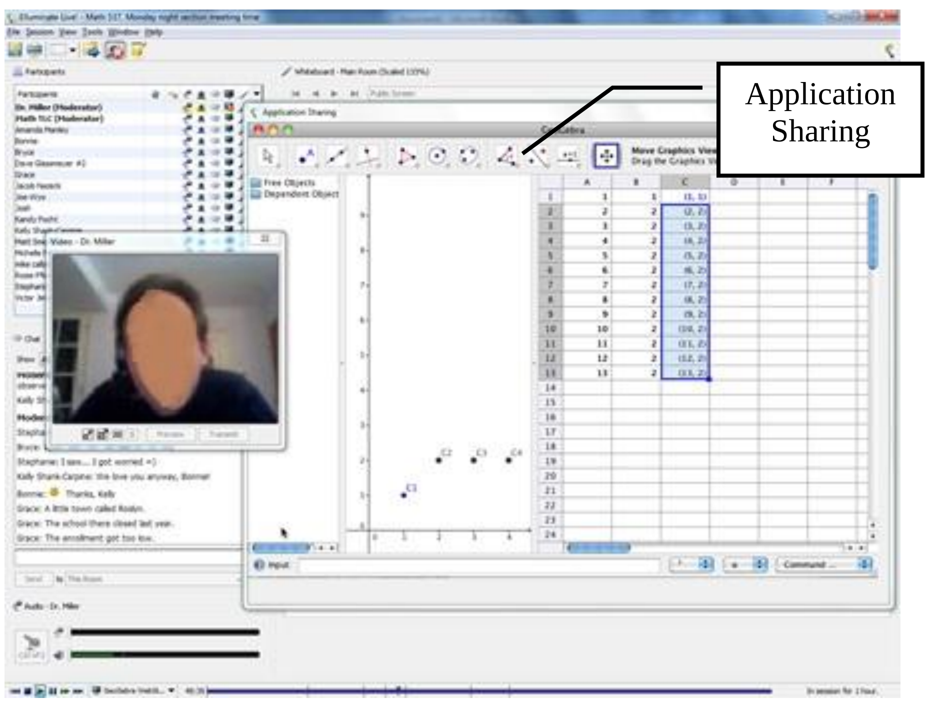


Figure 4. Elluminate *Live!*® application sharing function.

Furthermore, an instructor can create breakout rooms in an Elluminate *Live!*® session. Similarly to the main room, the breakout room can be used to facilitate small group activities. Each breakout room has its own audio, video, whiteboard, and application sharing, features. Therefore, students can see their group members while they are working together in the same breakout room. An instructor can generate any number of breakout rooms at any time during a session as shown in Figure 5. An instructor can also move participants and content into and between breakout rooms and the main room. However, all activities that occur in the breakout room cannot be recorded by Elluminate *Live!*®.

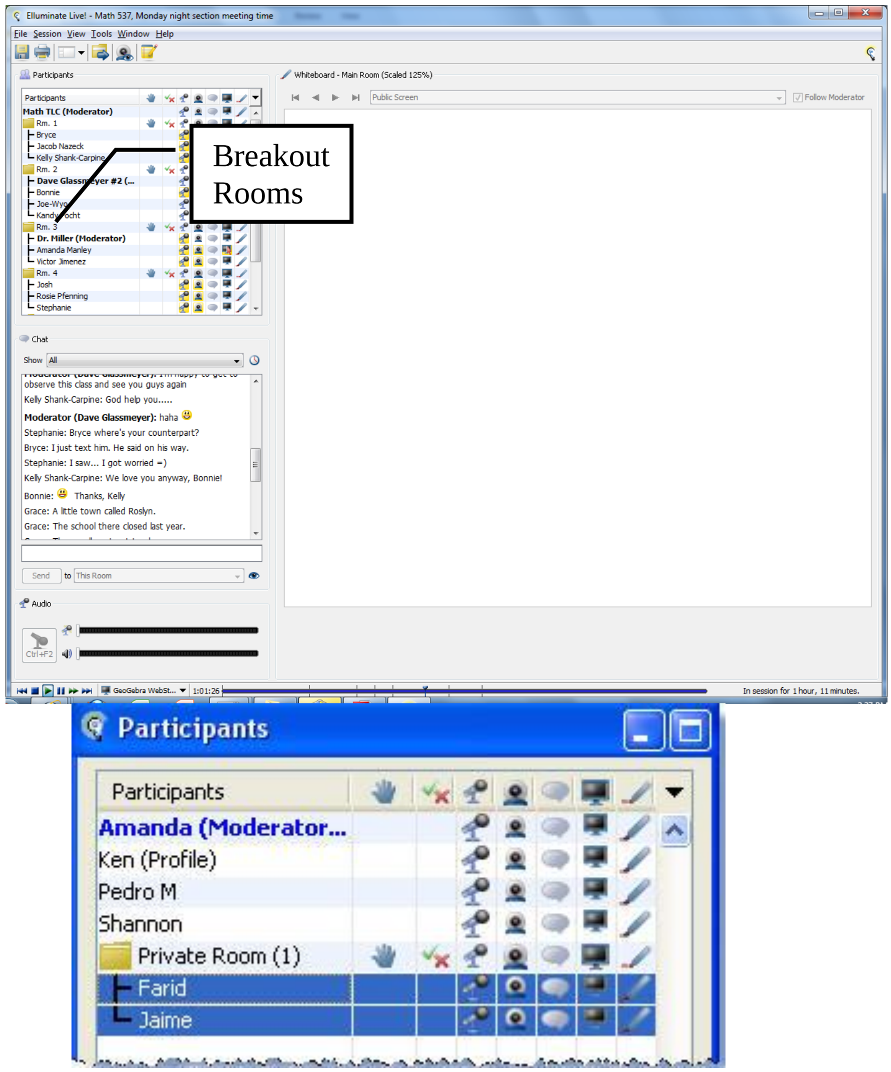


Figure 5. Elluminate *Live!*® breakout rooms.

The 16-week Mathematics Modeling (Math 537) course schedule is shown in Table 1. This course was designed to teach students how to apply mathematics to situations in the real world, to understand the real problem, to make recommendations and predictions, and to communicate the findings to others clearly. The course syllabus is included in Appendix B. The mathematical modeling course has four learning objectives, at the end of the course, the student will:

1. Gain experience with modeling as an open-ended process including investigation, analysis, and communication
2. Explore connections to K-12 curriculum, especially algebra and data analysis
3. Explore modeling related to current events and quantitative literacy
4. Gain experience with the Rule of Four, connecting graphical, algebraic, numerical, and verbal descriptions of problems

Table 1

Class Schedule

Week	Course Assignment Problem
1	Rabbit Populations
2	Financial Models part 1
3	Financial Models part 2/ Ft. Collins Temperature
4	More Population Growth Part 1
5	More Population Growth Part 2
6	More Population Growth 4 Part 2
7	Continuous Models Part 1
8	Continuous Models Part 2
9	Iteration
10	Iteration
11	Iteration
12	Controlling Animal Populations
13	Modeling Contest
14	Housing Prices
15	Final Exam given out
16	Final Exam due

Although the mathematics modeling class was offered online, students were required to attend the class during their registered time, Monday (section 970) or Tuesday (section 971) from 7:00-8:30 p.m. via Elluminate *Live!*®. Students' participation from two sections of the mathematical modeling class was evaluated based on their weekly discussions in both the synchronous whole-class and small-group sessions via Elluminate *Live!*® as well as asynchronous whole class threaded discussions via Blackboard.

For the synchronous whole-class sessions, the whole class met each Monday (section 970) and Tuesday (section 971) from 7:00-7:45 p.m. via Elluminate *Live!*®. All students were expected to participate in the live interactive discussion sessions. For the Elluminate synchronous small group sessions, there were four groups of three or four participants in each section. Each group of participants met from 7:45-8:30 p.m. after the synchronous whole-class session completed either on Monday (section 970) or Tuesday (section 971) depending on their registered day. For the asynchronous threaded discussions, students were required to post messages to weekly threaded discussions on Blackboard based on the discussion topic. Students were required to post at least one substantive post on the threaded discussion board per week.

In order to meet the course requirements, students were required to complete a total of nine assignments at the end of the semester. Samples of problems include an introduction to the modeling process, financial models, population growth models, continuous models, and discrete dynamical systems. Students had two consecutive weeks to complete each assignment. For Assignments One and Two, students had to work collaboratively in groups but were required to submit these two assignments as individual projects. Additionally, online collaborative learning was essential for this class. Therefore, to cultivate group collaboration, students were required to work in groups for the remaining seven assignments.

To start working on the assignment, students were introduced to the new modeling problems and then familiarized to the possible ways of solving the problem for approximately 45 minutes (from 7:00 – 7:45 p.m.) each week in the synchronous whole-class session. Subsequently, the instructor assigned students into groups of three or four participants. Students were required to work on these problems during class meeting time via Elluminate *Live!*® for another 45 minutes (from 7:45 – 8:30 p.m.) each week in the synchronous small-group discussion session. For Assignment Three, students were assigned into groups randomly while for Assignments Four to Nine, students were able to choose their group members.

Through collaborative problem-based learning, students in each group solved problems by compiling resources from the instructor's presentation delivered during the synchronous whole-class session. Afterwards, the students started discussing ideas with teammates, propose potential resolutions, and share possible solutions. According to Hmelo-Silver (2004), the discussion of a relevant problem among students working in collaborative small groups facilitates the process of students' new knowledge construction. If students were unable to finish their group assignment during their class time, they were able to continue working on their group work via students' preferred communication tools (e.g., Elluminate *Live!*®, Skype, or MSN) during the rest of the week.

Afterwards, students were required to write a report based on their group discussions. Students needed to submit the written reports to the instructor as group papers via Blackboard by posted deadlines. The instructor provided feedback on students' written reports. Subsequently, students had one additional week to revise the report and submit a final paper to the instructor.

Materials

The materials used in this study were the synchronous small group transcriptions, Interaction Analysis Model, teamwork attitude survey, learning environment attitude survey, and interview questions.

Synchronous Small-Group Discussion Transcriptions

Participants were instructed to utilize the Elluminate *Live!*® for a small group discussion during their synchronous meeting time. Each group member was able to communicate with their group members to work on the group assignment problem and brainstorm solutions. Therefore, two synchronous small groups from each section were observed each week and their discussions were audio-recorded by the researcher.

Due to the large number of messages that were generated in the synchronous small-group discussion sessions, the synchronous small-group discussions were collected three times (weeks 8, 10, and 12) to investigate how participants construct their knowledge while communicating with their group members. Therefore, the synchronous small-group discussions were collected during Assignment Five (Week 8: Continuous Models), Assignment Six (Week 10: Iteration), and Assignment Seven (Week 12: Controlling Animal Population). Sample discussion questions of the mathematics modeling are shown in Appendix C.

Interaction Analysis Model

To investigate the cognitive learning process or knowledge construction in all conversations generated from the synchronous small-group discussion transcriptions, the Interaction Analysis Model developed by Gunawardena et al. (1997) was applied.

The Interaction Analysis Model was selected based on three reasons. First, Gunawardena et al. (1997) introduced the Interaction Analysis Model for examining social construction of knowledge in computer conferencing presented in five different Phases. These five Phases are 1) Phase I: Sharing/comparing of information, 2) Phase II: Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements, 3) Phase III: Negotiation of meaning/co-construction of knowledge, 4) Phase IV: Testing and modification of proposed synthesis or co-construction, and 5) Phase V: Agreement statement(s) and applications of newly constructed meaning. Second, Luebeck and Bice (2005) stated that the Interaction Analysis Model was "capable of detecting cognitive conflict, analogous thinking, reflection, and higher-order cognitive processes"; thus, the Interaction Analysis Model was appropriate for the content analysis (p. 28). They further stated that the Interaction Analysis Model was developed "to measure quality rather than quantity of interaction" to find out whether an individual creates new personal knowledge construction (p. 28). Third, Garrison, Anderson, and Archer (2001) indicated that the Interaction Analysis Model is "more appropriate where applied knowledge is valued--particularly adult, continuing, and higher education" (p. 21).

In addition, the descriptions of the five Phases identity were presented as follows. First, sample descriptions of "Sharing/comparing of information," such as "A statement of observation or opinion" and "A statement of agreement from one or more other participants" presented the Phase I of the cognitive learning process. Second, sample descriptions of "Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements" definitions, such as "Identifying and stating areas of disagreement" and "Asking and answering questions to clarify the source and extent of disagreement" represented the Phase II of the cognitive learning process. Third, sample descriptions of “Negotiation of meaning/co-construction of knowledge,” such as “Negotiation or clarification of the meaning of terms” and “Negotiation of the relative weight to be assigned to types of argument” stood for the Phase III of the cognitive learning process. Fourth, sample descriptions of “Testing and modification of proposed synthesis or co-construction,” such as “Testing the proposed synthesis against ‘received fact’ as shared by the participants and/or their culture” and “Testing against existing cognitive schema” indicated the Phase IV of cognitive learning process. Finally, a sample of “Agreement statement(s)/applications of newly constructed meaning,” definitions such as “Summarization of agreement(s)” and “Application of new knowledge” represented the Phase V of cognitive learning process. The descriptions of the Interaction Analysis Model are presented in Table 2.

Table 2

Interaction Analysis Model

Phase	Identity	Description
I	Sharing/Comparing of information	• A statement of observation or opinion • A statement of agreement from one or more other participants • Corroborating examples provided by one or more participants • Asking and answering questions to clarify details of statements • Definition, description, or identification of a problem
II	Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements	• Identifying and stating areas of disagreement • Asking and answering questions to clarify the source and extent of disagreement • Restating the participant's position, and possible advancing of arguments experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view
III	Negotiation of meaning/co-construction of knowledge	• Negotiation or clarification of the meaning of terms • Negotiation of the relative weight to be assigned to types of argument • Identification of areas of agreement of overlap among conflicting concepts • Proposal and negotiation of new statements embodying compromise, co-construction • Proposal of integrating or accommodating metaphors or analogies

(table continues)

IV	Testing and modification of proposed synthesis or construction	• Testing the proposed synthesis against "received fact" as shared by the participations and/or their culture • Testing against existing cognitive schema • Testing against personal experience • Testing against formal data collected • Testing against contradictory testimony in the literature
V	Agreement statement(s)/ applications of newly constructed meaning	• Summarization of agreement(s) • Applications of new knowledge • Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction

Note: Summary of the Interaction Analysis Model Adapted from Gunawardena et al. (1997) and Luebeck and Bice (2005).

Teamwork Attitude Survey

The researcher adapted survey items and short open-ended questions for this study based on the *Teamwork Satisfaction Scale* (Tseng, Wang, & Ku, 2006) and the *Assessment and Evaluation of Collaborative Work* (Palloff & Pratt, 2005) to measure students' working experiences with their group members during synchronous small group activities on Elluminate *Live!*®. The teamwork satisfaction scale has been presented to reveal desirable factorial validity and internal consistency with the selected graduate student population with the Cronbach's Alpha of over 0.95 (Tseng et al., 2006) which indicates high internal consistency for the items set of the teamwork attitude survey.

The teamwork attitude survey consisted of a 10-item Likert-type questionnaire asking students to rate their level of attitude. These survey items were posed as statements, with possible responses on a 5-point scale: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. Sample survey items were "I like working in a collaborative group with my teammates"; "Interacting with the other members can increase my motivation to learn"; "I enjoy the experience of collaborative learning with my teammates"; "Working with my team has produced better project quality than working alone"; and "I gain online collaboration skills from the teamwork processes."

According to Palloff and Pratt (2005), participants should be inquired "to reflect on their participation in the activity and their contributions to the group" (p. 43). In addition to the Likert scale items, three open-ended questions were asked. These three open-ended questions were "Did you like or dislike learning in an online synchronous collaborative small group setting which occurred tonight? Please explain why or why not"; "How well did you work together as a group? Was it successful tonight, in your opinion?" and "Did this synchronous videoconferencing small group discussion that occurred tonight help you to understand the content of this course better? Please explain why or why not." The teamwork attitude survey is shown in Appendix D.

Learning Environment Attitude Survey

To measure students' attitudes with the technology supported synchronous collaborative small group environment as well as social community via Elluminate *Live!*®, the researcher developed survey items for the current study based on Lin's (2004) and Wu and Hiltz's (2004) studies. In addition, the Cronbach's Alpha of over 0.70 and 0.90 indicated high internal consistency for the items set of surveys developed by Lin (2004) and Wu and Hiltz (2004), respectively. Therefore, the researcher adapted some of the questions, which were relevant to the synchronous platform to measure students' attitudes measured in the study. The learning environment attitude survey includes three sections and is presented in Appendix E.

The first section of the learning environment attitude survey consisted of four demographic questions including name, age, gender, and years of teaching experiences. Additionally, the second section of the learning environment attitude survey consisted of a 21-item Likert-type questionnaire in which students rate their level of attitude on synchronous small-group sessions as well as their level of attitude with other technology (e.g., microphone, audio headset, web camera) and activities that supported learning in this course. Participants rated their degree of attitude on a 5-point scale: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree.

These survey items contained both positive and negative wordings in order to avoid the halo effect. Sample positively worded survey statements were "Synchronous small-group discussions in this class were effective for my learning"; "Synchronous small-group discussions in this class involved careful thought on my part in order to contribute"; "I have felt that I can rely on others in this course"; and "I have felt comfortable discussing concepts in this course with other students." Students' responses to these positively worded survey statements were assigned a score of 5 for a response of strongly agree, and a score of 1 for strongly disagree.

Sample negatively worded survey statements were "Synchronous small-group discussions in the class were an ineffective use of class time"; "Synchronous small-group discussions in the class did not relate directly to my course work"; "I would have understood the content better if I did not have to collaborate with peers for discussion"; and "I have not had a sense of belonging to a community with my peers in this course." These negatively worded items were reverse coded. Thus, students' actual responses to these negatively worded statements were coded to assign a score of 1 for strongly agree, and a score of 5 for strongly disagree.

Moreover, the third section of the learning environment attitude survey asked participants to respond to seven open-ended questions to reflect on their synchronous small group discussion experiences. These questions are as follows:

Q1. Please describe your overall learning experiences with synchronous small-group discussions in this mathematics modeling course.

Q2. Please provide examples from the course that illustrate what you liked BEST about the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) in this mathematics modeling course.

Q3. Please provide examples from the course that illustrate what you liked LEAST about the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) in this mathematics modeling course.

Q4. How have synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) played a part in developing a sense of community?

Q5. Please explain how the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) facilitated or hindered your learning in this mathematics modeling course.

Q6. Should the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) be incorporated into the mathematics modeling course? Please explain why or why not.

Q7. How might synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) be better used to improve your learning experiences?

Interview Questions

Fifteen participants were contacted to schedule for an individual face-to-face interview during the final week of the semester. Participants who could not be interviewed in person were interviewed via telephone or Skype, depending on participants' preferences. Each individual interview lasted approximately 20-30 minutes and was audio-recorded. The Interview protocol is shown in Appendix F, which includes the following questions:

Q1. Please share with us your overall learning experience in the synchronous small-group discussions in this course.

Q2. What did you like BEST about the synchronous small-group discussions in this course?

Q3. What did you like LEAST about the synchronous small-group discussions in this course?

Q4. Do you think the synchronous small-group discussions influence you to have a sense of belonging to the community with your classmates in this course? Please explain why or why not.

Q5. Please explain how the videoconferencing tool in synchronous small-group discussions facilitated or hindered your learning in the course.

Q6. Do you think that synchronous small-group discussions integrated with videoconferencing should be incorporated into the course? Please explain why or why not.

Q7. What challenges did you face when participating in the synchronous small-group discussion sessions in this course?

Q8. What types of support do you need to overcome these challenges?

Q9. Do you think group members in the synchronous small-group discussions should be rotated every week? Please explain why or why not.

Q10. Are there any recommendations you would make to improve the synchronous small-group discussion environment?

Procedures

Week One to Week Seven

The instructor of the participating class provided access for Blackboard to students via e-mail where they were able to find the class information such as course information, contacts, tools, and Elluminate *Live!*® link. During the first Monday (for section 970) and Tuesday (for section 971) of the class, the instructor asked participants to attend the class orientation on a synchronous whole-class meeting from 7:00-7:45 p.m. Participants were able to ask any questions regarding the course. In addition, the course instructor randomly assigned three or four participants into collaborative groups. Therefore, there were a total of eight collaborative groups. During week one through week seven, participants worked collaboratively on Assignment One (Week 1: Rabbit population), Assignment Two (Week 2: Financial Models), Assignment Three (Week 3: Ft. Collins' Temperature), and Assignment Four (Week 6: More Population Growth).

Week Eight to Week Nine

Prior to the beginning of class, the researcher informed participants regarding this research study and send the informed consent form to them via a Google Doc survey link. For Assignment Five (Week 8: Continuous Models), participants were able to choose their own group members, consisting of three or four students, to work on the assignment. The participants' synchronous small-group discussions were observed and recorded. Each observed group member was asked to complete and submit the teamwork attitude survey regarding their working experiences with their group members on Assignment Five at the end of week 8.

To analyze the synchronous small-group transcriptions, two coders coded all synchronous small-group discussions in order to assess reliability of the online discussions. One coder was a doctoral student majoring in mathematics who has expertise in mathematics contents and the other coder was the researcher of this study. These two coders performed the coding processes independently.

The two coders began the process by counting the total number of messages that each group discussed during the synchronous small-group discussions in week 8. Instead of coding the messages line-by-line or using word count, the coders looked for complete thoughts. According to Luebeck and Bice (2005), a complete thought is the unit of analysis needed to be a full message. They stated that "[t]oo often single sentences or phrases taken out of context must be scored at the lowest Phase of 'sharing and comparing' information, even though the message as a whole represents a higher Phase of knowledge construction" (p. 30). Garrison et al. (2001) suggested that submessage units are more complicated to classify between coders and can decrease reliability. After completing coding of all discussion messages of week 8, the two coders discussed their results with each other in order to discover the dictionary or theme of messages to code. If they did not agree on the messages coded, they revised their codings until they reach an agreement.

Week Ten to Week Eleven

Participants selected their own group members to work collaboratively on Assignment Six (Week 10: Iteration). The participants' synchronous small-group discussions of four groups were randomly observed and recorded. The Assignment Five teamwork attitude survey was sent to each observed group member to complete after class and submitted by the end of week 10. Discussion transcriptions were coded for this assignment.

Week Twelve

Participants worked collaboratively on Assignment Seven (Week 12: Controlling Animal Population). The participants' synchronous small-group discussions of four groups were randomly observed and recorded. The teamwork attitude survey on Assignment Six was due at the end of week 12. Transcriptions were coded and shared between two coders.

Week Thirteen to Week Fourteen

Participants worked collaboratively on Assignment Eight (Week 13: Modeling contest) and Assignment Nine (Week 14: Housing Prices).

Week Fifteen to Week Sixteen

During week fifteen, the learning environment attitude survey assessing students' attitude with the technology supported synchronous collaborative small-group environment was distributed via SurveyMonkey, web-based surveys. Participants were required to complete this survey by the end of week 16.

In addition, 15 participants were contacted for scheduling of an individual interview. However, participants who were unable to be interviewed in person were interviewed via telephone or Skype, depending on participants' preferences. Each individual interview lasted approximately 20-30 minutes. The summary of research procedures is shown in Figure 6.

Week	Activities
Week 1 to 7	• Class orientation • Assignment 1 to 4 (Rabbit Populations, Financial Models, Ft. Collins' Temperature, and More Population Growth)
	↓
Week 8 to 9	• Assignment 5 (Continuous Models) synchronous small-group discussion session was observed and recorded • Discussion transcripts were coded • All group members of observed groups completed the teamwork attitude survey at the end of week 8
	↓
Week 10 to 11	• Assignment 6 (Iteration) synchronous small-group discussion session was observed and recorded • Discussion transcriptions were coded • All group members of observed groups completed the teamwork attitude survey at the end of week 10
	↓
Week 12	• Assignment 7 (Controlling Animal Populations) synchronous small-group discussion session was observed and recorded • Discussion transcriptions were coded • All group members of observed groups completed the teamwork attitude survey at the end of week 12
	↓
Week 13 to 14	• Assignment 8 to 9 (Modeling Contest and Housing Prices)
	↓
Week 15 to 16 (Finals week)	• All participants completed the learning environment attitude survey and seven open-ended questions at the end of week 16 • Participants were contacted for an individual interview

Figure 6. Summary of research procedures.

Data Analysis

The data analysis in this study involved descriptive statistics and thematic analysis. A total of four data sources were used to answer three research questions. Table 3 demonstrates how each question was answered by each of the four different data sources.

Table 3

Relevant Data Sources for the Three Research Questions

Research Questions	Data Sources
1. How did students perform in the online synchronous collaborative small group discussions with videoconferencing integrated based on the Interaction Analysis Model?	• Synchronous small-group discussion transcriptions
2. What were students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated?	• Teamwork attitude survey • Learning environment attitude survey • Interview
3. What recommendations can be provided to improve the online synchronous collaborative small-group discussions with videoconferencing integrated?	• Learning environment attitude survey • Interview

Research Question One

To answer research question one – How did students perform in the online synchronous collaborative small-group discussions with videoconferencing integrated based on the Interactive Analysis Model? The synchronous small-group discussions of 12 groups (two groups from each section working on three projects) were transcribed and coded by employing the Interaction Analysis Model to categorize each complete thought message belonging to Phase I, Phase II, Phase III, Phase IV, or Phase V of the cognitive learning process. The total number of Phase I messages through Phase V messages were collected during weeks 8, 10, and 12. After completing the content analysis of each participant's discussions, the results revealed the descriptive data for frequency of occurrence in various Phases in weeks 8, 10, and 12 as well as across these three weeks.

Research Question Two

To respond to research question two – What were students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated? First, the responses of the teamwork attitude survey which were conducted during weeks 8, 10, and 12 and across these three weeks were calculated by using descriptive statistics and ranked for each survey item. In addition, students' responses to the three open-ended questions of the teamwork attitude survey were analyzed by applying a thematic analysis to identify themes as well as frequent patterns for responses to each question. The use of themes helped the researcher to analyze students' responses by forming core ideas and then organizing those ideas into layering and interconnecting themes to present sequence of events (Creswell, 2008).

Second, students' responses to the learning environment attitude survey were calculated by using descriptive statistics and ranked for each survey item. Moreover, students' responses to the open-ended questions #1 to #6 of the learning environment attitude survey were analyzed to identify themes and also patterns.

Third, students' responses to the interview questions #1 to #7 were transcribed and analyzed by applying a thematic analysis to identify emerging themes and recurring patterns for responses to each question.

Research Question Three

To respond to research question three – What recommendations can be provided to improve the online synchronous collaborative small-group discussions with videoconferencing integrated? The recommendations that students provide on the open-ended questions #7 of the learning environment attitude survey were analyzed by applying a thematic analysis to identify themes and patterns. Moreover, students' responses to the interview questions #8, 9, and 10 were analyzed to discover emerging themes and recurring patterns. In addition to that, some lower ranked learning environment attitude survey items were identified and recommendations were provided.

Rigor of Data Analysis

For the quantitative data, the teamwork attitude survey items was adapted from the *Teamwork Satisfaction Scale* developed by Tseng, Wang, and Ku (2006) to measure students' working experiences with their group members during the synchronous small group activities on Elluminate *Live!*®. The teamwork satisfaction scale of Tseng, Wang, and Ku (2006) has shown to reveal desirable factorial validity and internal consistency with the selected graduate student population with Cronbach's Alpha of over 0.95 which indicates high internal consistency for the items set on the teamwork attitude survey.

For the learning environment attitude survey, the researcher developed survey items to measure students' attitudes toward the synchronous collaborative small group environment given the technology support. In addition, students' attitudes on social community was measured via Elluminate *Live!*® based on Lin's (2004) and Wu and Hiltz's (2004) studies. Additionally, Cronbach's Alpha of over 0.70 and 0.90 indicates high internal consistency for the items set of surveys developed by Lin (2004) and Wu and Hiltz (2004), respectively.

For the qualitative data, the trustworthiness was addressed in three important areas: 1) credibility which corresponds with the positivist concept of internal validity, consistency, and reliability; 2) transferability which is a form of external validity; and 3) confirmability which is a matter of how to present (Lincoln & Guba, 1985).

To ensure credibility, the researcher communicated with the participants whether the tentative result of the analysis was plausible or not by including some direct quotes from participants' responses to interview questions. As for the confirmation of consistency, the method of triangulation was applied, whole or partial of the data source, number of participants, or number of investigators for further enhancement of credibility (Merriam, 2009).

Transferability was achieved by maximizing variation when selecting the right sample (Merriam, 2009). Thus, the researcher selected seven interviewees by referring their responses to open-ended questions on the learning environment attitude survey, not only in positive experiences but also in neutral and negative ways toward the learning environment. Consequently, the findings presented not only various participants' points of views regarding to their experiences toward the learning environment with videoconferencing integrated, but might also represent similar responses of other disciplines.

Finally, Schwandt (2007) suggested that the best way to maintain the confirmability of qualitative research is to present adequate trail in which the auditor can determine if the conclusions, interpretations, and recommendations can be traced to their sources. Therefore, the researcher recruited a doctoral student who is the co-coder and has expertise in Mathematics to read participants' responses to interview questions to ensure that the researcher's interpretations was not deficient in any important information of the participants' responses. Moreover, the researcher did not only include participants' responses but also the interpretive characteristic of circumstances while interviewing participants for the thick description (Schwandt, 2007).

Summary

A triangulation mixed methods design was utilized to investigate how an online problem-based learning (PBL) approach influences graduate students' knowledge construction in the online synchronous collaborative learning environment and explore students' attitudes toward taking a course in this online synchronous collaborative learning environment. Finally, this study provided recommendations for best practices, which involve communication mode tools and social interaction in an online synchronous collaborative learning environment. In this study, participants were randomly assigned to work collaboratively on group assignments. The online course format, materials, procedures, and data analysis were described in detail in this chapter.

CHAPTER IV

RESULTS

This chapter presents descriptive statistics and thematic analysis of data collected from the online Mathematical Modeling course. A total of four different data sources was used to answer three research questions. These data sources were synchronous small-group discussion transcriptions, a teamwork attitude survey, a learning environment attitude survey, and interviews. The following discussion summarizes the results of the data analyses and the accompanying answers to three research questions.

Research Question One

This section provides answers to research question one as asked this way: "How did students perform in the online synchronous collaborative small group discussions with videoconferencing integrated based on the Interaction Analysis Model?" To respond to this question, a total of 12 synchronous small-groups were observed and their discussions were audio-recorded by the researcher during weeks 8, 10, and 12. Each participant communicated with their group members via Elluminate *Live!*® to work on the group assignments and brainstorm solutions. These 12 synchronous small-group discussions were transcribed first and then coded by employing the Interaction Analysis Model to categorize each complete thought message to Phase I, Phase II, Phase III, Phase IV, or Phase V of the cognitive learning process.

To analyze the synchronous small-group transcriptions, two coders coded all synchronous small-group discussions independently in order to assess reliability of the online discussions. Both coders began by reading, analyzing, and counting the total number of messages that each group discussed during the synchronous small-group discussions in weeks 8, 10, and 12. Instead of coding the messages line-by-line or using word count, the coders looked for complete thoughts. By coding all 987 messages, this achieved the interrater reliability rating of the intraclass correlation coefficient of 0.80. Finally, both coders discussed differences in coding for individual messages until a final code was agreed on for all messages.

To investigate the cognitive learning process or knowledge construction in all conversations generated from the synchronous small-group discussion transcriptions, the Interaction Analysis Model developed by Gunawardena et al. (1997) was applied. The following messages represented synchronous small-group discussions of each phase in the Interaction Analysis Model.

Phase I: I was looking at column M, and I couldn't figure out why that rate never changed. Can you tell me what's going on there?

Phase II: I don't think it makes much sense. But if we go back… if we go through the birth rate of the world, it is going down.

Phase III: It does actually change because if you look at the top of that… it changes probably because my capacity is so large and your K is really small. All right. Or you could just take the capacity and get the K value.

Phase IV: So that's the rate times the saturation level, so if you see how the saturation levels are all similar, and you multiply that by a very small decimal, that's not going to change by much.

Phase V: Right, it's not going to change much, and that's why I was—and I just needed to look at a few more decimal places, which I just did. I think that kind of makes sense, and I think that's what I was trying to do with like linear regression on a whole bunch of rates.

After completing the content analysis of each participant's discussions, the findings revealed the total number of messages generated in each of five phases in weeks 8, 10, and 12 as follows:

Week 8. A total of 452 messages were coded using the Interaction Analysis Model developed by Gunawardena et al. (1997) in week 8. First, the findings indicated that participants performed 263 of 452 (58%) messages of sharing and comparing information as indicated in Phase I. Second, participants performed the discovery and exploration of dissonance or inconsistency among their ideas as 57 of 452 (13%) messages in Phase II. In addition, 54 of 452 (12%) messages represented that participants were engaged in negotiating meaning and constructing knowledge in Phase III. Moreover, 51 of 452 (11%) messages revealed the testing and modification of proposed synthesis in Phase IV, and 27 of 452 (6%) messages represented the agreement and application of newly constructed meaning in Phase V. The total numbers of messages coded and its corresponding percentage at each phase in week 8 are shown in Table 4.

Table 4

Coding Results for 4 Synchronous Small-Group Discussions during Week 8

Interaction Analysis Model	Phase I Sharing/ Comparing	Phase II Dissonance/ Inconsistency	Phase III Negotiation/ Construction	Phase IV Testing/ Modification	Phase V Agreement/ Application	Total
Coded Messages	263	57	54	51	27	452
(%)	58	13	12	11	6	100

Week 10. A total of 234 messages were coded using the Interaction Analysis Model in week 10. The findings showed that participants performed 102 of 234 (44%) messages of sharing and comparing information in Phase I during their synchronous small-group discussion session. Whereas participants performed 45 of 234 (19%) messages of the discovery and exploration of dissonance or inconsistency among their ideas as indicated in Phase II. Additionally, participants were engaged 40 of 234 (17%) messages in negotiating meaning and constructing knowledge in Phase III. Moreover, 33 of 234 (14%) messages represented the testing and modification of proposed synthesis in Phase IV, and 14 of 243 (6%) messages indicated the agreement and application of newly constructed meaning in Phase V. The total number of messages coded and its corresponding percentage at each phase in week 10 are shown in Table 5.

Table 5

Coding Results for 4 Synchronous Small-Group Discussions during Week 10

Interaction Analysis Model	Phase I Sharing/ Comparing	Phase II Dissonance/ Inconsistency	Phase III Negotiation/ Construction	Phase IV Testing/ Modification	Phase V Agreement/ Application	Total
Coded Messages	102	45	40	33	14	234
(%)	44	19	17	14	6	100

Week 12. A total of 301 messages were coded using the Interaction Analysis Model in week 12. During their synchronous small-group discussion session, the findings presented that participants performed 154 of 301 (51%) messages of sharing and comparing information in Phase I while participants performed 48 of 301 (16%) messages of the discovery and exploration of dissonance or inconsistency among their ideas as indicated in Phase II. Furthermore, participants were engaged 48 of 301 (16%) messages in negotiating meaning and constructing knowledge in Phase III. In addition, 36 of 301 (12%) messages represented the testing and modification of proposed synthesis in Phase IV, and 15 of 301 (5%) messages characterized the agreement and application of newly constructed meaning in Phase V. The total number of messages coded and its corresponding percentage at each phase in week 12 are shown in Table 6.

Table 6

Coding Results for 4 Synchronous Small-Group Discussions during Week 12

Interaction Analysis Model	Phase I Sharing/ Comparing	Phase II Dissonance/ Inconsistency	Phase III Negotiation/ Construction	Phase IV Testing/ Modification	Phase V Agreement/ Application	Total
Coded Messages	154	48	48	36	15	301
(%)	51	16	16	12	5	100

Overall, a total of 987 messages across three weeks (weeks 8, 10, and 12) were coded using the Interaction Analysis Model. The findings showed that participants performed 519 of 987 (53%) messages of sharing and comparing information in Phase I during their synchronous small-group discussion with videoconferencing integrated sessions. Whereas participants performed 150 of 987 (15%) messages of the discovery and exploration of dissonance or inconsistency among their ideas as indicated in Phase II. In addition, 142 of 987 (14%) messages represented that participants were engaged in negotiating meaning and constructing knowledge in Phase III. Furthermore, 120 of 987 (12%) messages revealed the testing and modification of proposed synthesis in Phase IV, and 56 of 987 (6%) messages indicated the agreement and application of newly constructed meaning in Phase V. The total number of messages coded and its corresponding percentage at each phase across three weeks are presented in Table 7.

Table 7

Coding Results for 12 Synchronous Small-Group Discussions

Week	Phase I Sharing/ Comparing	Phase II Dissonance/ Inconsistency	Phase III Negotiation/ Construction	Phase IV Testing/ Modification	Phase V Agreement/ Application	Total
8	263 (58%)	57 (13%)	54 (12%)	51 (11%)	27 (6%)	452
10	102 (44%)	45 (19%)	40 (17%)	33 (14%)	14 (6%)	234
12	154 (51%)	48 (16%)	48 (16%)	36 (12%)	15 (5%)	301
Total (%)	519 (53%)	150 (15%)	142 (14%)	120 (12%)	56 (6%)	987

Research Question Two

Research question two asked, "What are students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated?" To respond to this question, students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated were examined by three different data sources: a teamwork attitude survey, a learning environment attitude survey, and interview questions. Results were organized in the following sections: (1) the teamwork attitude survey including descriptive statistics data with ranked survey items and responses to three open-ended questions; (2) the learning environment attitude survey including descriptive statistics data with ranked survey items; and (3) the attitudes of participants including themes of responses from open-ended questions #1 to #6 of the learning environment attitude survey and interview questions #1 to #7.

Teamwork Attitude Survey

The teamwork attitude survey was sent to all participants at the end of weeks 8, 10, and 12 after the synchronous small-group discussions had been observed and recorded in weeks 8, 10, and 12, respectively. Each observed group member was asked to complete and submit the teamwork attitude survey regarding their working experiences with their group members. Participants' responses to the teamwork attitude survey and three open-ended questions in weeks 8, 10, and 12 were reported as follows:

Week 8. A total of nine participants filled out the teamwork attitude survey in week 8. The overall mean score and standard deviation across the 10 teamwork attitude survey items were 4.27 and 0.71, respectively. This rating indicated that students had positive working experiences with their group members during the synchronous small-group activities through videoconferencing using Elluminate *Live!*® in week 8. The Cronbach's alpha reliability for this survey was 0.93.

Among the 10 teamwork attitude survey times, two highest-rated statements on the survey were "I have benefited from my teammates' feedback" (*M* = 4.78) and "My team members are sharing knowledge during the teamwork processes." On the contrary, two lowest-rated statements were "Online teamwork promotes creativity" (*M* = 3.67) and "Working with my team has produced better project quality than working alone" (*M* =

3.89). The teamwork attitude survey results in week 8 are summarized in Table 8.

Table 8

Teamwork Attitude Survey Results in Week 8

Rank	Item #	Statement	Mean	S.D.
1	5	I have benefited from my teammates' feedback.	4.78	.44
1	9	My team members are sharing knowledge during the teamwork processes.	4.78	.44
3	4	I have benefited from interacting with my teammates.	4.67	.50
4	6	I enjoy the experience of collaborative learning with my teammates.	4.44	.73
5	1	I like working in a collaborative group with my teammates.	4.33	.71
6	2	I like solving problems with my teammates in group projects.	4.11	.78
7	3	Interacting with the other members can increase my motivation to learn.	4.00	.87
7	10	I gain online collaboration skills from the teamwork processes.	4.00	.87
9	8	Working with my team has produced better project quality than working alone.	3.89	.93
10	7	Online teamwork promotes creativity.	3.67	.87
		Overall	4.27	.71

Note. Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Therefore, the higher the score, the more positive was the response.

Open-ended questions. After completing the Likert scale items, participants were asked to reflect on their participation in their synchronous small-group discussion activity and their contributions to their group by answering three open-ended questions.

The first open-ended question asked participants whether they liked learning in their online collaborative synchronous small-group setting, which occurred that night. All nine participants (100%) liked to work as groups. They mentioned that they were able to share ideas. One participant stated that he would "arrive at better strategies, processes, solutions, etc. than working alone."

Then, participants were asked how well they worked together as a group. Seven participants (78%) indicated that they worked well together and were successful working as a group. However, two participants (22%) mentioned that their respective group was a little bit behind with their group discussions.

Last, participants were asked whether their synchronous small-group discussion, which occurred that night, helped them to better understand the content of this course. Six participants (67%) believed their synchronous small-group discussion led to better course comprehension. However, three participants (33%) were unsure whether the synchronous small-group discussion helped them achieve better course comprehension since they thought the content was not that difficult to understand.

Week 10. A total of seven participants completed the teamwork attitude survey in week 10. The overall mean score and standard deviation across the 10 teamwork attitude survey items were 3.86 and 1.27, respectively. This rating indicated that students had positive working experiences with their group members during synchronous small-group activities in week 10. The Cronbach's alpha reliability for this survey was 0.95.

Among the 10 teamwork attitude survey times, two highest-rated statements on the survey were "My team members are sharing knowledge during the teamwork processes" (M = 4.43) and "I have benefited from interacting with my teammates" (M = 4.29). In contrast, three lowest-rated statements (two survey items were tied in the eighth place) were "Online teamwork promotes creativity" (M = 3.43), "Interacting with the other members can increase my motivation to learn." (M = 3.57), and "I like solving problems with my teammates in group projects." (M = 3.57). The teamwork attitude survey results in week 10 are summarized in Table 9.

Table 9

Teamwork Attitude Survey Results in Week 10

Rank	Item #	Statement	Mean	S.D.
1	9	My team members are sharing knowledge during the teamwork processes.	4.43	.54
2	4	I have benefited from interacting with my teammates.	4.29	.76
3	10	I gain online collaboration skills from the teamwork processes.	4.00	1.16
3	5	I have benefited from my teammates' feedback.	4.00	1.53
5	8	Working with my team has produced better project quality than working alone.	3.86	1.46
6	1	I like working in a collaborative group with my teammates.	3.71	1.60
6	6	I enjoy the experience of collaborative learning with my teammates.	3.71	1.60
8	2	I like solving problems with my teammates in group projects.	3.57	1.51
8	3	Interacting with the other members can increase my motivation to learn.	3.57	1.51
10	7	Online teamwork promotes creativity.	3.43	.98
		Overall	3.86	1.27

Note. Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Therefore, the higher the score, the more positive was the response.

Open-ended questions. In addition to the 10-Likert scale items, participants were asked three open-ended questions, asking them to reflect on their participation in their synchronous small-group discussion activity and their contributions to their group.

The first open-ended question asked participants whether they liked learning in the online collaborative synchronous small-group setting, which occurred that night. Six participants (86%) liked to work as a group by stating that it allows them to process their thoughts, share ideas, “to hear other classmates' perceptions” as well as to learn from others. However, one participant (14%) disliked the online collaborative synchronous small-group setting because each person was committed to his or her own way of thinking and it was hard to get to a common plan.

Then, participants were asked how well they worked together as a group. Five participants (72%) mentioned they were very productive as a group. For example, they stated that they “split up the responsibility and work load” and “asked each other questions to solve the problem.” However, two participants (28%) considered their groups were not successful that week. One of them stated “[t]he only issue [when] working with my group is the technology issue. I have been experiencing delays between when I talk and when they hear me…I get frustrated because it is hard to hold a real conversation like that.”

The third open-ended question asked participants whether their synchronous small-group discussion, which occurred that night, helped them to better understand the content of this course. Five participants (72%) affirmed that their synchronous small-group discussion assisted them in attaining better course comprehension. Some representative comments included: “[w]e all brought different skills into our group that helped in completion of this problem” and “…each member of the group offers different perspectives and different background knowledge that often sheds light on a particular problem.” However, two participants (28%) thought that instead of using synchronous small-group discussions, more instruction from the class instructor during the whole class discussion would help them to better understand the course content.

Week 12. A total of eight participants completed the teamwork attitude survey in week 12. The overall mean score and standard deviation across the 10 teamwork attitude survey items were 4.24 and 0.96, respectively. This rating indicated that students had positive working experiences with their group members during synchronous small-group activities in week 12. The Cronbach’s alpha reliability for this survey was 0.94.

Among the 10 teamwork attitude survey items, three highest-rated statements on the survey (three survey items were tied for first place) were “I have benefited from my teammates’ feedback” (*M* = 4.50), “I like working in a collaborative group with my teammates” (*M* = 4.50), and “I like solving problems with my teammates in group projects” (*M* = 4.50). On the other hand, two lowest-rated statements were “Working with my team has produced better project quality than working alone” (*M* = 3.75) and “Online teamwork promotes creativity” (*M* = 4.00). The teamwork attitude survey results in week 12 are summarized in Table 10.

Table 10

Teamwork Attitude Survey Results in Week 12

Rank	Item #	Statement	Mean	S.D.
1	5	I have benefited from my teammates’ feedback.	4.50	1.07
1	1	I like working in a collaborative group with my teammates.	4.50	.54
1	2	I like solving problems with my teammates in group projects.	4.50	.54
4	6	I enjoy the experience of collaborative learning with my teammates.	4.38	.74
5	10	I gain online collaboration skills from the teamwork processes.	4.25	.71
5	4	I have benefited from interacting with my teammates.	4.25	1.39
7	3	Interacting with the other members can increase my motivation to learn.	4.13	1.13
7	9	My team members are sharing knowledge during the teamwork processes.	4.13	1.13
9	7	Online teamwork promotes creativity.	4.00	1.07
10	8	Working with my team has produced better project quality than working alone.	3.75	1.28
		Overall	4.24	.96

Note. Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Therefore, the higher the score, the more positive was the response.

Open-ended questions. The first open-ended question asked participants whether they liked learning in their online collaborative synchronous small-group setting, which occurred that night. Seven participants (89%) had positive experiences working within a group. They described that the group setting allowed them to share their knowledge and help each other to solve the assigned problem. In contrast, one participant (11%) disliked working in a group setting because his (or her) teammates did not put enough effort or contribution to the group work.

Then, participants were asked how well they worked together as a group. Six participants (75%) considered that they worked well and were successful as a group. One participants (12.5%) reasoned that being with the right group members helped them to accomplish works. However, one participant (12.5%) remarked that his (or her) group was not successful because instead of starting a new assignment, he (or she) had to spend most of the time explaining or summarizing the previous discussions to the group members.

Finally, participants were asked whether their synchronous small-group discussion, which occurred that night, helped them to better understand the content of this course. Six participants (74%) agreed that their synchronous small-group discussion helped increase their understanding of the course content. They noted that each person brought different information to the group discussions, which helped them to understand and solve the assigned problem. However, one participant (13%) stated that it “[m]aybe not [help me to understand] so much on the course content as a whole but definitely [it facilitates me to understand on] the problems which we are currently doing.” Another participant (13%) mentioned that he (or she) had to work independently throughout the week to accomplish the necessary task because his (or her) group members did not have the same level of understanding as he (or she) did.

In summary, a total of nine, seven, and eight participants completed the teamwork attitude survey in weeks 8, 10, and 12, respectively. Across weeks 8, 10, and 12, the findings of the teamwork attitude survey indicated that participants had overall positive working experience with their group members during synchronous small group activities via videoconferencing (overall weight mean = 4.14) as presented in Table 11.

Table 11

Summary of Teamwork Attitude Survey Results across Weeks 8, 10, and 12

Rank	Item#	Statement	Weighted Mean
1	9	My team members are sharing knowledge during the teamwork processes.	4.46
1	5	I have benefited from my teammates' feedback.	4.46
3	4	I have benefited from interacting with my teammates	4.42
4	6	I enjoy the experience of collaborative learning with my teammates.	4.21
4	1	I like working in a collaborative group with my teammates.	4.21
6	10	I gain online collaboration skills from the teamwork processes.	4.08
6	2	I like solving problems with my teammates in group projects.	4.08
8	3	Interacting with the other members can increase my motivation to learn.	3.92
9	8	Working with my team has produced better project quality than working alone.	3.83
10	7	Online teamwork promotes creativity.	3.71
		Overall	4.14

Note. Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Therefore, the higher the score, the more positive was the response.

Across weeks 8, 10, and 12, the data revealed that the two highest-rated statements on the survey were "My team members are sharing knowledge during the teamwork processes" (M = 4.46) and "I have benefited from my teammates' feedback" (M = 4.46). Conversely, the two lowest-rated statements were "Online teamwork promotes creativity” (*M* = 3.71) and “Interacting with the other member can increase my motivation to learn” (*M* = 3.83).

After completing the 10-Likert scale items, participants also reflected on their participations in their synchronous small-group discussion activity and their contributions to their groups by answering three open-ended questions. The research findings of the three open-ended questions on the teamwork attitude survey during weeks 8, 10, and 12 are summarized as the following:

First, the majority of participants expressed that they liked learning in their online collaborative synchronous small-group setting. They stated that learning in such environments allowed them to share ideas, knowledge, and information. Participants also indicated that they learned from others, which helped them to work on assignments more effectively. However, a few participants disliked the online collaborative synchronous small-group setting due to different ways of thinking and insufficient contributions of group members.

Second, most participants mentioned that they worked very well as a group. Yet, a few participants mentioned that technology problems and unprepared group members could cause the group work to be inefficient.

Last, the majority of participants affirmed that their synchronous small-group discussion helped facilitate better understanding of the course content. They noted that each person brought different skills and perspectives into group discussions, which helped them to solve the problem. However, a few participants felt the synchronous whole class discussion--rather than the synchronous small-group discussions--helped them to better understand the course content. In addition, some group members did not participate much in the discussions because they did not have a similar level of understanding or knowledge when comparing to other group members.

Learning Environment Attitude Survey

During week 15, a learning environment attitude survey assessing students' attitude with the technology supported synchronous collaborative small-group environment was distributed via Elluminate *Live!*®. A total of 15 participants completed the learning environment attitude survey. The percentages of responses on each item of the learning environment attitude survey are presented in Table 12.

Table 12

Learning Environment Attitude Survey Responses

Item #	Statement	SD	D	N	A	SA
1	Synchronous small group discussions in the class were effective for my learning.	0	7%	0	53%	40%
2	Synchronous small group discussions in the class involved careful thought on my part in order to contribute.	0	0	7%	73%	20%
3	Synchronous small group discussions in the class were beneficial for understanding the material.	0	7%	7%	47%	40%
4	Synchronous small group discussions in the class were an inefficient use of class time **(Recoded scale item)**.	27%	53%	0	13%	7%
5	Synchronous small group discussions in the class did not relate directly to my course work **(Recoded scale item)**.	40%	60%	0	0	0
6	Synchronous small group discussions in the class facilitated my learning.	0	0	7%	47%	47%
7	Synchronous small group discussions in the class enabled me to share my knowledge with peers.	0	0	0	67%	33%
8	Synchronous small group discussions in the class were enjoyable for me.	0	13%	13%	47%	27%
9	Synchronous small group discussions in the class motivated me to learn more.	0	13%	7%	53%	27%
10	Synchronous small group discussions in the class increased my interest in the subject.	0	7%	13%	53%	27%
11	Synchronous technology in the class made me feel like I was part of a group in the course.	0	0	13%	67%	20%

(*table continues*)

12	Synchronous technology in the class enabled me to ask the instructor questions comfortably.	0	7%	13%	60%	20%
13	Synchronous technology in the class supported my developing a productive relationship with the course instructor.	0	13%	20%	54%	13%
14	I would have understood the content better if I did not have to collaborate with peers for discussion **(Recoded scale item)**.	60%	33%	7%	0	0
15	I have felt that I can rely on others in this course.	0	0	7%	60%	33%
16	I have felt the small-groups were rotated enough so I could work with different individuals.	0	7%	7%	60%	27%
17	I have not had a sense of belonging to a community with my peers in this course **(Recoded scale item)**.	40%	40%	20%	0	0
18	I have felt comfortable discussing concepts in this course with other students.	0	7%	7%	40%	47%
19	My overall learning experiences to date with this course have been successful.	0	0	7%	60%	33%
20	The use of the Elluminate *Live!*® Whiteboard to communicate in this class has been working well.	0	7%	13%	60%	20%
21	I have been satisfied with the quality of the online conferencing tool (Elluminate *Live!*®).	0	0	7%	60%	33%

Note. SD: Strongly Disagree, D: Disagree, N: Neutral, A: Agree, and SA: Strongly Agree.

The overall mean score and standard deviation across the 21 survey items were 4.13 and 0.75, respectively. This rating indicated that students had positive attitudes with the technology supported synchronous collaborative small-group environment via

Elluminate *Live!*®. The Cronbach's alpha reliability for this survey was 0.94 and the learning environment attitude survey results are summarized in Table 13.

Across the 21 learning environment attitude survey items, the three most positive responses on the survey were, participants believed that they would have understood the content better if they have to collaborate with peers for discussion (M = 4.53), they felt that synchronous small group discussions in the class related directly to their course works (M = 4.40), and they considered that synchronous small group discussions in the class facilitated their learning (M = 4.40).

In contrast, the three statements that had the least positive responses were "Synchronous technology in the class supported my developing a productive relationship with the course instructor" (M = 3.67), "Synchronous small group discussions in the class were an inefficient use of class time (Recoded scale item)" (M = 3.80), and "Synchronous small group discussions in the class were enjoyable for me" (M = 3.87).

Table 13

Learning Environment Attitude Survey Ranked Item Results

Rank	Item #	Statement	Mean	Original Mean	S.D.
1	14	I would have understood the content better if I did not have to collaborate with peers for discussion **(Recoded scale item)**.	4.53	1.47	.64
2	5	Synchronous small group discussions in the class did not relate directly to my course work **(Recoded scale item)**.	4.40	1.60	.51
2	6	Synchronous small group discussions in the class facilitated my learning.	4.40		.63
4	7	Synchronous small group discussions in the class enabled me to share my knowledge with peers.	4.33		.49
5	19	My overall learning experiences to date with this course have been successful.	4.27		.59
5	1	Synchronous small group discussions in the class were effective for my learning.	4.27		.80
5	21	I have been satisfied with the quality of the online conferencing tool (Elluminate).	4.27		.59
5	18	I have felt comfortable discussing concepts in this course with other students.	4.27		.88
5	15	I have felt that I can rely on others in this course.	4.27		.59
10	17	I have not had a sense of belonging to a community with my peers in this course **(Recoded scale item)**.	4.20	1.80	.78
10	3	Synchronous small group discussions in the class were beneficial for understanding the material.	4.20		.86
12	2	Synchronous small group discussions in the class involved careful thought on my part in order to contribute.	4.13		.52
13	16	I have felt the small-groups were rotated enough so I could work with different individuals.	4.07		.80
13	11	Synchronous technology in the class made me feel like I was part of a group in the course.	4.07		.59
15	10	Synchronous small group discussions in the class increased my interest in the subject.	4.00		.85

(*table continues*)

16	20	The use of the Elluminate Whiteboard to communicate in this class has been working well.	3.93		.80
16	12	Synchronous technology in the class enabled me to ask the instructor questions comfortably.	3.93		.80
16	9	Synchronous small group discussions in the class motivated me to learn more.	3.93		.96
19	8	Synchronous small group discussions in the class were enjoyable for me.	3.87		.99
20	4	Synchronous small group discussions in the class were an inefficient use of class time **(Recoded scale item)**.	3.80	2.20	1.21
21	13	Synchronous technology in the class supported my developing a productive relationship with the course instructor.	3.67		.90
		Overall	4.13		.75

Note. Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). Therefore, the higher the score, the more positive was the response.

Attitudes of Participants

This section presented participants' attitudes including themes of 15 participants' responses to the six open-ended questions on the learning environment attitude survey as well as seven interviewees' responses to the seven interview questions. In addition to the teamwork attitude survey and learning environment survey, the researcher emailed participants to schedule an individual interview at the end of week 16. A total of seven participants agreed to be interviewed. They were Andrew, Kim, Betty, Julia, Ken, Roxy, and Pam. All of them were interviewed via Elluminate *Live!*® and each individual interview lasted approximately 20-30 minutes.

This section described the central themes of open-ended questions #1 to #6 on the learning environment attitude survey as well as interview questions #1 to #7 in order to expand a greater understanding of the participants' attitudes toward synchronous small-group discussions through videoconferencing, their sense of community, and their learning in technology supported learning environments. The researcher coded and then categorized the students' attitudes toward synchronous small-group discussions through videoconferencing into six themes. These six emerged themes included 1) participants' overall learning experiences; 2) favorable experiences; 3) unfavorable experiences; 4) senses of community; 5) learning facilitations; and 6) significance of sessions as presented below.

Participants' overall learning experiences. The first open-ended question of the learning environment attitude survey asked participants to describe their overall learning experiences with synchronous small-group discussions in the Mathematical Modeling course. Thirteen participants (86%) had positive experiences with the synchronous small-group discussion, one participant (7%) had a neutral opinion, which involved both positive and negative responses, and one participant (7%) had negative responses with the synchronous small-group discussion sessions.

For positive experiences, participants viewed the synchronous small-group discussions as helpful to their learning. For example, such discussions facilitated their ability to understand assignments, materials, and topics clearly, to work collaboratively, and to connect with their classmates. One participant stated, "Working in the small groups was very helpful in understanding the material. I feel that if I don't have my group members, I would have not been successful in this class." Similarly, another participant mentioned:

> The small-group discussions have been extremely important in helping gather ideas as well as for gaining clarification on course assignments. Without these discussions, I do not believe I would have done as well as I have in this course.

Moreover, another participant indicated, "I enjoyed working in the small groups. It gave me a chance to connect with my peers since I wasn't in a classroom setting with them." Likewise, one participant remarked:

> Most small group discussions were centered around working on a specific problem and analyzing how to solve them. We shared documents back and forth by using application sharing and were able to write on the white board when needed.

Whereas, one participant had the neutral experience and commented that although he (or she) enjoyed working with other students in this learning environment, he (or she) felt that working with others in a face-to-face environment would be better as stated:

> I enjoyed working with other students, although working together via technology is never as good as face-to-face. In particular, the fact that only one student can share a program and work on it at any given time was at times frustrating.

In addition to positive and neutral experiences, one participant disliked participating in these synchronous small-group discussion sessions anymore as stated:

> By the end of the semester, I did not want to participate in them anymore. I need some time to individually think about a problem before I want to discuss it, and we didn't have much time between seeing the problem for the first time and trying to 'group think' it.

Similar to the positive responses to the first open-ended question of the learning environment attitude survey, all seven interviewees also provided positive points of view and described their overall learning experiences with the synchronous small-group discussions through videoconferencing. Jim stated that he liked sharing application synchronously and enjoyed working with his group. Moreover, Roxy appreciated the communication via videoconferencing by indicating:

> We weren't waiting on an answer. It would probably be very frustrating if we didn't have the videoconferencing and didn't have that ability to ask these questions and get instant feedback so that we could keep moving forward on our project.

Favorable experiences. The second open-ended question of the learning environment attitude survey asked participants to provided examples from the course that illustrated what they liked BEST about the synchronous small-group discussion though videoconferencing (Elluminate *Live*!®) in the Mathematical Modeling course. Primarily, nine participants (60%) liked the synchronous small-group discussion though videoconferencing (Elluminate *Live*!®) because these discussions allowed them to brainstorm ideas and share possible solutions among group members as well as to gain better understanding of concepts or problems.

Some representative comments included: “I liked getting to bounce my ideas off of other people and talk through the solution to the models we were creating”; “These groups allowed me to see other problem solving ideas that I had not considered”; and “Being able to seek help from classmates, but also to be able to bounce ideas back and forth to find the best method to solve a problem.” Additionally, one participant mentioned:

> Examples include any time we worked on an assignment together. Being able to ask questions of each other and gaining a better understanding of concepts is what I like best about the small-group discussions.

In addition, favorable attitudes were also recognized by interviewees on how technology allowed peer collaboration, which was viewed as helpful towards participants’ learning. Pam explained:

> It’s nice to be able to be in a group with a few people, see their videos, and be able to talk to them…It was a very project-based discovery type learning classroom environment and Elluminate or videoconferencing helped with that.

Furthermore, Roxy appreciated the function of videoconferencing using in this Mathematical Modeling course by stating:

> …without it [videoconferencing], it would be much more difficult. I can’t imagine taking the course like mathematical modeling and not having that time together to talk about things and work on the problems together and not just do that through like a discussion board or something like that. It’s much more helpful to use the videoconferencing tool or Elluminate and know that you’re conferencing.

Another feature of the synchronous small-group discussions through videoconferencing (Elluminate *Live*!®) in which three participants (20%) mentioned what they liked best about was being able to engage in comfort and personal conversation during these sessions as stated:

> Honestly, the thing I like best was the chance to catch up with folks that I was getting to know and to find out how their lives were going and … being able to laugh, joke, and suffer together was a great experience.

Likewise, interviewees often related the small-groups to strong feelings of community and learning when they answered the interview question about their favorable experiences in the synchronous small-group discussion via videoconferencing. Ken and Kim mentioned that the intimacy of synchronous small-group discussions through videoconferencing facilitated their learning. Kim described, "It's just you there with your partner or partners and you can joke a little, you can talk about math, and I just felt really comfortable. So I like that piece where, just the intimacy of it."

Additionally, three participants (20%) mentioned that the videoconferencing tool facilitated them to work in group project better each week.

Unfavorable experiences. Subsequently, the third open-ended question of the learning environment attitude survey inquired participants to provide examples from the course that illustrated what they liked least about the synchronous small-group discussion though videoconferencing (Elluminate *Live*!®) in the Mathematical Modeling course. Three participants (20%) noted that the limitations of technology were the least positive benefits. One participant stated:

> Trying to work on the same model at the same time, sometimes it seemed like one person was working and the rest of us were just watching. It would have been great to all [of us] be around a table together working and sharing ideas.

Julia also expressed the similar experience while being interviewed as she mentioned:

> That was very frustrating when, when the thought, when the camera, when the headset or mic would freeze up, if the Elluminate session would freeze up. I thought that was most frustrating.

In addition to technology issues, three participants (20%) were concerned about their assigned group members who did not contribute much to group-works and they did not wish to work with others when they were assigned to groups.

Similarly, Ken and Andrew also pointed out that the issue of group members who were not well prepared when they participated in the small-group discussion sessions, disturbed the group work process. Ken stated:

> When I was in a group with people who weren't prepared for class or didn't do what they were supposed to beforehand. I always prepare and I always look at the problems beforehand and I felt, I'm ready to discuss when we came to the group. Since some people just arrived, not ready to do anything and that irritates me. So, that, again, isn't a problem with technology but with human beings.

Furthermore, two participants (13%) considered that the time assigned to participate in synchronous small-group discussions via videoconferencing (Elluminate *Live*!®) was too short. They would have liked to have had more time for small-group discussions. In addition, two participants (13%) mentioned that inability to choose their own groups as well as to have entire group rotation each week made them "difficult to get used [to] some people's schedules and then [they] have to adjust to new people again." In contrast, instead of staying at the same group, one participant (7%) preferred to have more group rotation in order to increase chances to be able to communicate with everyone in the class. Four participants (27%) were unable to provide any example of what they liked least about the synchronous small-group discussion though videoconferencing (Elluminate *Live*!®).

Sense of community. Followed by the fourth open-ended question of the learning environment attitude survey, participants were inquiring to describe how synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) have played a part in developing a sense of community. Eleven participants (73%) agreed that the synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) have helped them to enhance and maintain a sense of community by allowing them to get to know other students personally and by having comfortable communication while working together. Some representative comments included: "They [discussions though videoconferencing] are more personal" and "They [synchronous small-group discussions though videoconferencing] definitely helped me get to know other students better, and to feel a greater connection to them. We depended on each other, and everyone whom I worked with was more than willing to bear their share of the burden." Similarly, another participant mentioned:

> They [synchronous small-group discussions though videoconferencing] have allowed us to work together, but also to discuss general frustrations and successes. Without these small group discussions, we would have felt as if we were all alone in this class… just us as individuals and the professor. With them, we feel as though we are all in this together.

For the interview, Andrew also believed that the synchronous small-group discussions through videoconferencing helped them to build a sense of community in the course. Roxy added another opinion that the videoconferencing not only encouraged people to feel connected to their classmates but also to the professor. She remarked, "I do think videoconferencing tool encourages people to feel connected in building relationships with each other and to the professors, and allowing there to be a richer discussion."

Furthermore, the synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) have helped participants to develop a sense of community by providing them opportunities to have face-to-face communication in real-time as one participant stated "It allows you to see each other face-to-face and talk to each other right away. Email is not personal but this is." Likewise, one participant stated:

> The small-group discussions felt much more connected than the whole-class discussions. It is hard for me to feel connected through a computer monitor, but being in a smaller group and being able to see everyone's face helped. The discussions felt more comfortable and open during the small-group sessions.

Similarly, Betty also appreciated the ability to see her group members while discussing the problem as she stated:

> It definitely helped me to feel connected, for the same reason, it wouldn't have been for the fact that I could see your face and I can hear you, at the same time. If that's not there for me, then I just feel like I might as well be talking to a computer. And with the video feed and the live audio, it was second best to being in the same room with me alive.

However, three participants (20%) felt that the small-group discussions might encourage them to build up a sense of community but they were unsure whether this sense of community would have been possible if participants didn't know each other before or they did not have a chance to meet one another earlier. Similarly, Kim and Pam were doubtful whether the discussion sessions through videoconferencing could build a connection with their classmates. Nevertheless, the connections could be maintained while they were in the synchronous small-group discussion through videoconferencing. They explained the same reason mentioned earlier that they had a chance to meet their classmates in person before taking this class. Kim said, "I knew these people from the summer courses so I felt like I already had a connection with some of them."

In contrast, one participant (7%) expressed that these synchronous small-group discussions though videoconferencing (Elluminate *Live*!®) did not really help him/her to build up a sense of community if he (or she) has not met or knew each other before in other classes, "it didn't really help unless I was working with the people I knew well."

Learning facilitations. For the fifth open-ended question of the learning environment attitude survey, participants were asked to explain how the synchronous small-group discussions through videoconferencing (Elluminate *Live!*®) facilitated or hindered their learning in the Mathematical Modeling course. Thirteen participants (87%) expressed that the synchronous small-group discussions through videoconferencing (Elluminate *Live!*®) facilitated their learning, for example, by helping their thinking process, communicating and sharing ideas among group members, and assisting them in overcoming some obstacles. Some representative comments included: "I benefited from being able to share my thoughts with my classmates. They were able to correct me, share their own insights, and to help me develop my overall understanding of the material"; "Small group discussions enable me to process and brainstorm possible solutions to modeling problems before working on the problem on my own"; and

> The small-groups set up through Elluminate (videoconferencing) provided a secure feeling and an environment where I felt like I could be open with my struggles without the intimidation of the whole-group setting. This was very beneficial for helping me overcome some of the obstacles I ran into.

Additionally, Andrew pointed out that the synchronous small-group discussions through videoconferencing not only made the communication more personal and more enjoyable but Pam also highly valued the collaboration and communication in which videoconferencing facilitated. Pam remarked:

> [B]eing able to be with people that you're working with and being able to see their video and talk to them and bring up the document [application] sharing that

> was huge. I mean, that's awesome to be able to have somebody to bring that up and you all work on that one document rather than three separate documents, work on one and each other, I thought that was pretty cool.

Furthermore, Betty reflected that she would get easily distracted for small-group discussions if there were only audio provided. She stated:

> It was really nice to be able to see each other's face and then, [it] almost like you were actually working together in the same room. I think you would have done much more technical to do the same topics or the same projects if we only had audio. For me, anyways, I get way too easily distracted. And so, if I can't see the person I'm talking to then I'm too likely to kind of zone out or get off-task.

However, two of 15 participants (13%) expressed that the synchronous small-group discussions through videoconferencing (Elluminate *Live!*®) facilitated their learning, they also felt it was difficult to contribute things sometimes due to the limitations of the technology as well as lack of group working dynamics. For example, one participant remarked: "It really helped to share ideas and bounce ideas off classmates but at times it felt difficult to contribute because of the limitations of the technology." One participant also mentioned that there were only a few times that his (or her) group worked productively but most of times they only discussed what next steps should be.

Significance of sessions. Subsequently, the sixth question of the learning environment attitude survey asked participants to explain whether the synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) should be incorporated into the Mathematical Modeling course. Twelve participants (80%) considered that synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) were important and should be incorporated into the Mathematical Modeling course. They stated that due to the nature of the Mathematical Modeling course that focuses on problem-based learning, the synchronous small-group discussion though videoconferencing (Elluminate *Live!*®) encouraged them to work collaboratively with their group members by sharing ideas and understanding different perspectives.

Some representative comments included: “It [the synchronous small-group discussions though videoconferencing] provides a nice foundation for being introduced to problems, strategies to use, and time for brainstorming”; “It is extremely helpful to talk to a handful of students about a problem to gain understanding and different perspectives”; and “This type of math in particular requires a lot of processing time and being able to ask and work with others in small groups was helpful.” One participant remarked about the content or nature of Mathematical Model course:

> The synchronous small-group discussions should be incorporated into the modeling course—the ability to seek help, work together, and bounce ideas off of one another is a key ingredient in most of the math classes we learn and this component should be preserved in this course.

Likewise, one participant mentioned:

> The synchronous small-group discussions were essential to successfully completing the problems posed by the instructor. If the course were not problem-based, they might not be so important, but as it is, they are vital.

Similarly, another participant also stated:

> The synchronous small-group discussions should be incorporated for this class because it was taught in a discovery type of learning environment that it was nice to talk to others who might have figured it out long before you would have, and it is nice to have peers explain materials because it reinforces their learning and helps you learn in a comfortable environment.

Similar to the sixth open-ended question that participants responded regarding the learning environment attitude survey above, Julia stated that synchronous small-group discussion through videoconferencing was a vital component and should be incorporated in this Mathematical Modeling course: “Particularly with the math content, I think it’s so important to see some of the math in action.” Betty also emphasized how she thought synchronous small-group discussions though videoconferencing should be incorporated into the Mathematical Modeling course:

> I don't think that without the synchronous piece…I would have been successful in this course…It was critical to be able to interact in a live setting…be able to ask why, [and] work with each other.

However, three participants (20%) believed that synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) were important but they were concerned about the limitation of technology and time. They stated: "Despite the limitations [of technology], the synchronous small-group discussions were valuable, and allowed us to increase our understanding and share ideas"; and "Probably,[synchronous small-group discussions should be incorporated in this class]but with more time to understand the problem at hand before discussions." One of these three participants also mentioned that these synchronous small-group discussions though videoconferencing (Elluminate *Live!*®) sessions were helpful; however, the answers or ideas for solving problems should derive from the whole group discussion instead of only from one person's idea.

Research Question Three

This section provides answers to research question three, "What recommendations can be provided to improve the online synchronous collaborative small-group discussions with videoconferencing integrated?" According to the results from the two lowest ranked survey item of the learning environment attitude survey items (#4 and #13), open-ended question #7 of the learning environment attitude survey, and students' responses to the interview questions #8, 9, and 10, the recommendations are summarized and emerged in the areas of (1) technical assistance, (2) group rotation, (3) clear course expectations, (4) increased preparation time, and (5) increased learner-instructor interaction.

The last open-ended question (#7) of the learning environment attitude survey asked participants to explain how synchronous small-group discussions though videoconferencing (Elluminate *Live*!®) might be better used to improve their learning experiences. The results showed that six participants (40%) stated that synchronous small-group discussions though videoconferencing (Elluminate *Live*!®) had already been executed effectively; therefore, they would not change anything.

Overall, participants and interviewees provided five recommendations, which would benefit their learning in the synchronous small-group discussion environment from the instructors. These included technical assistance, group rotation, clear course expectations, increased preparation time, and increased learner-instructor interaction.

Technical Assistance

Taking classes online, participants encountered the challenge of technical problems. Therefore, a recommendation that participants mentioned was to provide more assistance with the technology used for the online course. One participant mentioned the technical issue he (or she) encountered throughout the course was audio problem and this had affected his (or her) group discussions and activities. The same participant suggested that the instructor or group members should check and ensure that all hardware and software are working properly before the discussion takes place.

Additionally, two participants suggested ways to provide technical support, such as utilizing a troubleshooter (a person on-call or a website) or implementing a frequently-asked question internet site where students could find answers to those technical questions.

Group Rotation

Most interviewees agreed that group members in the synchronous small-group discussions should be rotated for every new assignment or task. They believed that the group rotation would provide students an opportunity to move to a new group, to get to know new people, and to be able to learn from new group members. Betty mentioned that the group rotation would give her a new chance to be able to move to a new group when she was not working well or getting along with her group members. She remarked:

> You get in a group with someone you agreed you're not working well with…it gives you a chance to be in a different group the next week. Also, it was nice to learn other people's ideas, other people's kind of strategy about how they go about solving problems and that was nice. Of course, that helped me get to know some people who have had worked and I wouldn't have gotten to know otherwise.

Similar to Betty's comment, Andrew thought the group rotation would provide an opportunity to receive the new information when working with the new group members. He stated:

> I think it is nice to be able to work with different people [because] you share different things [information] out with different people. Working with the same people whom you work with all the time and probably [those people] tended to speak the same.

Moreover, one participant stated that being able to choose group members would allow students to find people who have similar working habits and learning styles.

Clear Course Expectation

When the course instructor assigned students to work in groups, participants suggested that it was essential for the instructor to provide a clear expectation of each discussion or assignment. Andrew stated that "giving a direction or purpose when breaking out into small groups would help me to know what I need to do." Kelly also recognized the necessity of clear course expectations:

> We always had a topic, which was really important to our successful discussions. We knew exactly what we were supposed to talk about the minute we got into our small group. He [course instructor] was very explicit and I think that was so important. It really gave us a clear direction.

Participants recommended that giving a clear direction when students were in small-group discussion sessions assisted online students not only to prepare themselves when participating in the online learning environment but also to provide a clear understanding of the course content.

Greater Preparation Time

In responding to the survey item #4, “Synchronous small group discussions in the class were an inefficient use of class time (Recoded scale item)”, which was the second lowest-rated statements on the learning environment attitude survey, two participants proposed that it would be helpful to have more time for individual thinking about the problems before joining the groups. Kim also said that she had a hard time staying focused and she needed more time to think about problems before sharing them with a group.

Due to the problem-based learning class, some participants also felt that they did not have enough time to discuss or work on problems as a group during the synchronous small-group discussion sessions. Therefore, they would like to have had more time for group discussions in the synchronous small-group environment.

Increased Learner-Instructor Interaction

Participants also addressed the recommendation in responding to the survey item #13, “Synchronous technology in the class supported my developing a productive relationship with the course instructor,” which was the lowest-rated statement on the learning environment attitude survey.

Two participants mentioned that by providing additional time for students and setting up virtual office hours via videoconferencing would be beneficial for them to discuss assignments or technology issues outside of classes with their instructor. Ken suggested that "having some virtual office hours via Elluminate *Live!*® each week would promote the learner-instructor interaction as students can receive immediate feedback from the instructor."

Summary

This chapter presents descriptive statistics and thematic analysis of data collected from the online Mathematical Modeling course. A total of four different data sources was used to answer three research questions. These data sources were synchronous small-group discussion transcriptions, a teamwork attitude survey, a learning environment attitude survey, and interviews.

First, to respond to the research question one, a total of 12 synchronous small-groups transcriptions generated during weeks 8, 10, and 12 were analyzed. According to the Interaction Analysis Model**,** students performed 519 (53%) messages at Phase I, 150 (15%) messages at Phase II, 142 (14%) messages at Phase III, 120 (12%) messages at Phase IV, and 56 (6%) messages at Phase V during the online synchronous collaborative small group discussions with videoconferencing integrated.

Second, to respond to the research question two, students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated were examined by three different data sources: the teamwork attitude survey, the learning environment attitude survey, and interview questions. Participants had positive attitudes toward their teamwork (overall weighted mean = 4.14) as well as their learning environments (overall mean= 4.13). For open-ended questions #1 to #6 of the learning environment attitude survey and interview questions #1 to #7, the students' attitudes toward synchronous small-group discussions through videoconferencing were analyzed and categorized into six themes. These six themes included 1) participants' overall learning experiences; 2) favorable experiences; 3) unfavorable experiences; 4) senses of community; 5) learning facilitations; and 6) significance of sessions.

Finally, to respond to research question three, according to the results from the two lowest ranked learning environment attitude survey items (#4 and #13), participants' responses to the open-ended question #7 of the learning environment attitude survey, and interviewees' responses to the interview questions #8, 9, and 10, recommendations are summarized in the areas of technical assistance, group rotation, clear course expectations, greater preparation time, and increased learner-instructor interaction.

CHAPTER V

DISCUSSION

This chapter first presents the summary of findings as well as discussions and interpretations to each of the three research questions investigated in this study. Subsequently, recommendations for improving students' collaborative experiences as well as the best practices in an online synchronous collaborative learning environment are provided. Lastly, the recommendations for future research are concluded in this chapter.

Summary of Findings

The main findings of the three research questions were the following: 1) students frequently performed the sharing and comparing of messages at Phase I rather than Phase IV or Phase V in the online synchronous collaborative small-group discussions with videoconferencing integrated based on the Interaction Analysis Model; 2) students had positive attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated involving the sense of community, learning facilitation, and significance of sessions but some of their unfavorable experiences were related to technology problems and unprepared group members; and 3) the technical assistance, group rotation, clear course expectation, greater preparation time, and increased learner-instructor interaction were all important factors in improving the online synchronous collaborative small-group discussions with videoconferencing integrated.

Discussion and Conclusion

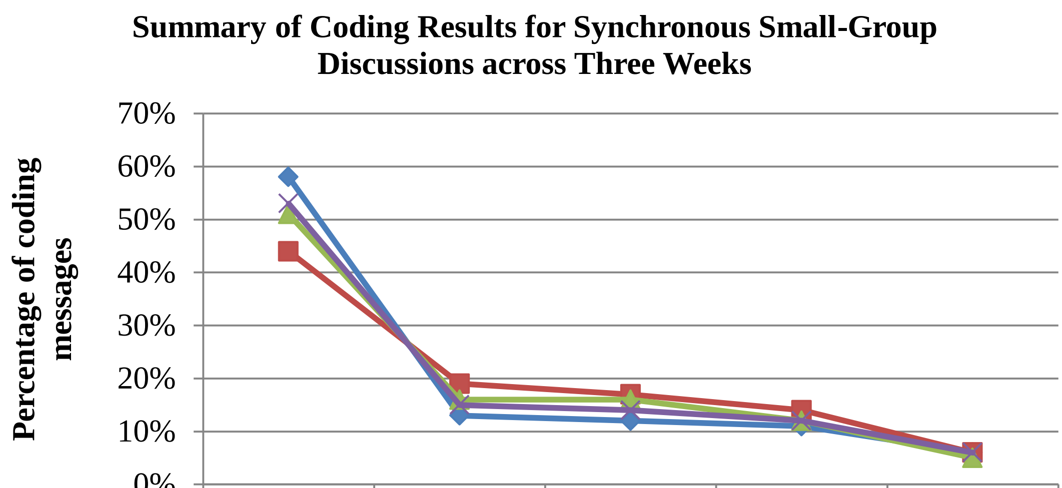
Students' Performances on Knowledge Construction

Research question one. How did students perform in the online synchronous collaborative small group discussions with videoconferencing integrated based on the Interaction Analysis Model? To investigate the cognitive learning process or knowledge construction, a total of 987 messages were coded by applying the Interaction Analysis Model developed by Gunawardena et al. (1997). Across weeks 8, 10, and 12, the coding results from 12 synchronous small-group discussions via videoconferencing in the Mathematical Modeling course revealed that students performed 519 (53%) messages at Phase I, 150 (15%) messages at Phase II, 142 (14%) messages at Phase III, 120 (12%) messages at Phase IV, and 56 (6%) messages at Phase V during the online synchronous collaborative small group discussions with videoconferencing integrated. The following sections explain possible reasons for such findings.

Participants generated messages in sharing and comparing of information more at Phase I (53%) than during any other Phases. According to Gunawardena et al. (1997), messages generated at Phase I were considered the lowest level of knowledge construction. Such messages involved the statement of asking and answering questions to clarify the details of problems as well as to corroborate the examples provided by one or more group members. This result was supported by the highest ranked teamwork attitude survey item #9, which stated that "My team members are sharing knowledge during the teamwork processes" (M = 4.46). Thus, students perceived that their group members liked to share information during their synchronous small-group discussions. Another possible reason was that some participants pointed out some of their group members were not well prepared for group discussions. Consequently, when unprepared group members came to synchronous small-group discussions, they might spend more time and generate more messages at Phase I by asking for further explanation of assigned problems than discussing or brainstorming some possible solutions.

Additionally, when considering the nature of a Mathematical Modeling course with problem-based learning activities, it was not surprising that the descriptive results of this study revealed that the participants engaged in more of their discussions at Phase I than the other Phases. Due to the synchronous environment, participants might lack adequate reflection time to provide clarifications and thoughts on assigned problems immediately (Branon & Essex, 2001; Veerman & Veldhuis-Diermanse, 2006). Therefore, participants might ask more questions among their group members before working on their problems, and such discussions were considered as the lowest level of knowledge construction.

Furthermore, across weeks 8, 10, and 12, the overall distribution of each phase did not differ much from week to week. Participants performed 150 (15%) messages at Phase II, 142 (14%) messages at Phase III, and 120 (12%) messages at Phase IV. This trend was evident that participants in the Mathematical Modeling course appeared to move beyond the exploration of inconsistency among the ideas stage at Phase II and generated a similar number of messages at Phases III, and IV as presented in Figure 7. According to another highest ranked item of the teamwork attitude survey (#5), which stated, “I have benefited from my teammates’ feedback” ($M = 4.46$), such a statement could imply that participants benefited from their group members’ feedback by hearing different viewpoints and ideas. Subsequently, such discussions at Phase I could lead students to the exploration of inconsistency among the ideas stage at Phase II (15%) and to the negotiation of meanings or the identification of the areas of agreement of overlap among their conflicting concepts stage at Phase III (14%). This might also help participants to test the proposed synthesis against information or fact as shared by the group members stage at Phase IV (12%).



	Phase I	Phase II	Phase III	Phase IV	Phase V
Week 8	58%	13%	12%	11%	6%
Week 10	44%	19%	17%	14%	6%
Week 12	51%	16%	16%	12%	5%
Overall	53%	15%	14%	12%	6%

Figure 7. Summary of coding results for synchronous small-group discussions across three weeks.

In contrast to the 53% of messages that students generated at Phase I, students only generated 6% of messages at Phase V, which was considered the highest level of cognitive activity in the Interaction Analysis Model. One possible explanation might be due to the insufficient working group time in the class. Through interviews, participants mentioned that they were unable to complete each assignment within the allocated time frame, but they were able to meet with their group members to continue working on the assigned problems after the session. As a result, most discussions of Phase V might take place during the discussion sessions outside of the class; therefore, it was impossible for the researcher to capture such discussions.

Furthermore, although many researchers applied the Interaction Analysis Model to analyze students' discussions (Gunawardena et al., 1997; Hou et al., 2008; Luebeck & Bice, 2005; Osman and Herring, 2007), to the researcher's knowledge, only Osman and Herring's (2007) study attempted to analyze transcripts of students' discussions in synchronous chat in the online educational setting. Osman and Herring's (2007) study assessed the effectiveness of online synchronous chat for conceptual learning in the cross-cultural distance certification/training program. The results from Osman and Herring's (2007) study revealed that their participants generated only 1% of Phase V messages while utilizing the synchronous chat as the primary communication tool in the online instructional administrator training program. In the current study, participants generated 6% of Phase V messages which far exceeded 1% of Phase V messages in Osman and Herring's (2007) study.

One possible explanation of such finding may be due to the benefit of videoconferencing, which facilitated students to perform more discussions at Phase V. According to Ertl, Kopp, and Mandl (2007), participants were able to collaborate with their groups to discover a problem resolution or have more meaningful knowledge transferred with the assistance of the shared application of videoconferencing. From the responses of the open-ended learning environment question and interview, participants affirmed that they liked the application sharing of videoconferencing since they could share their works with their group members while testing possible solutions.

Consequently, participants might have more opportunities to reach the stage of agreement statements or final solution which were considered as Phase V messages.

In addition, although online synchronous chat could help learners developing immediacy of interaction and providing feedback promptly (Davidson-Shivers et al., 2001), it also contained some limitations. For example, many students may lack adequate typing skills so they were not be able to follow and participate in online synchronous discussions (Branon & Essex, 2001). Another challenge for online synchronous chat is that it can be difficult for students to perceive the relationship between and among different messages (Bober & Dennen, 2001). The more students participated in the online synchronous discussions, the more difficult it was for them to follow messages (Branon & Essex, 2001). Therefore, the videoconferencing could be a potential tool to facilitate participants to perform more messages at Phase V.

Students' Attitudes

Research question two. What were students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated? In term of students' attitudes toward the online synchronous collaborative small-group discussions with videoconferencing integrated, participants had optimistic working experiences with their group members (overall weighted mean = 4.14) as well as positive attitudes toward the technology supported synchronous collaborative small-group environment through videoconferencing or via Elluminate *Live!*® (overall mean = 4.13). These results were consistent with several studies when employing the videoconferencing as a tool to facilitate class activities (Allen et al., 2003; Bello, Knowton, & Chaffin, 2007; Choi & Johnson, 2007; Gillies, 2008; Li et al., 2010).

For the most favorable experiences toward these synchronous small-group discussions through videoconferencing, participants often mentioned the sense of community, learning facilitation, and significance of the synchronous small-group discussion via videoconferencing sessions.

Sense of community. The sense of community was found to be an important element for online collaborative synchronous small-group discussions through videoconferencing. Participants believed the synchronous small-group discussions through videoconferencing effectively established and maintained their sense of community by allowing them to get to know other students, feel connected, and have comfortable real-time communication. Consistently, this finding reinforced the similar results in the prior studies, demonstrating that synchronous computer-mediated communication technologies could reduce feelings of isolation among students and by encouraging learners' sense of community (Gunawardena & Mclssac, 2004; Hrastinski, 2008; Thurston, 2005). Synchronous technologies helped learners to be aware of “themselves as members of a community rather than isolated individuals communicating with a computer” (Haythornthwaite & Kazmer, 2002, p. 459). The results also support findings of Murphy and Ciszewska-Carr (2007), who found that the use of synchronous two-way audio and text based applications (i.e. Elluminate *Live!*®) was useful to support not only the pedagogical aspect but also the social facet of learning in online courses.

Learning facilitations. Furthermore, another favorable attitude toward the synchronous small-group discussions through videoconferencing was students’ learning facilitations such as helping their thinking process, communicating and sharing ideas among group members, and assisting to overcome some obstacles. Vonderwell (2003) also established that, “[s]ocial interaction among learners plays an important part in the learning process and can have a significant impact on learning outcomes” (p. 78). The collaboration improved learner performance regarding complex or higher-order thinking activities when learners discussed the problems, brainstormed potential solutions, and arrived at final solutions (Johnson & Chung, 1999; Mergendoller et al., 2000). Participants liked learning in their online collaborative synchronous small-group setting because such an environment allowed them to be able to share ideas, facilitated them toward a better understanding of the concepts, and helped them to work successfully as groups. Similar to Goold et al.’s (2006) study, students also enjoyed collaborating with their groups and reasoned that the process facilitated greater course content comprehension.

The synchronous environment not only allowed students to adjust their paces continuously (Murphy & Collins, 1997), but the videoconferencing also provided students opportunities to hear other people’s voices and views as well as to engage in mathematics discovery (Gage, 2004). Furthermore, a feature of videoconferencing that the interviewees mentioned was application sharing. Shared applications supported the knowledge exchanges and interactions among participants while they were discussing in groups. In videoconferencing, students at a distance and in different locations were able to work and revise the same problem simultaneously on their own screens in order to discover a problem solution collaboratively when utilizing application sharing (Ertl, Kopp, & Mandl, 2007).

*Significance of sessions***.** Due to the nature of problem-based learning, participants indicated that the synchronous small-group discussion though videoconferencing (Elluminate *Live!*®) should be incorporated into this Mathematical Modeling course. These sessions encouraged students to work collaboratively with other group members. Furthermore, the collaboration among students through the medium of videoconferencing has been found to be as effective as the collaboration among students in face-to-face interactions (Ertl, Reiserer, & Mandl, 2005). Through interviews, this finding also supported by Klemm (2005) and Mattheos et al.'s (2001) study that accomplishing problem-based tasks could not be done through emails or with asynchronous threaded discussion boards because these tools were too slow to allow group work in the virtual classroom.

Moreover, Gage (2004) stated that videoconferencing facilitated interactions by allowing students to ask questions and receive direct answers promptly. Likewise, Mattheos et al. (2001) recommended that virtual classes where applied PBL approach should be organized with tools that allow and encourage collaboration among the students. Anderson et al. (1997) also mentioned that videoconferencing enabled students to have frequent interactions and thus aided them in solving complex tasks.

On the contrary, participants also mentioned technology problems and unprepared group members as their unfavorable experiences toward the synchronous small-group discussions through videoconferencing. However, such negative experiences did not greatly affect their overall positive attitudes toward their learning environment.

Technology problem. For unfavorable experiences, participants of this study indicated the technology problems can be one drawback when discussing assignments with group members through the videoconferencing at a distance. Other studies on the usage of videoconferencing for small groups revealed similar results, thus emphasizing the importance of the quality of the audio transmission (Allen, et al., 2003; Angiolillo et al., 1997; O'Conaill, Whittaker, & Wilbur, 1993). Allen et al. (2003) correspondingly addressed issues that muting microphones, video quality, audio quality, and audio lag could hinder discussions. The delays in the transmission of video and audio at times caused some overlaps and interruptions in the dialog construction (Angiolillo et al., 1997). According to O'Conaill et al. (1993), in videoconferencing, if the audio transmission was reliable, collaboration processes would be successful.

Unprepared group members. Unprepared group members provided another unfavorable attitude issue toward working as a group in the synchronous small-group discussion learning environment. Through the interviews, some participants addressed the issue that when they came to groups, some group members were not ready to discuss group assignments, which in turn produced ineffective group discussions. According to Goold, Augar, and Farmer (2006), students would become frustrated when their group members did not participate in or contribute to group discussions. This finding was also aligned with Tseng's (2008) study that low levels of individual accountability and lack of communication were negative factors of their teamwork experiences.

Recommendations

Research question three. What recommendations can be provided to improve the online synchronous collaborative small-group discussions with videoconferencing integrated? Participants stated that technical assistance, group rotation, clear course expectations, increased preparation time, and increased learner-instructor interaction would benefit their learning.

Technical assistance. When taking online courses, proper functioning of technology during class is important. One of the technical issues that concerned students throughout the course was the audio problem. Some microphones only operated occasionally, which affected group discussions and activities. Therefore, prior to the class meeting time it is necessary to provide clear instruction for the testing of students' audio, webcam, and headsets to ensure that all equipment is functioning properly (Choy, McNickle, & Clayton, 2002).

Moreover, participants also suggested implementing the real-time chat box to discuss hardware and software issues during class might be helpful. Additionally, other methods of assistance could be implemented to support technical issues, such as troubleshooting (person on-call or website) or a frequently-asked questions internet site where students can find answers to those technical questions promptly. Likewise, these recommendations were also found from Ku, Akarasriworn, Rice, Glassmeyer, and Mendoza's (in press) study. Therefore, such technical assistance can ensure that group interactions will take place more smoothly.

Group rotation. Most participants suggested an entire group rotation prior to working on a new assignment or task when participating in the synchronous small-group discussion sessions. Participants affirmed that the entire group rotation would provide students a chance to move to a new group, to get to know new people, and to learn different viewpoints from new people. Interacting among new people or different group members would advocate group construction of new knowledge derived by different viewpoints. According to Levine and Resnick (1993), the social interaction among students who have different points of view would direct the creation of knowledge or the discovery of insights through conceptual improvement. Moreover, Jackson (1992) asserted that forming groups without the diversity of group members' experiences, perspectives, and knowledge, could undermine students' potential for learning and problem-solving effectiveness. Therefore, the entire group rotation could provide an opportunity to receive new information when working with the new group members.

Clear course expectation. In addition, providing clear course expectation was another recommendation suggested by the participants for the synchronous small-group discussion sessions. A precise course expectation and instruction should be provided for each discussion or assignment in advance in order to give students a clear direction when they were in small-group discussion sessions. Such information should be readily accessible to students before and during the assignment activity (Taylor, 2005). Consequently, students' confusion and frustration would be prevented or reduced (Moallem, 2003; Salmon, 2002). The clear course expectation assisted online students to not only prepare themselves when participating in the online learning environment but also to have a clear understanding of the course content and to help improve the learning community (Snyder, 2009).

Furthermore, to solve problems in the complex situation (i.e. online learning environment) easily produced the cognitive overload, which increased the failure of both the problem-solving and the learning process (Sweller, VanMerrienboer, & Paas, 1998). Therefore, Ertl, Kopp, and Mandl (2007) discovered that implementing both collaboration scripts (providing task-specific support) and content schemes (providing content-specific support) simultaneously could facilitate collaborative problem-solving learning in videoconferencing and promote the acquisition of knowledge.

Greater preparation time. Participants proposed they would like to have more time for individual thinking about the problems before joining groups. Thus, they would spend less time asking group members for clarification concerning problems. Instead they could start working on the assignment immediately after coming into their small-groups. In this case, the course instructors should guide the learning process (Palloff & Pratt, 1999; Snyder, 2009) and allow students to develop their own learning path (Cercone, 2008). In this study, due to the nature of problem-based learning, participants felt that they did not have enough time to discuss or work on problems as a group during the synchronous small-group discussion sessions. Therefore, providing students more time for synchronous small-group discussion sessions would facilitate their learning.

Furthermore, working collaboratively as groups, students may need more time to discuss individual and group learning as well as goals. Daradoumis and Xhafa (2005) suggested, "the clear identification of the goals and the responsibilities of each member would result in elaborating an adequate working methodology, good planning and timing, and a fair and viable assignment and distribution of the constituent tasks to be performed" (p. 227). Therefore, such goals and negotiations could facilitate high quality group interactions as well as help prevent the unprepared group member issues.

Increased learner-instructor interaction. Another instructional recommendation provided by the participants was how to utilize the synchronous technology in the class to support the development of a productive relationship with their course instructor. The use of synchronous technology to set up virtual office hours with the instructors via Elluminate *Live!*® could provide additional time for students to discuss assignments or technology issues outside of classes. This could facilitate student learning as well as improve instructor and learner interaction in the online environment (Serwatka, 1999). Similarly, the recommendation of Ku et al.'s (in press) study also suggested that by implementing online office hours, learner-instructor relationships could be more easily created to address isolation issues as well as to explain the course material in online learning.

Implications

The present study has implications for both educational practice and future research. The study offered examples regarding how to design and implement an online collaborative context using videoconferencing for educators or course designers. The findings of the study suggest that the synchronous small-group discussions through videoconferencing were appropriate for the problem-based learning and dynamic tasks; for example, asking questions, discussing possible solutions, and receiving direct answers promptly after problems have initially been presented. Moreover, the use of the synchronous two-way audio or videoconferencing tool was useful to support not only the pedagogical aspect but also the social facet of learning in online courses. In this study, the synchronous communication tool enables frequent participant interaction and facilitates knowledge construction in the online collaborative working group environments. Therefore, incorporating such a tool in an online collaborative learning course could foster a sense of belonging and address concerns in the lack of a sense of community and peer collaboration commonly associated with asynchronous threaded discussions.

In addition, the results also provided recommendations on how to effectively implement synchronous videoconferencing communication tools in the online collaborative problem-based learning environment. In practice, the findings of this study suggested that students had positive attitudes toward their teamwork as well as their learning environments. Therefore, some teaching strategies for online instructors, such as a clear expectation, specification of collaborative tasks, and increased preparation time for class discussions, are recommended to improve students' motivation to participate in the synchronous small-group discussion session via videoconferencing.

Furthermore, the results of this study can be added to the empirical research regarding the quality of synchronous online discussion with videoconferencing. The findings revealed that synchronous collaborative small-group discussions with videoconferencing can promote students' higher-level of thinking and knowledge construction in the context of online graduate mathematics coursework.

Recommendations for Future Research

In the section, the researcher provides the following recommendations for future research that might contribute to the literature of online collaborative learning and application of the Interaction Analysis Model.

First, at present, telecommunication technologies have been used extensively. Portable audio and video devices and faster communication speeds have brought the synchronous learning environment beyond the boundaries of a physical location. Therefore, it would be interesting for further research to investigate students' knowledge construction in online collaboration by utilizing other videoconferencing tools. Since the researcher only focused on the use of Elluminate *Live!*® in this study, other videoconferencing tools (e.g., Wimba, Skype, MSN messenger, Yahoo messenger, or

Google talk) can be potential devices that could promote students' knowledge construction in the synchronous online learning environment.

Second, working as a group allows students to work with other people collaboratively. The researcher noticed that some students would like to work with different group members to develop new ideas and practice different approaches. Moreover, there were researchers who similarly studied forming workgroups with diversity of background, value, knowledge, and its impact on performance but where different results were revealed (Ancona & Caldwell, 1992; Jackson, 1992; Jehn, Northcraft, & Neale, 1999). Therefore, it would be interesting to further examine whether having entire group rotation prior to the beginning of every new assignment when participating in the synchronous small-group discussion sessions would influence the students' level of knowledge construction rather than without group rotations.

Finally, this study applied the Interaction Analysis Model developed by Gunawardena et al. (1997) to measure students' knowledge constructions via videoconferencing. In order to validate students' level of knowledge acquisition via videoconferencing, the Practical Inquiry Model developed by Garrison, Anderson, and Archer (2001) or other cognitive models mentioned in Chapter II could be applied for future research.

Summary

This study investigated how an online problem-based learning (PBL) approach influenced graduate students' knowledge construction in an online synchronous collaborative learning environment. Based on the Interaction Analysis Model, students frequently performed messages at Phase I rather than at Phase IV or Phase V in the online synchronous collaborative small-group discussions with videoconferencing integrated. This may be due to the students' sharing information preferences, unprepared group members, the nature of the Mathematical Modeling course. However, the videoconferencing tool facilitated students to generate their messages at Phase V in this current study more than did the synchronous chat in Osman and Herring's (2007) study.

Furthermore, the findings revealed that students had positive attitudes toward the online synchronous collaborative learning environment. Consistent with previous research, participants often mentioned their most favorable experiences included the sense of community, learning facilitation, and significance of the synchronous small-group discussion via videoconferencing sessions. In contrast, technology problems and unprepared group members were unfavorable experiences when participating in the synchronous small-group members via videoconferencing. These findings were aligned with Allen, et al. (2003), Angiolillo et al. (1997), O'Conaill, Whittaker, and Wilbur (1993), and Tseng's (2008) studies.

In addition, recommendations for the best practices in an online synchronous collaborative learning environment via videoconferencing were provided based on participants' experiences, which included technical assistance, group rotation, clear course expectations, greater preparation time, and increased learner-instructor interaction.

Finally, implication and recommendations for future studies were provided, such as using other synchronous videoconferencing tools to facilitate online collaboration, investigating the effect of group rotation on students' knowledge construction, and applying other cognitive models to validate the level of students' knowledge construction in the synchronous small-group discussion via videoconferencing.

REFERENCES

Alavi, M. (1994). Computer-mediated collaborative learning: An empirical evaluation. *MIS Quarterly, 18*(2), 159-174. Retrieved from http://www.jstor.org/stable/249763

Alberta Ministry of Education. (2006). *Video-conferencing research community of practice research report.* Retrieved from http://www.vcalberta.ca/images/stories/pdf/Research_Summary_Report_word_version_final.pdf

Allen, M., Sargeant, J., Med, B. N., Mann, K., Fleming, M., & Premi, J. (2003). Videoconferencing for practice-based small-group continuing medical education: Feasibility, acceptability, effectiveness and cost. *Journal of Continuing Education in the Health Profession. 23*(2), 38-47.

Allen, I. E., & Seaman, J. (2010). *Learning on demand: Online education in the United States, 2009.* Needham, MA: Bobson Survey Research Group. Retrieved from http://sloanconsortium.org/publications/survey/pdf/learningondemand.pdf

Alper, Y. A. (2003). *The Effect of cognitive flexibility on students' achievement and attitudes in web mediated problem based learning* (Doctoral dissertation). Ankara University Graduate School of Educational Sciences: Ankara.

Althaus, S. (1997). Computer-mediated communication in the university classroom: An experiment with on-line discussions. *Communication Education, 46*(3), 158-174.

An, Y. J. (2006). *Collaborative problem-based learning in online environments.* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3219913)

Anastasiades, P. (2009). *Interactive videoconferencing and collaborative distance learning for K-12 students and teachers: Theory and practice.* NY: Nova Science Publishers, Inc.

Ancona, D., & Caldwell, D. (1992). Demography and design: Predictors of new product team performance. *Organization Science, 3*, 321-341.

Anderson, T. (2008). Is videoconferencing the killer App for K-12 distance education? *Journal of Distance Education, 22*(2), 109-124.

Anderson, A. H., O'Malley, C., Doherty-Sneddon, G., Langton, S., Newlands, A., Mullin, J., Fleming, A. M., & Van der Velden, J. (1997). The impact of VMC on collaborative problem solving: An analysis of task performance, communicative process, and user satisfaction. In K. E. Finn, A. J. Sellen & S. B. Wilbur (Eds.), *Video-mediated communication* (pp. 133-156). Mahwah, NJ: Lawrence Erlbaum Associates.

Andrews, T., & Klease, G. (2002). Extending learning opportunities through a virtual faculty: The videoconference option. *International Journal of Educational Technology, 3*(1). Retrieved from http://www.ascilite.org.au/ajet/ijet/v3n1/andrews/index.html

Angiolillo, J. S., Blanchard, H. E., Israelski, E. W., & Mané A. (1997). Technology constraints of video-mediated communication. In K. E. Finn, A. J. Sellen & S. B.

Wilbur (Eds.), *Video-mediated communication* (pp. 51-74). Mahwah, NJ: Lawrence Erlbaum Associates.

Aspy, D. N., Apsy, C. B., & Quinby, P. M. (1993). What doctors can teach teachers about problem-based learning. *Educational Leadership, 50*(7), 22-24.

Baron, R. A. (1991). Positive effects of conflict: A cognitive perspective. *Employees Responsibilities and Rights Journal, 4*, 25-36.

Barron, B. J. S. (2002). Achieving coordination in collaborative problem-solving groups. *The Journal of Learning Sciences, 9*(4), 403-436.

Barrows, H. S. (1994). *Practice-based learning: Problem based-learning applied to medical education.* Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H. S. (2000). *Problem-based learning applied to medical education*. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H. S., & Kelson, A. C. (1993). *Problem-based learning in secondary education and the problem-based learning institute* [Monograph]. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H. S., & Tamblyn, R. (1980). *Problem-based learning: An approach to medical education.* New York: Springer.

Bello, A. D., Knowton, E., & Chaffin, J. (2007). Interactive videoconferencing as a medium for special education: Knowledge acquisition in pre-service teacher education. *Interaction in School and Clinic, 43,* 38-47.

Berge, Z. L. (2002). Active, interactive, and reflective e-learning. *Quarterly Review of Distance Education, 3*(2), 181-190.

Bielefield, A., & Cheeseman, L. (2007). *Technology and copyright law*: *A guidebook for the library, research, and teaching professions* (2nd ed.). New York: Neal-Schuman Publishers, Inc.

Bonk, C. J., & Cunningham, D. J. (1998). Searching for learner-centered, constructivist, and sociocultural components of collaborative educational learning tools. In C. J. Bonk & K. S. King (Eds.), *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse* (pp. 25–50). Mahwah, NJ: Erlbaum Associates.

Bonk, C. J., & King, K. S. (1998). *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bordia, P. (1992). Face-to-face versus computer-mediated communication: A synthesis of the experimental literature. *The Journal of Business Communication, 34*(1), 99-120.

Boyle, E. A., Anderson, A. H., & Newlands, A. (1994). The effects of visibility on dialogue and performance in a cooperative problem solving task. *Language and Speech, 37*(1), 1-20.

Brandon, D., & Hollingshead, A. B. (1999). Collaborative learning and computer-supported groups. *Communication Education,* 48(2), 109-126.

Branon, R. F., & Essex, C. (2001). Synchronous and asynchronous communication tools in distance education: A survey of instructors. *TechTrends, 45*(1), 36-42.

Bransford, J. D., & McCarrell, N. S. (1977). A sketch of a cognitive approach to comprehension: Some thoughts about understanding what it means to comprehend. In P. N. Johnson-Laird, & P. C. Wason (Eds.), *Thinking: Readings in cognitive science* (pp. 377–399). Cambridge, UK: Cambridge University Press.

Bridges, E. M. (1992). *Problem-Based Learning for Administrators*. ERIC Clearinghouse on Educational Management, University of Oregon. Retrieved from the ERIC database. (ED347617)

Brown, S. W., & King, F. B. (2000). Constructivist pedagogy and how we learn: Educational psychology meets international studies. *International Studies Perspectives, 1*(3), 245-254.

Butler , R., Inrnan, D., & Lobb, D. (2005). Problem-based learning and the medical school: Another case of the emperor's new clothes? *Advances in Physiology Education, 29*(4), 194–196. doi:10.1152/advan.00032.2005

Carr-Chellman, A., Dyer, D. & Breman, J. (2000). Burrowing through the network wires: Does distance detract from collaborative authentic learning? *Journal of Distance Learning 15*(1), 39-62.

Cavanaugh, C. S. (2001). The effectiveness of interactive distance education technologies in K-12 learning. *International Journal of Educational Telecommunications, 7*(1), 73–88.

Cercon, K. (2008). Characteristics of adult learners with implications for online learning design. *AACE Journal, 16*(2), 137-159.

Chan, D. H., LeClair, K. & Kaczorowski, J. (1999). Problem-based small-group learning via the Internet among community family physicians: A randomized controlled trial. *M.D. Computing, 6*(3), 54-58.

Chandler, G., & Hanrahan, P. (2000). Teaching using interactive video: Creating connections. *Journal of Nursing Education*, *39*, 73–80.

Chen, C. C., & Shaw, R. S. (2006). Online synchronous vs. asynchronous software training through the behavioral modeling approach: A longitudinal field experiment. *Journal of Distance Education Technologies, 4*(4), 88-102.

Chen, Y., Chen, N.-S., & Tsai, C.-C. (2009). The use of online synchronous discussion for web-based professional development for teachers. *Computers & Education, 53*(4), 1155-1166. doi: 10.1016/j.compedu.2009.05.026

Cho, K. L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development*, *50*(3), 5-22.

Choi, H. J., & Johnson, S. D. (2007). The effect of problem-based video instruction on learner satisfaction, comprehension and retention in college courses. *British Journal of Educational Technology*, *38*(5), 885-895.

Choy, S. C., McNickle, C., & Clayton, B. (2002). Learner expectations and experiences. Student views of support in online learning. In H. Guthrie (Ed.), *Online learning: Research readings* (pp. 106-122). Adelaide Australia: National Centre for Vocational Education Research. Retrieved from http://eprints.qut.edu.au/7250/1/7250.pdf

Chun, D. M., & Plass, J. L. (2000). Networked multimedia environments for second language acquisition. In M. Warschauer & R. Kern (Eds.), *Network-based language teaching: Concepts and practice* (pp. 151-170). Cambridge: Cambridge University Press.

Cognition and Technology Group at Vanderbilt (1997). *The jasper project: Lessons in curriculum, instruction, assessment, and professional development*. Mahwah, NJ: Erlbaum Associates.

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1-35.

Coombs, G., & Elden, M. (2004). Introduction to the special issue: Problem-based learning as social inquiry-PBL and management education. *Journal of Management Education, 28*(5), 523-535.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Daradoumis, T., & Xhafa, F. (2005). Problems and opportunities of learning together in a virtual learning environment. In T. S. Roberts (Ed.), *Computer-supported collaborative learning in higher education* (pp. 218-233). Hershey, PA: Idea Group Inc.

Davidson-Shivers, G. V., Muilenburg, L. Y., & Tanner, E. J. (2001). How do students participate in synchronous and asynchronous online discussions? *Journal of Educational Computing Research, 25*(4), 351-366.

DeGrave, W. S., Boshuizen, H. P. A., & Schmidt, H. G. (1996). Problem-based learning: Cognitive and metacognitive processes during problem analysis. *Instructional Science, 24*(5), 321–341.

Dennis, A. R., & Valacich, J. S. (1999). Rethinking media richness: Towards a theory of media synchronicity. *Proceedings of the 32nd Hawaii International Conference on System Sciences, Los Alamitos, CA.* doi: 10.1109/HICSS.1999.772701

Dennis, J. K. (2003). Problem-based learning in online vs. face-to-face environments. *Education for Health, 16*(2), 198–209.

Dewey, J. (1916). *Democracy and education.* New York: Macmillan.

Donnelly, R. (2006). Blended problem-based learning for teacher education: Lessons learnt learning. *Media and Technology, 31*(2), 93–116.

Driscoll, M. P. (2005). *Psychology of learning for instruction (3rd ed.).* Boston, MA: Allyn & Bacon.

Duffy, T. M. & Jonassen, D. H. (1991). Constructivism: New Implications for Instructional Technology? *Educational Technology, 31*(5), 7–12.

Dunlop, J. C. (2005). Problem-based learning and self-efficacy: How a capstone course prepares students for a profession. *Educational Technology Research and Development, 53*(1), 65-85.

Dunlap, J. C., Sobel, D., & Sands, D. I. (2007). Supporting students' cognitive processing in online course: Designing for deep and meaningful student-to-content interactions. *TechTrends, 51*(4), 20- 31.

Eastman, C. M. (1969). *Cognitive processes and ill-defined problems: A case study from design.* Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.75.5926&rep=rep1&type=pdf.

Elluminate *Live!*® (2010). *Version 10.* Retrieved from http://www.elluminate.com/Products/Elluminate_Learning_Suite/Elluminate_Live!/What%E2%80%99s_New_in_v10/?id=391

Ertl, B., Fischer, F., & Mandl, H. (2006). Conceptual and socio-cognitive support for collaborative learning in videoconferencing environments. *Computers & Education, 47*(3), 298-315.

Ertl, B. Kopp, B., & Mandl, H. (2007). Supporting collaborative learning in videoconferencing using collaboration scripts and content schemes. *Computer-Supported Collaborative Learning Series, 6*(3), 213-236. doi: 10.1007/978-0-387-36949-5_13

Ertl, B., Reiserer, M., & Mandl, H. (2005). Fostering collaborative learning in videoconferencing: The influence of content schemes and collaboration scripts on collaboration outcomes and individual learning outcomes. *Education, Communication and Information, 5*(2), 147-166.

Falconer, K. B., & Lignugaris-Kraft, B. (2002). A qualitative analysis of the benefits and limitations of using two-way conferencing technology to supervise pre-service teachers in remote locations. *Teacher Education & Special Education, 25*, 368-384.

Fox, E. J. (2008). Contextualistic perspectives. In J. M. Spector, M. D. Merrill, J. V. Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (pp.485-506). New York, NY: Routledge Taylor & Francis Group.

Gage, J. (2003). *Videoconferencing in the mathematics lesson.* Paper presented at the BERA Conference, Edinburgh. Retrieved from http://74.125.155.132/scholar?q=cache:A4nMa2QeDaYJ:scholar.google.com/+Videoconferencing+in+the+mathematics+lesson&hl=en&as_sdt=0,6

Gage, J. (2004). Video-conferencing: Case studies in the mathematics classroom. In S. Johnston-Wilder & D. Pimm (Eds), *Teaching secondary mathematics with ICT* (pp.191-202). New York, NY: McGraw-Hill Companies, Inc.

Garrison, D. R., & Anderson, T. (2003). *E-learning in the 21st Century: A framework for research and practice.* London: Routledge Falmer.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education, 15*(1), 7-23.

Gillies, D. (2008). Student perspectives on videoconferencing in teacher education at a distance. *Distance Education, 29*(1), 107-118.

Goodyear, P. (2006). Technology and the articulation of vocational and academic interests: Reflections on time, space and e-learning. *Studies in Continuing Education, 28*(2), 83-98.

Goold, A, Augar, N., & Farmer, J. (2006). Learning in virtual teams: Exploring the student experience. *Journal of Information Technology Education, 5*, 477-490.

Greeno J. G., Collins A. M., & Resnick L. (1996). Cognition and learning. In R. C. Calfee & D. C. Berliner (Eds.), *Handbook of educational psychology* (pp. 15-46). New York: Simon & Schuster Macmillan.

Gunawardena, C., Lowe, C., & Anderson, T. (1997). Analysis of global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research 17*(4), 397–431.

Gunawardena, C. N., & Mclsaac, M. (2004). Distance education. In D. H. Jonassen, (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp.355-394). Mahwah, NJ: Lawrence Erlbaum Associates.

Halpern, D. F. (1999, Winter). Teaching or critical thinking: Helping college students develop the skills and dispositions of a critical thinker. *New Directions for Teaching and Learning, 80*, 69-74.

Hampel, R. & Hauck, M. (2004). Towards an effective use of audio conferencing in distance language courses. *Language Learning and Technology, 8*(1), 66–82.

Hanson, W. E., Creswell, J. W., Plano-Clark, V. L., Petska, K. S. & Creswell, J. D. (2005). Mixed methods research designs in counseling psychology. *Journal of Counseling Psychology, 52*(2), 224-235. doi: 10.1037/0022-0167.52.2.224

Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science, 28*(2), 115-152.

Harasim, L., Calvert, T., & Groeneboer, C. (1997). Virtual-U: A web-based system to support collaborative learning. In B. H. Khan (Ed.), *Web-based instruction* (pp. 149-158). Englewood Cliffs, NJ: Educational Technology Publications.

Haythornthwaite, C, & Kazmer, M. M. (2002). Bringing the Internet home: Adult distance learners and their Internet, home, and work worlds. In B. Wellman & C.

Haythornthwaite (Eds.), *The Internet in everyday life* (pp. 431-463). Maiden, MA: Blackwell Publishing.

Hewitt, J. (2005). Toward an understanding of how threads die in asynchronous computer conference. *The Journal of Learning Science*, *14*(4), 567–589.

Hillman, D. C. A., Willis, D. J. & Gunawardena, C. N. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *American Journal of Distance Education*, *8*(2), 30-42. doi: 10.1080/08923649409526853

Hiltz, S. R. (1998). Collaborative learning in asynchronous learning networks: Building learning communities. Retrieved from the ERIC database. (ED427705)

Hmelo, C. E., & Ferrari, M. (1997, Summer). The problem-based learning tutorial: Cultivating higher order thinking skills. *Journal for the Education of the Gifted, 20*, 401–422.

Hmelo, C. E., & Lin, X. (2000). The development of self-directed learning strategies in problem-based learning. In D. Evensen, & C. E. Hmelo (Eds.), *Problem-based learning: Research perspectives on learning interactions* (pp. 227–250). Mahwah, NJ: Erlbaum Associates.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do student learn? *Educational Psychology Review*, *16*(3), 235-266.

Holfelder, W. (1998). Interactive remote recording and playback of multicast videoconference. *Computer Communications, 21*(15), 1285-1294.

Holmes, B., Tangney, B., FitzGibbon, A., Savage, T., & Mehan, S. (2001). *Communal constructivism: Students constructing learning for as well as with others.*

Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.25.98&rep=rep1&type=pdf.

Hong, K. -S., Lai, K. -W., & Holton, D. (2003). Students' satisfaction and perceived learning with a web-based course. *Educational Technology & Society, 6*(1). Retrieved from http://www.ifets.info/journals/6_1/hong.html

Hou, H. T. (2011). A case study of online Instructional collaborative discussion activities for problem-solving using situated scenarios: An examination of content and behavior cluster analysis. *Computer & Education, 56*(3), 712-719.

Hou, H. T., Chang, K. E., & Sung, Y.-T., (2008). Analysis of problem-based online asynchronous discussion pattern. *Educational Technology & Society, 11*(1), 17-28.

Hrastinski, S. (2008). The potential of synchronous communication to enhance participation in online discussions: A case study of two e-learning courses. *Information & Management, 45,* 499-506.

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. In J. M. Spector, M. D. Merrill, J. V. Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed. pp.485-506). New York, NY: Routledge Taylor & Francis Group.

Iverson, K. M. (2004). *E-learning Games: Interactive Strategies for Digital Delivery.* Upper Saddle River, NJ: Pearson Prentice Hall.

Jackson, S. (1992). Team composition in organizations. In S. Worchel, W. Wood, and J. Simpson (Eds.), *Group process and productivity* (p.1-12). London: Sage.

Jenn, K. A., Northcraft, G. B., & Neale, M. A. (1999). Why differences make a difference: A field study of diversity, conflict, and performance in workgroups. *Administrative Science Quarterly, 14*(4), 741-763 Retrieved from http://www.jstor.org/stable/2667054

Johnson, D. W., & Johnson, R. T. (1975). *Learning together and alone: Cooperation, competition, and individualization*. Englewood Cliffs, NJ: Prentice-Hall.

Johnson, D. W., Johnson, R. T., & Smith, C. A. (1991). *Cooperative learning: Increasing college faculty instructional productivity*. Washington, DC: School of Education and Human Development, the George Washington University.

Johnson, E. L., & Green, K. H. (2007). Promoting mathematical communication and community via blackboard. *Problems, Resources, and Issues in Mathematic Undergraduate Studies, 17*(4), 325-337.

Johnson, S. D., & Chung, S. P. (1999). The effect of thinking aloud pair problem solving (TAPPS) on the troubleshooting ability of aviation technician students. *Journal of Industrial Teacher Education, 37*(1), 7-25.

Jolliffe, A., Ritter, J. & Stevens, D. (2001). *The online learning handbook: Developing and using web-based learning.* London: Kogan Page.

Jonassen, D. H. (1994). Thinking Technology: Toward a constructivist design model. *Educational Technology, 34*(3), 34-37.

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology Research and Development, 45*(1), 65-95.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development*, *48*(4), 63-85.

Kamin, C., Deterding, R., Wilson, B., Armacost, M. & Breedon, T. (1999). The development of a collaborative distance learning program to facilitate pediatric problem-based learning. *Medical Education Online, 4* (2). Retrieved from http://www.med-ed-online.org/t0000008.htm#top.

Kanuka, H. (2005). An exploration into facilitating higher levels of learning in a text-based internet learning environment using diverse instructional strategies. *Journal of Computer-Mediated Communication, 10*(3). Retrieved from http://jcmc.indiana.edu/vol10/issue3/kanuka.html

Katzenbach, J. R., & Smith, D. K. (1993). *The wisdom of teams: Creating the high-performance organization.* Boston: Harvard Business School Press.

Kim, K.-J. (2009). Motivational challenges of adult learners in self-directed e-learning. *Journal of Interactive Learning Research, 20*(3), 317-335.

Klemm, W. R. (2005). Use and mis-use of technology for online, asynchronous, collaborative learning. In T. S. Roberts (Ed.), *Computer-supported collaborative learning in higher education* (pp.172-200). Heyshey, PA: Idea Group Publishing.

Knowlton, D. S. (2003). Evaluating college students' efforts in asynchronous discussion: A systematic process. *Quarterly Review of Distance Education, 4*(1), 31-41.

Koh, J. H. L., Herring, S. C., & Hew, K. F. (2010). Project-based learning and student knowledge construction during asynchronous online discussion. *Internet and Higher Education, 13*(4), 284-291. doi: 10.1016/j.iheduc.2010.09.003

Ku, H.-Y., Akarasriworn, C., Rice, L., Glassmeyer, D., & Mendoza, B. (in press). An action research on teaching and online graduate mathematics education course for in-service mathematics teachers. *The Quarterly Review of Distance Education, 12* (2).

Lahaie, U. (2007). Strategies for creating social presence online. *Nurse Educator*, *32*(3), 100-101.

Lawson, T., Comber, C., Gage, J., & Cullum-Hanshaw, A. (2010). Images of the future for education? videoconferencing: A literature review. *Technology, Pedagogy and Education*, *19*(3), 295-314. doi: 10.1080/1475939X2010.513761

Levine, J. M., & Resnick, L. B. (1993). Social foundations of cognitions. *Annual Review of Psychology*, *41*, 585-612.

Li, Q., Moorman, L., & Dyjur, P. (2010). Inquiry-based learning and e-mentoring via videoconference: A study of mathematics and science learning of Canadian rural students. *Educational Technology Research and Development*, *58*(6), 729-753. doi: 10.1007/s11423-010-9156-3

Lin, S. Y. (2004). *Synchronous text-based chat vis-à-vis asynchronous threaded discussion: An instructional strategy for providing and option in two course delivery schemes* (Doctoral dissertation). Retrieved from http://education.odu.edu/eci/idt/research/dissertations/2004-SLin.pdf

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Newbury Park, CA: Sage Publications, Inc.

Lou, Y. (2004). Understanding process and affective factors in small group versus individual learning with technology. *Journal of Computing Research*, *31*(4), 337-

369.

Luebeck, J. L., & Bice, L. R. (2005). Online discussion as a mechanism of conceptual change among mathematics and science teachers. *Journal of Distance Education, 5*(2), 21-39.

Maddux, C. D., Johnson, D. L., & Willis, J. W. (1997). *Educational computing, learning with technologies* (2nd ed.). Needham Height, MA: Allyn & Bacon.

Mattheos, N., Nattestad, A., Schittek, M., & Attstrom, R. (2001). A virtual classroom for undergraduate period ontology: A pilot study. *European Journal of Dental Education, 5*, 139–147.

McConnell, D. (2002). Action research and distributed problem-based learning in continuing professional education. *Distance Education, 23*(1), 59-83.

McGrath, J. E., & Hollingshead, A. B. (1994). *Group interacting with technology: Ideas, evidence, issues and an agenda.* London: Sage.

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of Community Psychology, 14*(1), 6-23.

Mergendoller, J. R., Bellisimo, Y., & Maxwell, N. L. (2000). Comparing problem-based learning and traditional instruction in high school economics. *Journal of Educational Research, 93*(6), 374-383.

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

Moore, M. G. (1993). Three types of interaction. In K. Harry, M. John, & D. Keegan (Eds.), *Distance education: New perspectives* (pp. 19-24). London, UK: Routledge.

Moore, M. G. (2001). Surviving as a distance teacher. *American Journal of Distance Education, 15*(2), 1-5.

Moore, M. G., & Kearsley, G. (1996). *Distance education: A systems view.* New York: Wadsworth.

Mullins-Dove, T. (2006). Streaming video and distance education. *Distance Learning, 3*(4), 63-71.

Murphy, E., & Ciszewska-Carr, J. (2007). Instructors' experiences of web based synchronous communication using two-way audio and direct messaging. *Australasian Journal of Educational Technology, 23(1),* 68-86.

Murphy, K. L., & Collins, M. P. (1997). Development of communication conventions in instructional electronic chats. *Journal of Distance Education, 12*(1/2), 177-200. Retrieved from http://disted.tamu.edu/aera97a.htm

Naidu, S., & Järvelä, S. (2006). Analyzing CMC content for what? *Computers & Education, 46*(1), 96-103. doi: 10.1016/j.compedu.2005.04.001

National Center for Accessible Media (2005). *Guidelines for developing accessible synchronous communication and collaboration tools.* Retrieved from http://www.imsglobal.org/accessibility/accessiblevers/sec7.html

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

Nelson, L. M. (1999). Collaborative problem solving. In C. M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (Vol. 2, pp. 241- 267). Mahwah, NJ: Lawrence Earlbaum Associates.

Newman, S. (2008). Videoconferencing and the K12 classroom: What is it? And why do it? In D. Newman, J. Falco, S. Silverman, & P. Barbanell (Eds.), *Videoconferencing technology in K-12 instruction, best practices and trends.* Hersley, NY: Information Science Reference.

O'Conaill, B., Whittaker, S., & Wilbur, S. (1993). Conversations over video conferences: An evaluation of the spoken aspects of video-mediated communication. *Human Computer Interaction, 8,* 389-428.

O'Donnell, A. M. (1999). Structuring dyadic interaction through scripted cooperation. In A. M. O'Donnell, & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 179–196). Mahwah, NJ: Erlbaum Associates.

Olivares, O. J. (2007). Collaborative vs. cooperative learning: The instructor's role in computer supported collaborative learning. In K. L. Orvis & A. L. R. Lassiter (Eds.), *Computer-supported collaborative learning: Best practices and principles for instructors* (pp. 20-39). Hershey, NY: Information Science Publishing.

O'Malley, C., Langton, S., Anderson, A., Doherty-Sneddon, G., & Bruce, V. (1996). Comparison of face-to-face and video-mediated interaction. *Interacting with Computers, 8*(2), 177-192.

Orrill, C. H. (2002). Supporting online PBL: Design considerations for supporting distributed problem solving. *Distance Education, 23*(1), 41-57. doi: 10.1080/01587910220123973

Osman, G., & Herring, S. C. (2007). Interaction, facilitation, and deep learning in cross-cultural chat: A case study. *The Internet and Higher Education, 10*(2), 125-141.

Ozdemir, S. (2005). *The effects of individual and collaborative problem-based learning using an online asynchronized learning tool on critical thinking abilities, academic achievements, and attitudes toward internet use* (Doctoral dissertation). Gazi University Graduate School of Educational Sciences: Ankara.

Palincsar, A. S., & Herrenkohl, L. R. (1999). Designing collaborative contexts: Lessons from three research programs. In A. M. O'Donnell, & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 151–178). Mahwah, NJ: Erlbaum Associates.

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

Palloff, R. M., & Pratt, K. (2005). *Collaborating online: Learning together in community*. San Francisco, CA: Jossey-Bass.

Pattillo, R. E. (2007). Decreasing transactional distance in a Web-based course. *Nursing Educator, 32*(3), 109-112.

Plonczak, I. (2010). Videoconferencing in math and science preservice elementary teachers Field placements. *Journal of Science Teacher Education, 21*(2), 241-254. doi: 10.1007/s10972-009-9166-3

Poole, D. M. (2000). Student participation in a discussion-oriented online course: A case study. *Journal of Research on Computing in Education, 33*(2), 162-179.

Ram, P., Ram, A., & Sprague, C. (2004). A web-based system to bring PBL into your classroom. *Proceedings of Society for Information Technology and Teacher Education international conference, USA.*

Relan, A., & Gillani, B. B. (1997). Web-based instruction and the traditional classroom:

Similarities and differences. In B. H. Khan (Ed.), *Web-based instruction* (pp. 41-46). Englewood Cliffs, NJ: Educational Technology Publications.

Reznich, C., & Werner, E. (2001, April). *Integrating technology into PBL small groups in a medical setting.* Michigan State University. Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA. Retrieved from the ERIC database. (ED452786)

Riley, P. E. (2009). Video-conferenced music teaching challenges and progress. *Music Education Research, 11*(3), 365-375.

Roblyer, M. D., & Ekhaml, L. (2000). How interactive are your distance courses? A rubric for assessing interaction in distance learning. *Online Journal of Distance Learning Administration, 3*(3). Retrieved from http://www.westga.edu/~distance/ojdla/summer32/roblyer32.html

Romiszowski, A., & Mason, R. (2004). Computer-mediated communication. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 397-431). New Jersey: Lawrence Erlbaum.

Rovai, A. P. (2002). Building sense of community at a distance. *International Review of Research in Open and Distance Learning, 3*(1), 1-16. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/79/152

Rovai, A.P., & Grooms, L.D. (2004). The relationship of personality-based learning style preferences and learning among online graduate students. *Journal of Computing in Higher Education, 16*(1), 30-47.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *The Interdisciplinary Journal of Problem-based Learning, 1*(1), 9-20. Retrieved from http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1002&context=ijpbl&sei-redir=1#search="Savery,+2006"

Savery, J. R. & Duffy, T. M. (1995). Problem-based learning: an instructional model and its constructivist framework. *Educational Technology, 35*(5), 31-38.

Saw, K. G., Majid, O., Abdul Ghani, N., Atan, H., Idrus, R. M., Rahman, Z. A., et al. (2008). The videoconferencing learning environment: Technology, interaction and learning intersect. *British Journal of Educational Technology, 39*(3), 475-485.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97-118). New York: Cambridge University Press. Retrieved from http://ikit.org/fulltext/2006_KBTheory.pdf

Schmidt, H. G., DeVolder, M. L., De Grave, W. S., Moust, J. H. C., & Patel, V. L. (1989). Explanatory models in the processing of science text: The role of prior knowledge activation through small-group discussion. *Journal of Educational Psychologist, 81*, 610–619.

Schoenfeld, A. H. (1985). *Mathematical Problem Solving*. Orlando, FL: Academic Press.

Schrage, T. M. (1990). *Shared minds: The new technologies of collaboration*. New York, NY: Random House.

Schwandt, T. A. (2007). *The sage dictionary of qualitative inquiry* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Şendağ, S., & Odabaşi, H. F. (2009). Effects of an online problem based learning course on content knowledge acquisition and critical thinking skills. *Computers & Education, 53*(1), 132-141.

Sieber, S. D. (1973). The integration of field work and survey methods. *American Journal of Sociology, 78*, 1335-1359.

Simonson, M., Smaldino, S., Albright, M., & Zvacek, S. (2009). *Teaching and learning at a distance: Foundations of distance education* (4th ed.). Boston, MA: Allyn & Bacon.

Sims, R. (1999). Interactivity on stage: Strategies for learner-designer communication. *Australian Journal of Educational Technology, 15*(3), 257-272.

Sing, C. C., & Khine, M. S. (2006). An analysis of interaction and participation patterns in online community. *Educational Technology & Society, 9*(1), 250-261.

Slavin, R. E. (1987). *Cooperative Learning: Student Teams* (2nd ed.).Washington, DC: National Educational Association.

Snyder, M. M. (2009). Instructional-design theory to guide the creation of online learning communities for adults. *TechTrends, 53*(1), 48-56.

Spector, M. J., Merril, D. M., Merriënboer, V. J., & Driscoll, M. P. (2008). *Handbook of research on educational communications and technology* (3rded.). New York, NY: Routledge Taylor & Francis Group.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic in organizational communication. *Management Science, 32*(11), 1492-1512.

Squire, K., & Johnson, C. (2000). Supporting distributed communities of practice with interactive television. *Educational Technology Research and Development*, *48(*1), 23–43.

Stacey, E. (1999). Collaborative learning in an online environment. *Journal of Distance Education, 14*(2), 14-33.

Sweller, J., VanMemenboer, J. J. G., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251-296.

Tallent-Runnels, M. K., Thomas, J. A., Lan, W.Y., Cooper, S., Ahern, T.C., Shaw, S. M., & Liu, X. (2006). Teaching courses online: A review of the research. *Review of Educational Research, 76*(1), 93-135.

Taylor, V. (2005). Online group projects: Preparing the instructors to prepare the students. In T. S. Roberts (Ed.), *Computer-supported collaborative learning in higher education* (pp.19-50). Hershey, PA: Idea Group Inc.

Thurston, A. (2005). Building online learning communities. *Technology, Pedagogy and Education*, *14*(3), 353-369.

Torp, L., & Sage, S. (2002). *Problems as possibilities: Problem-based learning for K–12 education* (2nd ed.). Alexandria, VA: ASCD.

Tseng, H. (2008). *The relationships between trust and satisfaction and performance among the virtual teams with different developmental processes* (Doctoral dissertation). Retrieved from http://0-proquest.umi.com.source.unco.edu/pqdweb?index=0&did=1691052951&SrchMode=2&sid=2&Fmt=6&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1307856550&clientId=9577

Tseng, H. W., Wang, C. H., & Ku, H.-Y. (2006, October). *The relationship between teamwork outcomes, teamwork satisfactions, and collaboration factors in an online environment.* Paper presented at the annual meeting of the Association for the Advancement of Computer in Education (AACE), Honolulu, HA.

Uribe, D. Klein, J. D., & Sullivan, H. (2003). The effect of computer-mediated collaborative learning on solving ill-defined problems. *Educational Technology Research and Development, 51*(1), 5-19.

Valaitis, R. K., Sword, W. A., Jones, B., & Hodges, A. (2005). Problem-based learning online: Perceptions of health science students. *Advances in Health Sciences Education, 10* (3), 231–252.

Veerman, A., & Veldhuis-Diermanse, E. (2006). Collaborative learning through electronic knowledge construction in academic education. In A. M. O'Donnell, C. E. Hmelo-Silver, & G. Erkens (Eds.), *Collaborative learning, reasoning, and technology* (pp. 323-354). Mahwah, NJ: Lawrence Erlbaum Associates.

Vonderwell, S. (2003). An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. *Internet and Higher Educations, 6*, 77-90.

Von Glaserfield, E. (1989) Constructivism in Education. In T. Husen, & Postlewaite (Eds.), *International encyclopedia of education* (pp. 162-163). Oxford, England: Pergamon Press.

Vrasidas, C., & McIsaac, M. S. (1999). Factors influencing interaction in an online course. *American Journal of Distance Education, 13*(3), 22-36.

Vrasidas, C., & McIsaac, M. S. (2000). Principles of pedagogy and evaluation of web-based learning. *Educational Media International, 37*(2), 105–111.

Vye, N. J., Goldman, S. R., Voss, J. F., Hmelo, C., & Williams, S. (1997). Complex math problem-solving by individuals and dyads: When and why are two heads better than one? *Cognition & Instruction, 15*(4), 435–484.

Vygotsky, L.S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer supported collaborative learning. *Instructional Science*, *33*(1), 1-30.

Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, *46*(1), 71-95.

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

Wooley, D. R. (1998). *The future of web conferencing.* Retrieved from http://thinkofit.com/webconf/wcfuture.htm

Wu, D., & Hiltz, S. R. (2004). Predicting learning from asynchronous online discussions. *Journal of Asynchronous Learning Networks, 8*(2), 139-152.

Yamada, M. (2009). The role of social presence in learner-centered communicative language learning using synchronous computer-mediated communication: Experimental study. *Computers & Education, 52*(4), 820-833. doi: 10.1016/j.compedu.2008.12.007

Yeh, H.-H., & She, H.-C. (2010). Online synchronous scientific argumentation learning: Nurturing students’ argumentation ability and conceptual change in science context. *Computers & Education, 55*(2), 586-602. doi: 10.1016/j.compedu.2010.02.020

Younie, S., & Leask, M. (2001). Communal constructivist theory: Information and communications technology pedagogy and internationalization of the curriculum. *Journal of Information Technology for Teacher Education, 10*(1&2), p. 117-134.

APPENDIX A

INFORMED CONSENT FORM

UNIVERSITY of NORTHERN COLORADO

Informed Consent for Participation in Research
University of Northern Colorado

Project Title: Students' Knowledge Construction and Attitudes toward Synchronous Videoconferencing in an Online Collaborative Problem-Based Learning Environment

Researcher: Chatchada Akarasriworn
Doctoral Student, Department of Educational Technology
832-643-9780

akar8225@bears.unco.edu

Project Advisor: Heng-Yu Ku, Ph.D.
Department of Educational Technology
970-351-2935
heng-yu.ku@unco.edu

You are being invited to participate in a research study that will help me to better understand the importance of an online problem-based learning (PBL) approach influencing graduate students' knowledge construction as well as assists how to improve the quality of online synchronous collaborative learning environment. I will take every precaution in order to protect your anonymity. The pseudonym will be assigned to you. Your real name will not be used in any report. All data collected and analyzed for this study will be kept in my personal files and a locked cabinet in my place, which is only accessible by me.

In this study, I will audio-record your discussion while you are working as a group during the synchronous small group session. At the end of week eight, ten, and twelve, you will be asked to fill out the Teamwork Satisfaction Survey and three open-ended questions. The 10-item Teamwork Satisfaction Survey is to measure your working experiences with your group members during synchronous small group activities via Elluminate. It should only take 5-10 minute to complete. All items are measured on a 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In addition, the 21- item Learning Environment Satisfaction Survey is to measure your satisfaction with the technology supported synchronous collaborative small group environment as well as social community via Elluminate. This survey also includes four demographic questions. At the end of week fifteen, you will be given the Learning Environment Satisfaction Survey and seven open-ended questions. It should take you approximately 10-15 minutes to complete.

During the final week, I will conduct individual face-to-face interview with you. The interview consists of ten questions. Each individual interview will last approximately 30-45 minutes and will be audio-recorded. Moreover, a $10 Starbucks gift card will be provided to all participants who complete an interview.

Please remember that your participation with this study is completely voluntary and you may refuse to participate without any consequence. Please be assured that your thoughtful responses or nonparticipation or withdrawal from the study will in no way influence your grade in the course. Please do not hesitate to contact me if you have any questions or concerns about this research via e-mail at akar8225@bears.unco.edu or phone at 832-643-9780 and please retain one copy of this letter for your records.

I foresee no risks to participants beyond those that are normally encountered collaborative learning experience and teamwork development process in the online learning environment.

Participation is voluntary. Although, you have begun the participation this study, you may still decide to stop and withdraw at anytime. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-2161.

____________________________ ________________________

Participant's Signature Date

____________________________ ________________________

Researcher's Signature Date

APPENDIX B

COURSE SYLLABUS

SYLLABUS

MATH 537
MATHEMATICAL MODELING

INFO

Nathaniel Miller, Ph.D.

Ross Hall, Room 2210D
University of Northern Colorado, Greeley, CO 80639
Voice: 970 351-2297
E-mail: nathaniel.miller@unco.edu

OFFICE HOURS: On Ellumniate, Wednesdays, 3:30–5:00 pm, Thursdays 4:30–6:00 pm, and Sundays 9:00–10:00 am; and by appointment.

See the course Blackboard site for a link to the Elluminate sessions.
ELLUMINATE MEETING TIMES: M (section 970)/ T (section 971) 7:00–8:30 pm
OTHER AVAILABLE ELLUMINATE TIMES: Sessions will be available on Elluminate for groups to work together from 3 pm until 11:45 pm Wednesday to Friday, and 8 am until 11:45 pm on Saturdays and Sundays.

REQUIRED TEXT

- None

COURSE DESCRIPTION

CATALOG COURSE DESCRIPTION: Graduates only. Introduction to the process of mathematical modeling and its use in teaching secondary school mathematics. Emphasizes development and communication of models.

This is a class about mathematical modeling. It will be about using mathematics to model situations in the real world in order to understand it and to make recommendations and predictions. It will also be about clearly communicating your findings to others. We will try to understand situations from many different mathematical perspectives, including numerically, graphically, algebraically, and verbally (the “rule of four”).

Outline of Course Content:

a. Introduction to the modeling process
b. Financial models

c. Population growth models
d. Continuous models
e. Discrete Dynamical Systems

OBJECTIVES

COURSE OBJECTIVES:

f. Gain experience with modeling as an open-ended process including investigation, analysis, and communication
g. Explore connections to K-12 curriculum, especially algebra and data analysis
h. Explore modeling related to current events and quantitative literacy
i. Gain experience with the Rule of Four, connecting graphical, algebraic, numerical, and verbal descriptions of problems

CLASS ACTIVITIES

TECHNOLOGY: This will be a technology intensive course. In addition to using Elluminate to discuss problems, we will be using a variety of spreadsheet programs to model them, and word processing programs to write them up. We will be using Geogebra, Excel, and the Google Docs spreadsheet as spreadsheet programs. GeoGebra is a free program and can be downloaded from the link on the course webpage.

GROUP WORK: We will often work in groups in this course. Whenever a group hands in a written assignment, they are required to put on the paper the names of those who participated fully, and only those names. Your name on the assignment certifies that you participated equally in the project. It is dishonest to turn in work that is not solely and equitably the creation of the team members. You are not required to include on the report the name of someone who started but did not finish, or who did not contribute their share. Groups will be expected to find time to work together on the group problems outside of our class meeting time. This is a three credit course, so you should expect to be spending several hours a week working on this class outside of our official meeting time.

ELECTRONIC DISCUSSION BOARD: An electronic discussion board for this class has been set up on Blackboard. This is a great forum for continuing class discussions outside of our synchronous meeting time. Participation on this discussion board will count as part of your class participation grade. You should try to have on average at least one substantive post on the discussion board per week. If you'd like to, you can subscribe to the discussion board forum on Blackboard so that you get emailed whenever someone posts something.

HOMEWORK: Most homework for this class will be written reports. In writing them, you should imagine that you are writing a report as a consultant for a peer: someone who has roughly the same mathematical background that you do (such as another teacher at your school), but who has not yet thought carefully about the problem you are working on. Most reports will be submitted twice: once as a rough draft that I will make comments on, and once as a final report that will receive a grade.

Homework submission for this class will be online, through the course Blackboard site due on Sunday nights at midnight. Homework should be submitted as a .doc (the old Microsoft word format), .rtf, or .pdf file. Files in other formats will not be accepted. My preference is to receive files in the .doc format. If you are using the latest version of Microsoft word, the default format for files is.docx, but this format includes mathematical formulas that are not compatible between PCs and Macs, so you will need to save your files in the older format.

MODELING CONTEST AND EXAM: Towards the end of the class we will have a modeling contest, similar to the High School Contest in Modeling which is held every year. In this contest, groups will have a week to prepare a report on a new modeling problem without any outside help. There will also be a take-home final exam.

OUTSIDE SOURCES: The central aim of this course is to give you experience developing your own mathematical models. You therefore should not consult outside sources for information about ways that other people have constructed models for the same situations. However, you may wish to look for external data to compare your models to; this is acceptable and is encouraged. So, it is okay to look at external sources for data about situations you are modeling, but not okay to look for solutions to the problems we are working on.

GRADING SCALE

Grades: 80% of the grade will be determined by written individual and group assignments; 20% will be determined by the take-home final exam.

Method of Evaluation: letter graded, with a traditional grade breakdown (A = 93.33–100, A-= 90–93.32, B+ = 86.66-89.99, B = 83.33–86.65, B-= 80–83.32, C+ = 76.66-79.99, C = 73.33–76.65, C-= 70–73.33, D = 60-69.99, F = less than 60)

CALENDAR

(Very) Tentative Class Schedule

Week	Date	Problem
1	1/10	Rabbit Populations
2	1/17	Financial Models pt 1
3	1/24	Financial Models pt 2 / Ft. Collins Temp.
4	1/31	More Population growth Part 1
5	2/7	More Population growth Part 2
6	2/14	More Population growth 4 Part 2
7	2/21	Continuous Models Part 1
8	2/28	Continuous Models Part 2
9	3/7	Iteration
-	3/14	Spring Break—no class.
10	3/21	Iteration
11	3/28	Iteration
12	4/4	Controlling Animal Populations
13	4/11	Modeling contest
14	4/18	Housing Prices
15	4/25	Final Exam given out
16	5/2	Final Exam due

STUDENTS WITH DISABILITIES: Any student requesting disability accommodation for this class must inform the instructor giving appropriate notice. Students are encouraged to contact Disability Support Services at (970) 351-2289 to certify documentation of disability and to ensure appropriate accommodations are implemented in a timely manner.

ACADEMIC INTEGRITY: Students are expected to conduct themselves in accordance with the highest standards of scholarship and professional behavior and with UNC’s Honor Code. Cheating and plagiarism create an environment that makes it difficult for real learning to occur, and they are absolutely unacceptable. Evidence of cheating or plagiarism will be treated very seriously, and will result in a failing grade on the assignment or in the course, in addition to any University disciplinary action.

APPENDIX C

ASSIGNMENT DISCUSSION

Assignment Discussion

Assignment 5 (Week 8): Continuous population growth models part 2

Most of the situations we have modeled so far have divided time up into discrete time periods. This makes sense for many real-world situations, such as in animal populations that have one mating season per year. However, in many other real world situations, some kind of change is happening continuously. For example, human populations are always growing. We can often model situations where change is happening continuously by using differential equations. For example, rather than assuming that new births in a population are a fixed percentage of the population from one generation to the next, we can assume that the rate at which the population continuously increases is directly proportional to the current population. In the language of differential equations, we can express this by writing

$$\frac{dP}{dt} = kP.$$

In order to build a model of this situation, we can start with a given population at time t = 0 years and then estimate the population at some time in the future using the known slopes of the curve.

Assignment 6 (Week 10): Iteration

We have seen that in many modeling situations, it is helpful to iterate a function. In order to get a better understanding of iteration in general, we are going to spend some time exploring what happens when we iterate the function $f(x) = 2x(1-x)$ for different starting values in the interval [0; 1]. More generally, we can examine what happens when we iterate the function $fk(x) = kx(1-x)$ for different values of k. This equation is called the logistic equation because it represents the change in a population under logistic growth with carrying capacity 1. If x is the saturation of some population, then this equation says that the survival rate between generations is directly proportional to one minus the saturation. This differs from the logistic growth we have previously studied, in which the logistic equation gave the change in the population, rather than the new population. Explore what happens when we iterate the logistic equation. You should develop and explore whatever questions seem interesting to you. Write a report describing your findings.

Assignment 7 (Week 12): Controlling animal populations

A recent article in the New York Times discusses plans to reduce the number of resident Canada geese in New York State. The US Fish and Wildlife service is tasked with measuring and regulating the US populations of fish and wildlife. They have asked you as a consultant to write a report examining the result of several possible policies with respect to hunting and fishing. For different animals and fish, they have the option of allowing a fixed number of animals or a certain percentage of the current population to be killed by hunters each year. We can also model the growth of the population using either an exponential model, or else by using a logistic model. This gives rise to four possible scenarios: exponential growth with constant harvesting, exponential growth with proportional harvesting, logistic growth with constant harvesting, and logistic growth with proportional harvesting. Compare these four scenarios. In particular, can you describe the possible long term behaviors of each?

APPENDIX D

TEAMWORK ATTITUDE SURVEY

Teamwork Attitude Survey

Instruction: Please answer each of the following questions by placing an **(X)** into the row/column intersection of the option that best represents how you feel.

Note: The Teamwork Attitude Survey is adapted from Tseng, Wang, and Ku (2006) and Palloff and Pratt's (2005) studies.

Survey Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I like working in a collaborative group with my teammates.					
2. I like solving problems with my teammates in group projects.					
3. Interacting with the other members can increase my motivation to learn.					
4. I have benefited from interacting with my teammates.					
5. I have benefited from my teammates' feedback.					
6. I enjoy the experience of collaborative learning with my teammates.					
7. Online teamwork promotes creativity.					
8. Working with my team has produced better project quality than working alone.					
9. My team members are sharing knowledge during the teamwork processes.					
10. I gain online collaboration skills from the teamwork processes.					

Open-Ended Questions

1. Did you like or dislike learning in an online collaborative synchronous small group setting which occurred tonight? Please explain why or why not.
2. How well did you work together as a group? Was it successful tonight, in your opinion?
3. Did this synchronous small-group discussion that occurred tonight help you to understand the content of this course better? Please explain why or why not.

APPENDIX E

LEARNING ENVIRONMENT ATTITUDE SURVEY

Learning Environment Attitude Survey

Demographic Information

Please choose the appropriate response and, where necessary, fill in the blank.

1. Name: ______________________________
2. Age of years (choose one):
    a. 25 or under
    b. 26 to 35
    c. 36 to 45
    d. 46 to 55
    e. 56 to 65
    f. 66 or over
3. Gender (choose one):
    a. Female
    b. Male
4. How many years have you been teaching?
    a. Less than 5 years
    b. 6-10 years
    c. 11-15 years
    d. More than 16 years

Instruction: Please answer each of the following questions by placing an **(X)** into the row/column intersection of the option that best represents how you feel.
NOTE: “synchronous” refers to simultaneous, real-time interaction (e.g., a live Elluminate *Live!*® session).
Note: The Learning Environment Attitude Survey is adapted from Lin (2004) and Wu and Hiltz’s study (2004).

Survey Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Synchronous small-group discussions in this class were effective for my learning.					
2. Synchronous small-group discussions in this class involved careful thought on my part in order to contribute.					

3. Synchronous small-group discussions in this class were beneficial for understanding the material.					
4. Synchronous small-group discussions in this class were an inefficient use of class time.					
5. Synchronous small-group discussions in this class did not relate directly to my course work.					
6. Synchronous small-group discussions in this class facilitated my learning in this class.					
7. Synchronous small-group discussions in this class enabled me to share my knowledge with peers.					
8. Synchronous small-group discussions in this class were enjoyable for me.					
9. Synchronous small-group discussions in this class motivated me to learn more.					
10. Synchronous small-group discussions in this class increased my interest in the subject.					
11. Synchronous technology in this class made me feel like I was part of a group.					
12. Synchronous technology in this class enabled me to ask the instructor questions comfortably.					

13. Synchronous technology in this class supported my developing a productive relationship with the course instructor.					
14. I would have understood the content better if I did not have to collaborate with peers for discussions.					
15. I have felt that I can rely on others in this course.					
16. I have felt the small groups were rotated enough so I could work with different individuals.					
17. I have not had a sense of belonging to a community with my peers in this course.					
18. I have felt comfortable discussing concepts in this course with other students.					
19. My overall learning experiences to date with this course have been successful.					
20. The use of the Elluminate *Live!*® Whiteboard to communicate in this class has been working well.					
21. I have been satisfied with the quality of the online conferencing tool (Elluminate *Live!*®).					

Open-Ended Questions

Q1. Please describe your overall learning experiences with synchronous small-group discussions in this mathematics modeling course.

Q2. Please provide examples from the course that illustrate what you liked BEST about the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) in this mathematics modeling course.

Q3. Please provide examples from the course that illustrate what you liked LEAST about the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) in this mathematics modeling course.

Q4. How have synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) played a part in developing a sense of community?

Q5. Please explain how the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) facilitated or hindered your learning in this mathematics modeling course.

Q6. Should the synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) be incorporated into the mathematics modeling course? Please explain why or why not.

Q7. How might synchronous small-group discussions through videoconferencing tool (Elluminate *Live!*®) be better used to improve your learning experiences?

APPENDIX F

INTERVIEW PROTOCOL

Interview Protocol

Q1. Please share with us your overall learning experience in the synchronous small-group discussions in this course.

Q2. What did you like BEST about the synchronous small-group discussions in this course?

Q3. What did you like LEAST about the synchronous small-group discussions in this course?

Q4. Do you think the synchronous small-group discussions influence you to have a sense of belonging to the community with your classmates in this course? Please explain why or why not.

Q5. Please explain how the videoconferencing tool in synchronous small-group discussions facilitated or hindered your learning in the course.

Q6. Do you think that synchronous small-group discussions integrated with videoconferencing should be incorporated into the course? Please explain why or why not.

Q7. What challenges did you face when participating in the synchronous small-group discussion sessions in this course?

Q8. What types of support do you need to overcome these challenges?

Q9. Do you think group members in the synchronous small-group discussions should be rotated every week? Please explain why or why not.

Q10. Are there any recommendations you would make to improve the synchronous small-group discussion environment?