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A Comparison of Online and Face-To-Face Discussions in an Elementary Mathematics Methods Course

Julie Stephens James

A COMPARISON OF ONLINE AND FACE-TO-FACE DISCUSSIONS IN AN ELEMENTARY MATHEMATICS METHODS COURSE

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JULIE STEPHENS JAMES

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ABSTRACT

The purpose of this qualitative study was to determine if there is a difference between online and face-to-face discussions in terms of quality of responses. The researcher analyzed discussions among teacher candidates enrolled in a web-enhanced undergraduate elementary mathematics methods course. Data was collected through surveys, audio-recordings of face-to-face discussions and asynchronous discussion board transcripts. Transcripts from online and face-to-face discussions were analyzed for evidence of critical thinking using the practical inquiry model (Garrison, Anderson & Archer, 2001). The researcher found that discussions that utilized the asynchronous discussion board elicited more critical thinking from participants than face-to-face discussions. Also, the data revealed that the discussion prompts used to initiate discussion impacted levels of critical thinking. There was also evidence of fewer off-topic discussions during online interactions. The researcher concluded that additional research is needed to determine the impact of minimum participation expectations on teacher candidates' interactions during discussions. In addition, more research should be conducted to determine the optimal group size to foster critical thinking in both face-to-face and online discussions.

DEDICATION

This work is dedicated to my loving husband, Bill, our wonderful children Charlie, David, Jamie, Rena and Will, and my supportive family. I would not have been able to complete this journey without them.

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CHAPTER I: INTRODUCTION

Background

In recent years, there has been a rapid increase in the number of online courses offered by universities. Many institutions offer entire degree programs through online formats. In fact, surveys conducted annually have shown that enrollment in online courses more than doubled from 2002 to 2007 (Allen & Seaman, 2008). Lin (2008) predicted that the majority of courses offered at higher education institutions would include some type of online component by 2010. As a result, researchers have attempted to determine the quality of learning taking place in these courses as compared to traditional face-to-face courses. These studies have shown encouraging results and have illuminated some challenges (Cox & Cox, 2008; Hazari, 2004; Krentler & Willis-Flurry, 2005; Meyer, 2003; Vaughan, 2007; Wilson-Jones & Caston, 2006).

According to Vygotsky (1978), learning is a social process and requires discussion and collaboration. The use of online tools, such as asynchronous discussion boards (ADB), provides opportunities for this interaction among students (Cox & Cox, 2008). Asynchronous discussion boards are an online platform through which participants can post statements and comments for others to read and reply to. The ADB keeps a record of who posted each statement and uses levels of indentation to identify the statements that are original and those that are replies to other posts. The asynchronous nature of this medium allows participants to post their comments at any time and from any location. Participants can read and respond to each other's posts at times that are convenient for them. Researchers have shown that participation in ADBs can improve

students' performances on assigned coursework (Krentler & Willis-Flurry, 2005). Additionally, research has shown that students who participate in ADB in addition to face-to-face classroom interactions "were capable of more meaningful discussion of course material" (Vaughan, 2007, p. 4), since they had the opportunity to reflect on the material before responding. This opportunity to reflect results in learning that is not limited to the time constraints of classroom meetings. Courses that utilize this technology can extend face-to-face classroom discussions outside of class (Roth-McDuffie & Slavit, 2003; Shibley, 2009).

The interplay between face-to-face and online instruction allows students to assume a vital role in their own learning. Weaver (2005) described students becoming "leaders of the learning process" (p. 5) by sharing their experiences and taking the lead role in online discussions. This requires instructors to step back and assume the role of a facilitator of student learning (Hazari, 2004). The use of ADB can aide in facilitating this transition from teacher-centered instruction to student-centered instruction (Krentler & Willis-Flurry, 2005).

As students take a more active role in their learning by sharing their thoughts with others, evidence of higher-order thinking is needed to show that learning has occurred. Some efforts have been made to develop tools for assessing the level of thinking that is exhibited in online discussions (Garrison, Anderson, & Archer, 2001; Newman, Webb, & Cochrane, 1995). With the use of these tools, researchers have identified evidence of critical thinking in discussion board posts (Arnold & Ducate, 2006; Bai, 2009; Fahy, 2005; Guiller, Durndell, & Ross, 2008; Hazari, 2004; Lin, 2008; Meyer, 2003; Vaughan, 2007). Others have identified students who engage in questioning and challenging ideas as being engaged in higher order thinking (Cox & Cox, 2008; Hazari, 2004; Roth-McDuffie & Slavit, 2003)

Statement of the Problem

University faculty members are allotted a limited amount of time for classroom instruction. This limited amount of time precludes instructors from teaching all of the important material in such a way as to promote conceptual understanding. As previously stated, the use of ADB can extend instructional time and facilitate students' higher levels of thinking. Instructors must be selective, however, in the topics and activities that make up online interactions (Meyer, 2003).

In schools of education, instructors are faced with students who come to them with preconceived notions about what teaching should entail and look like (Hughes, 1994; Philipp et al., 2007). Instructors are therefore faced with the difficult task of facilitating a shift in those beliefs. This is especially true in the field of mathematics education. Many researchers have attempted to find effective strategies for impacting these long-held beliefs about teaching mathematics (Dunn, 2004; Groth & Bergner, 2007; Groth & Burgess, 2009; Roth-McDuffie & Slavit, 2003). These researchers have found that in order for teacher candidates and in-service teachers to begin to shift their beliefs, they need time to reflect on course readings (Dunn, 2004; Groth & Bergner, 2007; Groth & Burgess, 2009; Roth-McDuffie & Slavit, 2003) and other artifacts as well as the opportunity to engage in discourse with peers concerning issues related to mathematics teaching and learning (Dunn, 2004; Groth & Bergner, 2007; Groth & Burgess, 2009). These studies have also shown that the use of ADB can provide opportunities for teachers to reflect and engage in discourse.

Although much research has been conducted to analyze the effectiveness of using ADB as a learning tool, the vast majority of this research focuses only on the online interactions of students. Few studies have compared these interactions to similar face-to-face discussions,

particularly in the area of mathematics education. The current study addresses the gap in the current research by analyzing both online and face-to-face discussions around the teaching and learning of mathematics.

Purpose of the Study

The purpose of this qualitative study was to determine if there is a difference between online and face-to-face discussions in terms of quality of responses. The researcher analyzed discussions among teacher candidates enrolled in a web-enhanced undergraduate elementary mathematics methods course.

Research Questions

This study was designed to address the following questions:

1. How does the level of critical thinking evident in teacher candidates' responses during online discussions compare to those in face-to-face discussions?
2. How does prior experience with using communication technologies impact online class discussions?
3. How does existing interest in discussion topics impact online class discussions?

Importance of the Study

University faculty must make the most efficient use of the time and resources available to convey important material to students. Also, mathematics educators must find effective means to enable teacher candidates to think critically about mathematics teaching and learning. Previous research has shown that the use of ADB can address both of these issues (Dunn, 2004; Groth & Bergner, 2007; Groth & Burgess, 2009; Roth-McDuffie & Slavit, 2003; Shibley, 2009). This study was designed to build on these findings by comparing online and face-to-face discussions to determine if these are equivalently efficient and effective forms of student discourse. This

would provide university faculty justification for the use of ADB in their courses and evidence that such use would not hinder student learning.

Definition of Terms

In an effort to maintain consistency in terminology within this study and previous studies, important terminology will be used as described below.

1. *Online courses* refer to courses in which 80% or more of the course content is accessed online (Allen & Seaman, 2008).
2. *Blended courses* refer to courses in which some face-to-face class time is eliminated in order to accommodate an online component (Dzuiban, Hartman, & Moskal, 2004; Lin, 2008; Shibley, 2009; Vaughan, 2007) with 30 – 80% of course content being accessed online (Allen & Seaman, 2008).
3. *Web–enhanced courses* refer to courses that integrate both face-to-face class time and online components, but without eliminating any classroom instructional time (Dzuiban et al., 2004). Less than 30% of course content is accessed online (Allen & Seaman, 2008).
4. *Synchronous discussion* refers to online communication that occurs in "real-time." Participants can be in different locations, but must be available at the same time to communicate (Ashley, 2003).
5. *Asynchronous discussion* refers to online communication that occurs over longer periods of time. Participants can be in different locations and submit their responses at different times (Ashley, 2003).
6. *Teacher candidates* refer to undergraduate students enrolled in a teacher education program (National Council for Accreditation of Teacher Education, 2009).

Summary

As the use of technology becomes more prevalent in higher education, instructors should be informed as to the most effective and efficient uses of this technology. One technological tool that can be used to enhance the experiences of undergraduate students is asynchronous discussion boards. Chapter II will present the current research and how it lays a foundation for this study.

CHAPTER II: LITERATURE REVIEW

Introduction

Online interactions between students have been shown to provide platforms for students to think critically about course material and share their ideas. Through online discussions, all students enrolled in a course have the opportunity to share their thoughts and ideas about the material, whereas during face-to-face discussions, interactions among students can be limited due to time constraints and student personalities. As online learning becomes more and more prevalent in universities, it is important to determine the impact these courses are having on the students meant to benefit from them.

This chapter will outline the existing research related to the use of asynchronous discussion boards (ADB) in post-secondary education. Studies have examined various aspects of implementing online components into instruction. Specifically, several studies have addressed the ways instructors utilized ADB, while others have studied student beliefs about the impact of online discussion on their overall course experience. More recently, the literature has shifted toward analyzing evidence of critical thinking in ADB postings. This literature review will be organized around these three themes.

Uses of Online Discussion

Often when new technologies become available, educators seek to find ways that these technologies can benefit their students. Online communication tools have become one of many new technologies in which educators worldwide have become interested. Some researchers have

focused their research efforts on identifying ways in which instructors in post-secondary education are using these tools in their classrooms. Results of these studies have shown instructors using ADB as a means for facilitating group work (Watson, 2004), discussing course readings (Kumar, 2008a, 2008b), and engaging in and reflecting on course material outside of class (Kumar, 2008b; Roth-McDuffie & Slavit, 2003). Each of these will be discussed in the paragraphs that follow.

Some instructors have chosen to use online tools to facilitate group work. Watson (2004) used a case-study approach to compare group processes between face-to-face interactions and online interactions. Students enrolled in an online computer science course for undergraduates completed a task as a group. Since the course was housed at a residential university, the instructor gave each student group the option of completing the task by working together face-to-face or online through ADB. Two groups chose to complete the task face-to-face while four groups chose to complete the task through ADB.

Watson (2004) videotaped three face-to-face meetings and acquired transcripts of three online discussions for each group. The researcher analyzed participation in each format by counting each statement made face-to-face and each post submitted online. She found that online discussions lasted longer than face-to-face discussions. The number of posts for each online discussion was approximately double the number of statements made during each face-to-face discussion. While this seems remarkable at face value, it should be noted that online posts that consisted simply of "?" and ":)" were counted as one post each. This counting scheme contributed to a difference in the average length of statements made in each format. In online discussions, the average length of each statement was 12 words, whereas face-to-face statements contained an average of 40 words.

Watson (2004) reported that the interactions in both formats never moved beyond simple information sharing. Thus, no new knowledge construction was evident. This could have been due to the nature of the task that was assigned. Also, scores on group tasks were indistinguishable based on the format chosen for group interactions. Although Watson's study did not show that group interactions were more productive using one format over another, she did observe that some interactions seemed to be more conducive to one format, an observation supported by other studies as well. For example, Watson stated that brainstorming was more effective in the face-to-face discussion. On the other hand, thoughtful, reflective conversations were better suited for ADB (Ajayi, 2009; Lin, 2008; Meyer, 2003; Watson, 2004).

Kumar (2008a; 2008b) reported on an ongoing qualitative study designed to document ways in which instructors use ADB in web-enhanced graduate and undergraduate education courses. In one phase of this study, Kumar used semi-structured interviews with four faculty members who had used ADB in their courses for several years. These interviews focused on faculty goals for online discussions, ways online discussions were used, and faculty reflections on the use of online discussions. Based on these interviews, Kumar (2008b) reported that goals of the faculty who used ADB were to have teacher candidates engage in course material outside of class meetings, reflect on course content, and ensure that teacher candidates read assigned text and engaged in detailed discussions around these texts.

Kumar (2008b) found that faculty reported high rates of teacher candidate participation online, especially for those who were less vocal during class meetings. They were not sure, however, if the reason this occurred was due to a willingness to participate online or the fact that it was a requirement for the course. Online discussions also gave teacher candidates the opportunity to engage in course material prior to class discussions. This allowed class time to be

"extended" in a way. Additionally, instructors reported that ADB posts helped them to become more familiar with the struggles and issues teacher candidates were having with the course. Awareness of teacher candidates' struggles and issues enabled faculty to plan classroom discussions to address the struggles they had shared.

In another phase of her study, Kumar (2008a) sought to identify ways instructors integrated and evaluated online discussions. Interviews with eight instructors focused on reasons for integrating online discussions, types of feedback provided to teacher candidates about online discussions, and ways to evaluate participation in online discussions.

Reasons for utilizing online discussions were similar to her previous findings (Kumar, 2008b). Instructors used ADB to hold teacher candidates accountable for course readings and to ensure that all teacher candidates participated in class discussions. All instructors that participated in the study indicated that minimum participation requirements were outlined for teacher candidates in the course syllabi and that participation counted toward their overall grade in the course. The weight of these discussions on their grade, however, varied among the instructors from 10% to 40% of teacher candidates' overall grades. Only three of the eight instructors reported participating in the online discussions but strictly for the purpose of clarifying terminology or addressing misconceptions that were evident in teacher candidates' posts.

Roth-McDuffie and Slavit (2003) also reported that their goal for utilizing ADB was to encourage teacher candidates to engage in course material outside of class meetings. More specifically, however, they stated that ADB provided teacher candidates with opportunities to reflect on course material. Their study reported their personal experiences with using ADB in undergraduate elementary mathematics methods courses. Their goal was to have teacher

candidates reflect on the process of teaching and learning mathematics and to facilitate a shift in teacher candidate beliefs about these topics. Course instructors designed discussion prompts to force candidates to reflect deeply on their long held beliefs about mathematics teaching. They found that teacher candidates' online comments were "more focused and reflective than if spoken extemporaneously" (p. 462). They used online discussions as a way to assess their students' understanding of key concepts and theories that had been discussed in class.

One key advantage reported by Roth-McDuffie and Slavit (2003) was that ADB provided "opportunities for the [teacher candidates] to wrestle with and support each other in the process of changing beliefs" (p. 451). The researchers reported that teacher candidates referenced online discussions while discussing similar issues in class. This continuation of dialogue between the online and face-to-face settings helped teacher candidates to continually support each other in making sense of their changing beliefs about teaching mathematics. This supports the findings of other researchers who stated that ADBs could be used to engage students in course material beyond the allotted class time (Kumar, 2008a; Vaughan, 2007).

While advantages to using ADB were reported, some struggles were evident as well. Both instructors and students reported that participating in online discussions was time consuming (Lin, 2008; Roth-McDuffie & Slavit, 2003; Vaughan, 2007), and some reported that issues with technology made participation frustrating (Roth-McDuffie & Slavit, 2003).

Student Beliefs about the Impact of Online Discussions

Since there are advantages and disadvantages with the implementation of any new technology in an educational setting, it is important to understand how students perceive its effectiveness. If students do not feel that the technology is useful to their learning processes, they will be less likely to use it effectively. Therefore, some researchers have attempted to determine

how students feel about ADB and how it impacts their overall course experience. Specifically, this review will examine studies related to teacher candidates' perceptions of the effectiveness of ADB as a learning tool.

Wilson-Jones and Caston (2006) investigated the attitudes of undergraduate education majors toward the effectiveness of web-enhanced instructional strategies as compared to traditional face-to-face instructional strategies. Participants in the study were 100 teacher candidates enrolled concurrently in two required education courses. One course was taught using traditional face-to-face instructional strategies, while the second used a web-enhanced format. At the end of the semester, teacher candidates responded to a survey designed to reveal their impressions of the two instructional formats.

Results of the survey indicated that 56% of teacher candidates preferred web-enhanced instruction. Wilson-Jones and Caston (2006) noted that the 44% that preferred traditional instruction "were non-traditional students over the age of thirty-five" (p. 145). This could indicate that prior experience with certain technologies impacts teacher candidates' preferences for utilizing these technologies as learning tools. Although over half of the teacher candidates indicated a preference for the web-enhanced format, only 31% of teacher candidates indicated that they preferred online discussions, whereas 69% indicated a preference for face-to-face discussions.

In a similar study, Lin (2008) analyzed student perceptions of a blended course format. In this study, 58 teacher candidates enrolled in an undergraduate technology education course were surveyed. The course was scheduled to meet three days each week of the semester; however, one class meeting was eliminated to accommodate an online component that included discussions using ADB.

Results of the survey indicated that teacher candidates felt they had gained a better understanding of course material through online discussions. Sixty percent of teacher candidates reported increased interaction among teacher candidates and with the instructor. Many teacher candidates felt that the online components took up a disproportionate amount of time compared to in-class components. Due to this perception of increased time allotted to online assignments, many teacher candidates felt that the grading criteria of these assignments were unfair (Lin, 2008).

Lin (2008) suggested improvements for future blended courses. One improvement was to allow more time for teacher candidates to make the transition between traditional and online instruction as well as making assignment expectations more explicit. Another suggestion was to make online components more integrated with face-to-face class discussions, which has been echoed by other studies as well (Kumar, 2008a; Roth-McDuffie & Slavit, 2003; Vaughan, 2007).

In a comparable study, Ajayi (2009) found that teacher candidates believed that participating in ADB helped them understand the material better. Ajayi (2009) interviewed teacher candidates following a 16-week web-enhanced undergraduate literacy education course. In this study, the instructor directed teacher candidates to reflect on classroom discussions and formulate questions to be posed to the rest of the class to discuss online. This differed from other studies in that the instructor did not provide the initial discussion prompt.

Results of interviews with teacher candidates in this study indicated that 76% felt that ADB helped them to learn from their peers and provided an opportunity to ask questions about topics that were not discussed during class meetings. Eighty-two percent indicated that ADB forced them to reflect on course material before posting responses. In this study, the interviewer

served as the course instructor, which may have impacted teacher candidates' responses to interview questions (Ajayi, 2009).

Critical Thinking in Online Discussions

With students indicating that they believe that ADBs have helped them learn more and think critically about course content, researchers have sought to determine if there is evidence that this is actually occurring. In order to accomplish this, it is necessary to first define "critical thinking" and then to identify a tool that can be used to evaluate online transcripts for evidence of critical thinking.

Defining Critical Thinking

The term "critical thinking" implies importance in the process of thinking. The National Council for Excellence in Critical Thinking defines it as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Foundation for Critical Thinking, 2009, para. 1). Based on this definition and the research previously discussed, ADB should be an effective tool for facilitating critical thinking. As stated, researchers reported using ADB for reflection on course material (Ajayi, 2009; Lin, 2008; Meyer, 2003; Watson, 2004), and it certainly provided a platform for communication. With critical thinking defined, researchers have sought to create a tool to evaluate evidence of critical thinking.

Practical Inquiry Model

A team of Canadian researchers (Garrison, Anderson, & Archer, 2001) developed the practical inquiry model to assess cognitive presence, which "has the potential to assess the quality of critical inquiry in terms of providing a means to assess the systematic progression of thinking over time" (p. 11). Garrison et al. indicated that critical thinking is a cyclical process

that includes four phases, namely triggering events, exploration, integration, and resolution. Fahy (2005) described the triggering event as "a problem or dilemma, usually initially defined or identified in educational situations by the instructor/moderator" (p. 15). He described the exploration phase by an oscillation between discussion and reflection in an attempt to make sense of the problem. This phase is "characterized by brainstorming, questioning, and free exchanges of information" (Fahy, 2005, p. 15). During the integration phase, discussants synthesize ideas shared during the exploration phase to form meaning. They discuss connections between the information that has been shared and the problem being discussed. Finally, the resolution phase is characterized by taking action to solve the problem that was posed. Fahy (2005) pointed out that in many educational settings, the actions described in the resolution phase are "hypothetical" (p. 15) and that students may not actually have the opportunity to carry out the action, but rather discuss what the action could be.

Since the triggering event sets forth the problem to be discussed, and exploration is characterized by information sharing, many researchers using the practical inquiry model to analyze ADB transcripts have reserved the integration and resolution phases as being evidence of critical thinking (Arnold & Ducate, 2006; Bai, 2009; Fahy, 2005; Meyer, 2003).

Since the practical inquiry model was introduced by Garrison et al. (2001), several researchers have utilized the model as a tool for identifying evidence of critical thinking in ADB transcripts. Fahy (2005) compared the practical inquiry model with the Transcript Analysis Tool (TAT), a tool developed by Fahy and his colleagues that consisted of eight coding categories, in contrast to the four phases of the practical inquiry model. The researcher stated, "The TAT strives for accuracy and generalizability, at the expense of the reliability that greater simplicity would confer" (p. 14).

Fahy (2005) coded ADB transcripts from an online graduate level course. Discussions took place among 13 students and an instructor and included 462 total postings. The researcher coded each post using both the practical inquiry model and the TAT. When using the practical inquiry model, researchers categorized posts in their entire form into one of the four phases described previously, as opposed to the TAT for which researchers coded each sentence separately.

Using the practical inquiry model, Fahy (2005) reported that 9.1% of posts were categorized as triggering events, 71.6% were categorized as exploration, 14.1% fell into the integration category and 1.7% were evidence of resolution. The remaining 3.5% did not fall into any of the phases and were categorized as "other." When transcripts were coded using the TAT, they found that the triggering events, integration and other categories contained fewer sentences and that more sentences were categorized in the exploration and resolution phases. They explained that this was a reasonable result due to the amount of discussion that would be necessary to explore and/or resolve a problem.

Bai (2009) also noticed similar distributions of ADB posts. He stated that the majority of student responses were "shallow and trivial" (p. 157). He hypothesized that critical thinking could be facilitated by introducing the practical inquiry model to students as a guide for online postings. Students enrolled in a graduate level technology education course for elementary teachers participated in online discussions over the course of the Fall 2007 semester. During the following semester, students enrolled in the same course also engaged in online discussions. This time, however, students were introduced to the practical inquiry model and were instructed that it should be used as a guide for online participation.

Bai (2009) selected one online discussion from each semester for analysis using the practical inquiry model. He chose these discussions based on the fact that they addressed the same topic. Similar to Garrison et al. (2001) and Fahy (2005), Bai (2009) found that in both semesters, more than half of the posts fell into the exploration category. One interesting result of Bai's study was that during the first semester, all postings fell into only one category of the practical inquiry model. The following semester, however, several posts were placed in multiple categories. Also, the coding from the second semester had more posts fall into the integration category. Interestingly, neither semester had any postings that were categorized as resolution. The author explained that this was due to the nature of the discussion prompt as it did not lend itself to application of a solution.

Arnold and Ducate (2006) also used the practical inquiry model to analyze 27 discussions that took place among 23 teacher candidates enrolled in a blended course for undergraduate foreign language education students. Their goal was to determine how the use of ADB could cultivate social interaction and cognitive growth among teacher candidates. Similar to the studies discussed previously, Arnold and Ducate found that the exploration phase contained the most posts with the least number of posts falling into the resolution phase.

Since they were also interested in the social aspect of online discussions, Arnold and Ducate (2006) analyzed transcripts for evidence of two different types of responses, namely monologues and dialogues. They considered monologues to be independent statements that were not responses to other teacher candidates, nor were they comments that solicited responses from others. On the other hand, dialogues were comments posted in response to another teacher candidate or that led to further comment from other teacher candidates. Transcript analysis revealed that candidates "worked together to search for information and construct solutions"

(Arnold & Ducate, 2006, p. 57), which was interpreted as being evidence of an active dialogue between teacher candidates.

Summary

As demonstrated in this chapter, the review of literature revealed not only the multitude of ways that ADB has been utilized in higher education, but also its potential for providing evidence of critical thinking among students. Through self-reported data, students have indicated that their learning has increased with the use of ADB, and that is supported by the evidence of critical thinking found in discussion transcripts.

CHAPTER III: METHODOLOGY

Introduction

Online learning in higher education has more than doubled since 2002 (Allen & Seaman, 2008). With this increase comes a need to understand the benefits and shortfalls of this type of learning environment. Research has shown that the use of asynchronous discussion boards (ADB) allows for a student-centered approach to instruction (Hazari, 2004; Roth-McDuffie & Slavit, 2003; Weaver, 2005). This student-centered approach allows teacher candidates to take ownership of the learning process and apply new concepts to what they currently know. Since instructors are advised by the research to limit their involvement in online discussions (Kumar, 2008; Roth-McDuffie & Slavit, 2003; Weaver, 2005), greater interaction between students occurs, allowing more collaborative learning to take place (Wilson-Jones & Caston, 2006).

Learning is a social process that requires collaboration, which includes sharing ideas and experiences (Vygotsky, 1978). This process can be facilitated through discussions among students. While various formats can be employed to foster discourse, for the purposes of this study, only discussions that occurred during face-to-face class meetings and via asynchronous discussion boards were considered. To make efficient use of instructional time, faculty could reserve valuable class time for hands-on explorations and allow students to engage in discussions of some course material outside of class using ADB. This type of discussion will only be beneficial, however, if it is an effective tool that allows teacher candidates to think critically about the material.

Therefore, the purpose of this study was to determine if there is a significant difference between online and face-to-face discussions in terms of the level of critical thinking demonstrated in responses. The researcher analyzed both online and face-to-face discussions from a web-enhanced undergraduate elementary mathematics methods course.

In this chapter, the research questions along with a description of the design of the study will be presented, followed by a discussion of the population and sample of the study. Then, a description of the survey instrument will be provided. Next, the procedures will be outlined, followed by a description of the data analysis procedures for each of the research questions. Finally, the limitations of the study will be presented.

Research Questions

When making instructional decisions, professors should take into consideration the most effective and efficient instructional strategies. Historically, university faculty have employed a whole class or small group approach to discussing course material during face-to-face class meetings. In order to determine if the use of ADB provides an equivalent learning experience to face-to-face, in-class discussions, both formats were analyzed. This analysis sought to answer the following research questions.

1. How does the level of critical thinking evident in teacher candidates' responses during online discussions compare to those in face-to-face discussions?
2. How does prior experience with using communication technologies impact online class discussions?
3. How does existing interest in discussion topics impact online class discussions?

Design

This study employed a qualitative approach to analyze the critical thinking of teacher candidates enrolled in an undergraduate elementary mathematics methods course. This approach was appropriate for the study due to the nature of the data that was collected. Discussions among teacher candidates were analyzed for evidence of critical thinking. This process can be somewhat subjective, and therefore did not lend itself to the use of statistical analyses for interpretation.

Course

In the present study, the researcher analyzed discussions that occurred both face-to-face and using ADB for teacher candidates enrolled in a senior-level elementary mathematics methods course. This course was designed to teach candidates about children's mathematical thinking and pedagogical techniques for teaching mathematics. In addition, the course instructor emphasized the recommendations of the National Council for Teachers of Mathematics (NCTM). Specifically, a focus of the course was on the NCTM's process standards for school mathematics. These standards include student engagement in problem solving, communication, connections, representation, and reasoning (NCTM, 2000). Typically, teacher candidates enter the course with a traditional view of teaching mathematics. That is, they see the role of the mathematics teacher as being a dispenser of knowledge. The instructor designed this course to challenge that belief and allow candidates to consider the role of the mathematics teacher as being a facilitator of learning. In order to help candidates recognize this different view of mathematics teaching, the instructor utilized course readings taken from scholarly mathematics education journals. The researcher used discussions around these readings as the unit of analysis for this study.

Instructor

The instructor was a full-time, tenured faculty member who had been responsible for designing and teaching this course each semester over the previous five years. She would be considered an expert in the field of mathematics education. The instructor was not the researcher.

Survey Instrument

The researcher developed a survey in order to collect information about participants and their experiences with communication technologies (see Appendix A). Item 1 of the survey asked participants to describe their level of interest in course topics. Through items 2, 3, and 6, participants reported their prior experiences using communication technologies, including various features of Blackboard, the online course management system utilized by the university, as well as types of internet access available to them on a regular basis. Participants described their learning preferences, either classroom-based or online, through item 4. Participants also reported their experiences with teaching mathematics through item 5. Finally, item 7 was used to identify when and at what institution they had taken their elementary mathematics content courses. The first three items on the survey were intended to provide information to assist in answering research questions. The remaining items were intended to provide more information about the participants themselves.

The researcher administered the survey during the second class meeting of the semester. All 72 teacher candidates enrolled in two sections of the course completed the survey and agreed to participate in the study.

Population and Sample

The population of this study consisted of teacher candidates enrolled in a program of study leading to certification in elementary education. The sample was a convenience sample

composed of teacher candidates enrolled in two sections of an elementary mathematics methods course at a small southeastern university during the fall semester of 2010. Both sections of this course were taught by the same instructor.

Teacher Candidates

Participants included 72 teacher candidates enrolled in these two sections of the course. Thirty-six participants were enrolled in each section of the course. Teacher candidates were seniors who had been accepted into the teacher education program, which required them to maintain at least a 2.75 GPA. The average age of these participants was 22.5 years of age, with 9 participants over the age of 25 included in the sample. Similar to past enrollments in this course, the participants consisted of 69 female teacher candidates and 3 male teacher candidates. Since only 3 male participants were enrolled in the course, the number of males and females was highly disproportionate. Therefore, gender was not considered a variable in this study.

Since all discussions that took place online were to be conducted using the university's Blackboard system, it was important to determine participants' prior experiences with Blackboard capabilities. Therefore, the survey included a section where participants could indicate whether they were very comfortable, somewhat comfortable, not comfortable, or had no experience with several of the features available in Blackboard. Of particular interest to the researcher was the comfort level each participant had with accessing groups and utilizing the discussion board feature. Approximately 89% of participants indicated they were either somewhat or very comfortable accessing the groups feature. Over 95% of participants indicated they were either somewhat comfortable or very comfortable utilizing the discussion board. Table 1 shows the complete results for this portion of the survey.

Table 1

Participants' Prior Experience with Blackboard Features

Blackboard Feature	Very Comfortable	Somewhat Comfortable	Not Comfortable	No Experience with this Feature
Announcements	93.1%	6.9%	0.0%	0.0%
Downloading Documents	84.7%	13.9%	1.4%	0.0%
Submitting Assignments	69.4%	27.8%	2.8%	0.0%
Discussion Board	68.1%	27.8%	4.1%	0.0%
Sending Email	90.3%	8.3%	1.4%	0.0%
Accessing Groups	54.2%	34.7%	5.6%	5.6%
Accessing Grades	90.3%	9.7%	0.0%	0.0%

In order to gain more information about participants' prior experiences in mathematics education, the survey included one item used to determine what types of mathematics teaching experiences participants had engaged in prior to the beginning of this course. Participants' prior experiences with mathematics teaching varied greatly. Of the 72 participants, 38.9% indicated that they had tutored students in mathematics, 84.7% indicated they had observed at least one mathematics lesson taught by a classroom teacher, 15.3% of participants reported having taught a mathematics lesson themselves, and 5.6% reported having been employed as an assistant teacher in a school district.

Since participants were to engage in discussions that took place through an internet connection, they were asked to report the types of internet service they had available to them on a regular basis. They could select multiple forms of internet access if applicable. All 72

participants indicated that they had some type of internet access regularly available. Several types of internet access were reported, with many participants having more than one way of accessing the internet available. The majority of participants indicated being able to access the internet wirelessly (70.8%). Four participants indicated that their internet access was through a dial-up connection. Of those four participants, one indicated that a dial-up connection was the only form of internet connection available to her. Other forms of internet availability included digital subscriber line or DSL (25.0%), cable modem (20.8%), and via satellite (2.8%).

When asked if they preferred online or in-class learning activities, 38.9% of participants indicated they preferred only classroom learning activities, while 59.7% indicated they preferred a combination of online and classroom learning activities. One participant indicated that she preferred only online learning activities.

Process-oriented Teacher Candidates

As with other university settings, many teacher candidates had not completed their entire course of study at this institution. Specifically, 36 participants had completed both of their elementary mathematics content courses at the university; however, the remaining 36 participants completed at least one of these courses at other institutions. Since the content courses delivered by the university were known to address similar material and employ similar teaching methods, it was necessary to identify participants who had engaged in these experiences previously. These teaching methods were grounded in the recommendations put forth by the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM, 2000). In particular, these courses modeled the process standards for teaching mathematics described by NCTM. For this reason, participants that completed their content courses at the university were referred to as Process-oriented Teacher Candidates (PTCs).

Procedures

The researcher sought to determine the differences in levels of critical thinking that occur during face-to-face and online discussions. The paragraphs that follow will describe the procedures used to address this issue. A description of the process for selecting course readings will be presented, followed by a description of participant group assignments. In addition, a discussion of the schedule for assigned readings and discussion formats will be presented.

Selection of Course Readings

The use of scholarly articles provides a platform for teacher candidates to think critically about the teaching and learning of mathematics (Coffey & Billings, 2009). Therefore, discussions around scholarly articles were used as the unit of analysis for the present study. Scholarly readings are an existing and regular component of the elementary mathematics methods courses at this university and had previously been discussed in small groups during class meetings.

In order to determine the topics that assigned readings would address, the researcher met with the course instructor as well as drew upon her prior experience of teaching this course. Three main themes were identified, namely children's mathematical thinking, the National Council of Teachers of Mathematics' process standards (NCTM, 2000), and practical teaching tips. Once these topics were established, the researcher reviewed articles that had been used as assigned readings for this course in the past and identified which theme each of these articles addressed. Since the majority of the articles used as assigned readings for this course came from NCTM publications, the researcher used key word searches on NCTM's website to identify additional articles that could be used to address the course topics. The researcher established possible discussion questions as each article was read.

Once a variety of articles and discussion questions were developed, the researcher met with the instructor to determine which articles to use and how they supported the existing lessons for the course. After reviewing existing lessons, the researcher performed a more focused search for additional articles that would address course objectives. A second meeting was held with the instructor to finalize the article selection as well as discussion questions. Two readings were selected to address each of the three course themes for a total of six assigned readings for the course. For the purposes of comparing online and face-to-face discussions, these reading discussions were facilitated using both formats.

In order to compare both face-to-face and online discussions, teacher candidates alternated the format of each reading assignment during the semester. This alternating schedule also oscillated between the two sections of the course. The discussion format schedule for the two sections of the course as well as the selected course readings are outlined in Table 2.

Table 2

Discussion Format Schedule for Course Sections

		Course Section	
Reading	Course Theme	1	2
Behrend, 2001	Children's Mathematical Thinking	Face-to-Face	Online
Taylor, Breck & Aljets, 2004	Children's Mathematical Thinking	Online	Face-to-Face
Rigelman, 2007	NCTM Process Standards—Problem Solving	Online	Face-to-Face
Whitin & Whitin, 2002	NCTM Process Standards—Communication	Face-to-Face	Online
Chapin, O'Connor, & Anderson, 2003	Practical Teaching Tips	Face-to-Face	Online
Reinhart, 2000	Practical Teaching Tips	Online	Face-to-Face

This organization of discussions allowed the researcher to analyze both discussion formats for each class as well as for each assigned reading and course theme.

Group Assignments

The researcher randomly assigned participants to small groups consisting of three or four participants using a table of random numbers (Urbaniak & Plous, 2008). Once groups were established, participants remained in the same group throughout the semester. The researcher

assigned each group a number label to aid in identifying the groups. Also, the researcher identified each member of the group by his or her initials for transcribing purposes. Following transcription, the researcher assigned pseudonyms to participants in order to maintain anonymity, as only the researcher knew which pseudonym was assigned to each participant. This information was not shared with the instructor.

The researcher purposefully selected two groups from each section of the course to be followed throughout the study. Selection was based on the make-up of the group. The researcher had identified PTCs based on mathematics course completion status reported on the initial survey. All groups that were made up of two PTCs and two non-PTCs were identified as possible candidates for the purposefully selected groups. Two groups from each section of the course that consisted of this mixture of PTCs and non-PTCs were chosen by random draw to be followed throughout the study. This distinction was made to ensure that groups contained participants that were known to have had experience discussing issues relevant to mathematics education and those that may or may not have had opportunities to engage in this type of discourse. To maintain anonymity, the researcher assigned the two purposeful groups letter labels, Group A and Group B. Table 3 describes the participants who made up the purposefully selected groups.

Table 3

Purposefully Selected Groups

Group	Name	PTC
Section 1		
Group A	Rosie	Yes
	Beverly	No
	Tiffany	No
	Jana	Yes
Group B	Christy	No
	April	Yes
	Hannah	Yes
	Alice	No
Section 2		
Group A	Evelyn	Yes
	Wendy	No
	Waverly	No
	Candice	Yes
Group B	Charlotte	Yes
	Kim	No
	Kathy	No
	Melanie	No

Each purposefully selected group was composed of two PTCs and two non-PTCs with the exception of Group B from Section 2 of the course. The researcher originally selected a different group when the study began. However, due to absences during in-class discussions and an overall lack of participation by these group members in online discussions, the researcher chose to replace this group with another, randomly selected group. Without the interaction of all group members in either format, the researcher did not feel that enough data could be collected from the original group to capture a true picture of the levels of critical thinking. Therefore, the researcher transcribed and analyzed the discussions from the newly selected group in lieu of the originally selected group.

In addition to the two purposefully selected groups, a third group was randomly selected from the remaining groups to be included in the analysis. This third group was selected using random drawing, and a different group was selected for each discussion analysis. Since there were eight groups in Section 1 and seven groups in Section 2 of the course that were eligible for this random draw, some groups were chosen to be analyzed more than once throughout the study. Although these groups varied from discussion to discussion, the researcher assigned the randomly selected group the letter label Group C to maintain anonymity.

Schedule

During week 1 of the course, the researcher administered the survey described previously. Using the information from this survey, the researcher established the small groups for each section of the course. These groups remained intact for the remainder of the semester for both in-class and online discussions.

Discussions around assigned readings took place two to three weeks apart with two assigned readings along with their discussions each week. One discussion each week took place in class, and one took place using ADB. The first round of discussions focused on children's

mathematical thinking. These discussions took place during the third week of the semester. The first article discussed, "Are Rules Interfering with Children's Mathematical Thinking?" (Behrend, 2001), described a group of second- and third-grade students' misconceptions about a common rule for adding multi-digit numbers. Participants in Section 1 of the course discussed this article in class, and participants in Section 2 engaged in this discussion online.

Also during week 3 of the course, participants engaged in their second discussion around the assigned reading, "What Nathan Teaches Us About Transitional Thinking" (Taylor, Breck & Aljets, 2004). In this article, the author shared a first-grade teacher's struggle with understanding the invented algorithm of one student that was presented during the class's discussion about subtracting with regrouping. Participants in section 1 of the course discussed this article online, while participants in section 2 discussed the article in class.

Articles focusing on two of NCTM's process standards, namely problem solving and communication, were assigned during week 6 of the semester. The third assigned reading was an article titled "Fostering Mathematical Thinking and Problem Solving: The Teacher's Role" (Rigelman, 2007). Through this article, the author compared the implementation of two similar problem-solving tasks in different classrooms. The author highlighted how the teachers' actions while facilitating the task impacted the level of student learning. Participants in section 1 engaged in discussions around this article online, while participants in section 2 discussed the article in class.

Also during week 6, participants engaged in the fourth article reading, "Promoting Communication in the Mathematics Classroom" (Whitin & Whitin, 2002). The authors of this article described the various ways that fourth-grade students communicated about the differences in prime and composite numbers. These students communicated their ideas through speaking,

drawing and writing. The participants in section 1 of the course discussed this article in class, while participants in section 2 discussed this article online.

Participants discussed assigned readings that addressed practical teaching tips during week 8 of the semester. The fifth reading assignment was a chapter taken from the book *Classroom Discussions: Using Math Talk to Help Students Learn* (Chapin, O'Connor & Anderson, 2003). In this chapter, the authors outlined five talk moves that teachers can utilize in the classroom to facilitate discussions in the mathematics classroom. Participants in section 1 of the course discussed this reading assignment through face-to-face discussions in class, while section 2 discussed this chapter online.

In the sixth reading assignment, "Never Say Anything a Kid Can Say!" (Reinhart, 2000), the author shared his experiences creating a more student-centered classroom environment. He provided readers with a variety of strategies that teachers can easily implement to help them make the transition from a teacher-centered classroom to a more student-centered classroom. Participants in section 1 discussed this article online, while participants in section 2 discussed this article in class.

The researcher used transcripts of these discussions to address the research questions. A description of each discussion format will be presented in the following paragraphs.

Face-to-Face Discussions. The researcher developed focus questions for each assigned reading (see Appendix B). The instructor distributed copies of these questions to each group at the beginning of each class. For each discussion, the course instructor allowed small groups approximately ten minutes to discuss the questions and record their thoughts on poster paper. Groups then passed their posters to other groups to consider their responses to the questions and decide if they agreed or disagreed with the other groups' ideas. Each poster was generally passed

to two other groups, and participants had approximately three to four minutes to review the responses on the poster and add their reactions to the poster. After passing through at least two other groups, the original group was allotted approximately five minutes to read the reactions to their statements and discuss any disagreements. This allowed about 25 – 30 minutes of total discussion time per group to be analyzed.

Face-to-face discussions were collected through audio taping of classroom sessions. The researcher placed a separate audio recording device with each small group to capture that group's discussion. For the purpose of this study, only face-to-face discussions focused on course readings were recorded and analyzed. Also, only discussions that occurred in the small group format were analyzed. Any discussions of course readings that were open to the entire class were not coded. This was to ensure that online and face-to-face discussions were comparable as small group discussions rather than whole class discussions. The researcher was present during in-class, face-to-face discussions, but did not interact with participants. The researcher sat near the participant groups to be analyzed and made notes during group discussions. These notes were later used to identify group members when transcribing the audio recordings. The researcher collected audio recorders following reading discussions to eliminate recording class discourse that was not being considered in the study. Although all groups' discussions were recorded, the researcher only transcribed discussions from two purposefully and one randomly selected groups from each section of the course.

The researcher transcribed these face-to-face discussions as closely as possible to the way they actually occurred. Each time a different person began to speak, the researcher began a new line in the transcript to indicate a new statement. If one speaker interrupted another speaker, that was also indicated in the transcript. Every word, including "um", "yeah" and "like," was

captured. In addition, any pauses that were longer than two seconds were documented along with the amount of time the discussion was paused. If two conversations developed at the same time within the same group, the researcher captured that as well by using side-by-side columns in the transcript. Due to the nature of the transcriptions, the researcher coded each new statement separately. This led to 3,235 statements to be coded, many of which were very short statements.

Online Discussions. Online discussions took place using the university's Blackboard system through the "Groups" function. This allowed the discussion groups that existed during face-to-face, in-class discussions to remain intact for online discussions as well. The instructor began each discussion using the same questions established by the researcher that were used in the face-to-face discussions (see Appendix B). Participants were given minimum participation expectations at the beginning of the semester (see Appendix C). These expectations set forth the minimum number of original posts as well as response posts that each participant should produce. Participants were encouraged to engage in the online discussions beyond these minimal expectations; however, very few participants posted more than the minimum number of responses.

Blackboard provided participants the option to "subscribe" to discussion threads. With this feature enabled, the system would send e-mail messages to participants each time a response was posted to the discussion board. In order to promote active participation in online discussions, the researcher requested that participants subscribe to group threads. Blackboard did not retain a record, however, of participants that did or did not subscribe to the discussions.

The online discussion expectations also outlined the timelines for each discussion. Participants were to complete their online interactions for each article discussion over a one-week period. The researcher collected online transcripts two weeks following the completion of

the discussion to ensure that all participants had adequate time to post final comments. Since these discussions were less interactive than face-to-face discussions and participants had the opportunity to post complete thoughts without interruption, the statements captured during online discussions were fewer, 658 posts, but also typically much longer than verbal statements that occurred during face-to-face discussions. The researcher coded each complete statement in its entirety. If different parts of one statement could be coded at different levels, the researcher assigned the entire statement the highest category that was evidenced.

Data Analysis

Qualitative data analysis methods were utilized to address the research questions. A description of data analysis procedures for each question will be outlined in the following paragraphs.

Question 1: How does the level of critical thinking evident in teacher candidates' responses during online discussions compare to those in face-to-face discussions?

The researcher transcribed each face-to-face discussion as soon as possible following each discussion. To ensure that an entire discussion was collected, ADB transcripts were retrieved from the Blackboard system after approximately two weeks of inactivity.

The researcher used the deductive analysis approach to qualitative research (Patton, 2002) when coding transcripts from online and face-to-face discussions using the critical thinking categories outlined by the practical inquiry model (Garrison, Anderson, & Archer, 2001). These categories include (1) triggering, (2) exploration, (3) integration, and (4) resolution. Similar to other studies (Fahy, 2005; Meyer, 2003), the researcher used an additional category, other, for off-topic statements. As the researcher coded the transcripts, there emerged a sub-category within the exploration category that the researcher coded as "exploration-agreement."

These were statements that were simple "yes, I agree" statements or those that simply repeated what another participant had said along with a statement of agreement.

In order to maintain consistency with other studies that have used this model (Arnold & Ducate, 2006; Fahy, 2005; Heckman & Anabi, 2005; Meyer, 2003), statements that fell into the integration and resolution categories were considered as showing evidence of critical thinking. A detailed description of these categories can be found in Appendix D. After transcripts from online and face-to-face discussions were transcribed and coded, the researcher analyzed the statements that fell into each category to determine the level of critical thinking evidenced in each discussion format.

The analysis of this data consisted of recording the assigned codes into multiple spreadsheets organized around each reading, each group member and each coding category. The researcher then used the information in these spreadsheets to determine the number of each type of statement, i.e. triggering event, exploration, exploration-agreement, integration, resolution or other, as well as the percentage that each type of statement represented for each discussion. The data was then combined to determine overall percentages for each discussion format. The data was sorted further to determine the percentage of each type of statement for each participant as well as for each reading discussion. The researcher used the percentages of each type of statement to make comparisons between online and face-to-face discussions.

Question 2: How does prior experience with using communication technologies impact online class discussions?

Self-reported data obtained through the survey instrument administered during the initial class meeting included information related to teacher candidates' prior use of communication technologies such as e-mail, text messaging, social networking and online discussion forums.

The researcher recorded survey responses in a spreadsheet and determined percentages for each response based on all 72 participants. The researcher aimed to use the information from this spreadsheet to determine if prior experience with communication technologies impacted online discussions.

Since the sample of teacher candidates that participated in this study had very similar prior experiences with communication technology, they were indistinguishable based on the data collected from the survey. Due to this lack of diversity among participants, the researcher eliminated this question from the study.

Question 3: How does existing interest in discussion topics impact online class discussions?

On the initial survey, teacher candidates indicated areas of interest with respect to teaching mathematics. These areas corresponded to the course themes and the chosen readings. These themes included children's mathematical thinking, mathematics processes, and practical teaching tips.

The researcher identified the level of interest for each topic for the 16 teacher candidates that were followed throughout all six discussions. Once the level of interest was determined, the researcher used the coded transcripts from online discussions and the percentage of each type of statement to make comparisons between levels of critical thinking for each topic.

Limitations

Due to the qualitative nature of this study, the results were not intended to be generalizable, but rather descriptive of the particular participants and setting. Other limitations of this study included the participants themselves. First, the researcher relied on self-reported data on the survey instrument. The majority of this information was factual; however, the section in which participants were to report their level of comfort with Blackboard features was subjective. Second, participants were to report their level of interest in course topics without descriptions of

those course topics. Third, the level of participation in discussions, especially face-to-face discussions, was highly dependent on participants being prepared to discuss the assigned readings. The researcher had no way of ensuring that these articles were read prior to class, therefore some discussions were limited due to lack of preparation.

Finally, since the coding process did leave room for some interpretation by the researcher, personal bias could become evident. The researcher minimized this effect as much as possible by coding entire verbatim transcripts and aligning the coding as closely as possible to other studies that have utilized the practical inquiry model. The researcher also made notations in the transcripts to indicate why statements were coded as they were in order to maintain consistency between transcripts.

Summary

The methodology described in this chapter allowed the researcher to compare participants' discussions using two formats, namely, face-to-face and online. Additionally, each course theme was analyzed in both formats. This provided a complete view of participants' interactions while discussing course material. The survey data allowed the researcher to separate participants into various categories to analyze the transcripts further to identify evidence of trends that may exist in these categories.

CHAPTER IV: DATA AND ANALYSES

Introduction

Online learning has become more prevalent in institutions of higher education. While several researchers have conducted studies to determine how faculty and students utilize this new learning medium as one component of their overall university experiences (Kumar, 2008a; Kumar, 2008b; Roth-McDuffie & Slavit, 2003; Watson, 2004), others have investigated the level of critical thinking evident in online interactions (Arnold & Ducate, 2006; Bai, 2009; Fahy, 2005; Garrison, Anderson & Archer, 2001; Meyer, 2003). There exists, however, a gap in the existing literature that analyzes the critical thinking evident in online learning compared to similar in-class experiences. This study was designed to address this gap in the research.

Engaging in discussion is a pivotal part of the learning process. New ideas are built from shared thoughts and experiences (Dunn, 2004; Groth & Bergner, 2007; Groth & Burgess, 2009; Vygotsky, 1978). This study was designed to analyze the discussions that occurred in an elementary mathematics methods course in order to determine if the level of critical thinking differed by discussion format, namely online or face-to-face. This study was guided by the following research questions:

1. How does the level of critical thinking evident in teacher candidates' responses during online discussions compare to those in face-to-face discussions?
2. How does prior experience with using communication technologies impact online class discussions?

3. How does existing interest in discussion topics impact online class discussions?

In this chapter, an analysis of the discussion data will be shared beginning with the face-to-face discussion data, followed by the online discussion data. Specific emphasis on the research questions will follow.

Face-to-Face Discussions

For each section of the course, three face-to-face discussions were audio-recorded and transcribed for further analysis. These in-class discussions were focused around article readings that highlighted topics pertaining to the three main themes of the course, namely children's mathematical thinking, mathematics processes, and practical teaching tips. Once discussions were transcribed, individual statements were coded using the practical inquiry model outlined by Garrison, Anderson and Archer (2001). These levels include triggering events, exploration, integration and resolution. In addition to these categories, the researcher chose to include an "other" category to be used for statements that were off-topic. Also, a sub-category labeled "exploration-agreement" was included in order to identify statements that did not add to the discussion but rather implied simple agreement with what another participant had stated.

Triggering events

Triggering events are described by Garrison et al. (2001) as being either questions that initiate a discussion or statements that take a discussion in a different direction. Since the discussions during class meetings were organized around assigned readings, the researcher developed specific questions for participants to consider during their discussions (see Appendix B). These questions served as the triggering events for each discussion. For this reason, very few true triggering events were evidenced in the transcripts of the face-to-face discussions. There were only three instances of triggering events that were initiated by the participants, all three of which were offered by the same teacher candidate, Jana. While other participants made

statements that took discussions into a different direction, these statements triggered discussions that were off-topic and were therefore coded in the "other" category.

During two of the in-class discussions, Jana attempted to begin a new discussion that was related to the topic being discussed. When the group was analyzing the response from another group during the discussion around the article "Are Rules Interfering with Children's Mathematical Understanding?" (Behrend, 2001), she asked "what do you do when they get frustrated?" Rosie was the only group member that responded to her question, stating "[Because], then they are just [going to] tune out and not even want to learn anything." This discussion did not go any further.

Jana's next statement began another new discussion. "Well, how much of a struggle should they (pause), how much should they struggle?" This triggering event elicited more participation; but the discussion was still very short, and the group did not come to any conclusions. The discussions progressed as follows:

> Jana: Well, how much of a struggle should they (pause) how much should they struggle?
>
> Beverly: How long should you let them struggle? Because I don't, umm (pause) when I have to struggle with something, I usually put it up and don't worry about it anymore until later, because if I'm frustrated, I'm not [going to] know how to do it right.
>
> Rosie: Me too. Me too. That's what I'm saying, and a little kid is not going (pause) they'll be like "I don't get it" and put it up.

This is as far as this new discussion progressed. Group members then focused their attention back to recording their responses on the poster.

The third triggering event that was posed by Jana instigated a more developed discussion. Jana initiated the discussion that follows as the group was discussing the article "Promoting Communication in the Mathematics Classroom" (Whitin & Whitin, 2002).

> Jana: Whenever I was in school for spelling, like in kindergarten and all that stuff, like first grade, and I think it was up until like third grade, we had um (pause) they did this thing where it was either pass or fail. There wasn't like a (pause) a letter grade put to it. So because I always passed, I uh (pause) I ended up not having very good spelling skills because I was very (pause) like on the brink, and so they never really did catch it. But I wonder if they do that with math students or if they did that with math students back in the day.

By stating, "I wonder if they do that with math students . . . ," Jana was triggering a new discussion related to the topic. Her group's responses follow.

> Rosie: I'm just so confused about this way of teaching because nobody teaches this way.
>
> Beverly: They don't, you're right. My teacher doesn't have time to teach this way.
>
> Rosie: I was talking to my teacher yesterday, and she was like, I mean, you don't, you don't, there's no, you don't have time to do it like that. And there's so much more that you have to teach them for the test than focus on (interrupted).
>
> Beverly: And now to me there's so many kids packed in a room. I know our teacher had to create a whole nine weeks test and the math part that was just like the MCT. They're teaching the test; they're not teaching anything else.

Although Jana attempted to discuss relevant ideas with her group, the discussion did not address her ideas, nor did the group draw any conclusions.

During face-to-face discussions, participants would read the discussion questions from handouts that were distributed prior to the discussion time. As these statements were recognized in the transcript, they were coded as triggering events, but the researcher noted that these statements were instances where the candidates were reading from the handout and not eliciting original ideas. During several discussions, the participants would refer back to the guiding questions, repeatedly resulting in the triggering questions being read aloud multiple times. These verbatim readings of the discussion prompts accounted for 4.4% of the statements made during face-to-face discussions.

Exploration

Statements categorized as exploration were those in which participants made statements meant to assist the group in making sense of the question being asked, shared information directly from the reading, or made broad statements from personal experiences without direct explanation as to how they related to the question. These statements were often followed by interjections such as “Right?” or “I think,” indicating that the statement was not intended to be considered a complete or final response to the question being discussed. These statements were considered to represent a low level of critical thinking.

A total of 3,235 face-to-face statements were analyzed and coded. Of these, 41.5% were categorized as exploration, representing the highest percentage. During face-to-face discussions, participants began by sharing what they felt was meaningful information from the articles. This phase of the discussion became very revealing as the researcher was able to distinguish easily between candidates who had read the assigned reading prior to class and those who had not. Participants who were able to speak fluently about the content of the article showed evidence of coming to class prepared for the discussion.

The following interchange describes how the beginning of a discussion occurred about the book chapter titled "Tools of Classroom Talk" (Chapin, O'Connor, & Anderson, 2003). The participants were asked to list the five productive talk moves that were outlined in the chapter and describe how each supported communication in the mathematics classroom.

> Sydney: Well, the first one was revoicing. So, have it (pause) so I guess the teacher restating what the student just said. To me, I thought that was important, but it's easy to add on the right, like, what you want them to say instead of just what they said. I think as a teacher you have to be careful of making sure only what they said, so that everybody else can understand it without putting in there anything extra.
>
> Jalissa: And then it was asking students to restate someone else's reasoning. Which should mean that would make them be an active participant in the listening process, so they would know what each of their other classmates were saying. And it's just a way for them to pay attention and know what's going on in class.
>
> Sydney: Exactly. And I think, again, like, it would (pause) kind of like we talked about (pause) why it is important to get students talking. It helps them to, I guess, talk through their thoughts. And, like, as they talk it out, they either realize that maybe I don't understand it or (pause) it helps things click. Um (pause) then would someone like to add on. So asking for students to (pause) if there's anything else they'd like to say or (pause) I think it's just asking for more comments.
>
> Jalissa: Right.
>
> Sydney: It's a good way, if somebody's stuck, to ask for help.

As the researcher was listening to the interaction between these two participants, it was obvious that they had read the assigned chapter prior to class and were able to share their thoughts easily.

During this initial discussion phase, however, some participants made statements that revealed to the researcher that they had not come to class prepared to discuss the article. Consider the discussion around this same topic that occurred in a different group.

Member of nearby group: The first one is revoicing.

Hannah: I think the (pause) the first one is rejoicing and then (pause) um (pause) I guess.

April: Just, like, telling them that they did good.

Hannah: Right, like encouragement.

April: Uh-huh.

Hannah: Um.

(Pause—12 seconds)

Member of nearby group: Teachers need to revoice what the (inaudible)…

Hannah: I mean revoicing, was I saying rejoicing?

Christy: Yes (laugh).

Hannah: I don't know why I said rejoicing.

(Pause—12 seconds)

Speaker Unknown: If they're revoicing it, it helps them (pause) it helps them makes sense of like (pause) you know (pause) like, come out with the problem.

April: Uh-huh. It's like if they've made a mistake.

Hannah: I guess.

This interchange revealed that these participants were not familiar with the content of the assigned reading. Hannah seemed to be trying to interpret what was overheard from a nearby group rather than draw from her own understanding of the assigned reading. Also, they were unable to address how the talk moves could be used to support communication in the

mathematics classroom. The researcher noticed that a large part of the discussion time in this group was spent flipping through the pages of the chapter. Although these statements did not show understanding of the assigned reading, the researcher categorized them as exploration statements since they were intended to address the topic.

Exploration-agreement

As the researcher was coding the face-to-face transcripts, she noticed that often times as one teacher candidate was speaking, others would make statements implying agreement with what was being said. Statements such as "Yeah" or "Uh-huh" were categorized as exploration since they did not add any information to the discussion, but were coded separately due to the fact that they occurred several times during a discussion.

> Kim: What should problem solving look like? Like there should be a range of different problem solving (interrupted).
>
> Charlotte: Yeah, so it shouldn't look like one single technique.
>
> Melanie: Yeah.
>
> Charlotte: Or one single (pause) technique (pause) yeah, ok.
>
> Kim: It shouldn't all look the same, it should be a very (pause)—
>
> Melanie: Yeah.
>
> Kim: —raw.
>
> Melanie: Yeah, it should look different.

In this interchange, as Kim is developing her thought, her group members voiced agreement five times. This was typical during face-to-face discussions.

Overall, out of all the face-to-face discussions that were analyzed, 18.1% of statements were categorized as exploration-agreement. These statements combined with the statements

categorized as strictly exploration accounted for 59.6% of statements that occurred during the face-to-face discussions.

Integration

Integration statements were those that either added a new idea in order to extend one that had been stated by another participant, referenced other sources beyond the article being discussed, or justified an opinion with evidence from personal experiences, other readings, or prior class discussions. In face-to-face discussions, 6.6% of statements fell into this category, which was considered to be evidence of higher levels of critical thinking.

An example of an integration statement that was the result of extending another participant's statements is given below. In this example, the participants were reading the response that another group had written on their poster.

> Poster: "Positive Struggle" is important because it helps students move forward. There is little negativity that can lead to positive learning; however, there cannot be learning without some form of a struggle. This struggle should therefore be positively reinforced.
>
> Natasha: Oh yeah, I mean, I agree with the struggle because you're not [going to] grow if you don't have some sort of struggle. You are [going to] know what you know unless there is something that causes you to learn more.

There were a few instances where participants used prior readings or discussions to explain their reasoning. In the interchange that follows, the participants were discussing the reading "Promoting Communication in the Mathematics Classroom" (Whitin & Whitin, 2002) when one participant referred back to a previous reading, "Fostering Mathematical Thinking and Problem Solving: The Teacher's Role" (Rigelman, 2007).

> Christy: I think it kind of goes back to the (pause) um (pause) you know, when we talked about how (pause) well, actually this was in the last article, like the problem performers

versus the (pause) versus the problem solvers. Um (pause) I didn't feel like there was a lot of communication as far as, like, problem performers. So it was, like, there was one way to do it. That was the only way. There was no explanation, there was no communication, there was no reflection, like, it was just (pause) pretty cut and dry.

In this excerpt, Christy does not specifically state the name of the article, but is able to use the ideas that were discussed previously about problem solvers and apply that information to this topic of communication in the classroom. By making this connection between different ideas, the teacher candidate showed a higher level of critical thinking in the discussion.

The third type of integration statement that the researcher noticed was evidenced by participants who produced a well-developed justification for their opinion based on either the reading, personal experiences, or prior class discussions. This differed from the previous example in that these statements were typically of the form "I think this because . . ." and the participant was able to use evidence to justify her opinion rather than making connections between different ideas. Examples of this type of integration statement follow. These statements resulted from discussions around the article "What Nathan Teaches Us About Transitional Thinking" (Taylor, Breck & Aljets, 2004).

Waverly: This article was talking about how the teacher (pause) when Nathan started explaining how he did his problem and he didn't understand, like (pause) she didn't understand what he said, like, how he did it. And so she got other students to come up and kind of like start talking their way through it and, like, she made sure that she understood what he was saying instead of just being like "oh he's wrong" or something.

Evelyn: Right.

Waverly: Or his process was wrong. Like, she wanted to understand how he did it, and from that she was able to build and, like, teach him a rule or teach him something (interrupted).

Evelyn: Right, that's good, because, like, so often I feel like it's so easy for us to only find like one way to solve a problem. And then, like, kids that we've seen, um, you know through students' examples, like, they have really different ways of thinking about things.

Waverly: Yeah.

Evelyn: Even more, like, simpler ways than we do.

Waverly and Evelyn were using the reading to justify why students should be able to explore their own solution strategies when solving a problem. This justification using evidence shows a higher level of critical thinking according to the practical inquiry model.

Resolution

The resolution phase of Garrison et al.'s model involves testing solutions and applying ideas to real-world situations. Due to the nature of the discussions and the fact that these discussions took place among teacher candidates, conclusions that were drawn during the discussion could not be applied to actual real-world settings. For the purposes of this study, statements that described how ideas could be applied to an actual classroom were categorized as resolution, although that application was strictly hypothetical. Among all face-to-face discussions, there were 15 statements that were coded as resolution statements, accounting for 0.5% of face-to-face statements. Seven of these fifteen statements came from one group of participants across three discussions. Examples of resolution statements from this group that resulted from a discussion about "Fostering Mathematical Thinking and Problem Solving: The Teacher's Role" (Rigelman, 2007) are presented below.

Wendy: That's how it is in my class. Like, some of my (pause) um (pause), like, yesterday, for instance, there's a girl who's SPED and I was, um (pause) she cannot write her name. Like, she can't even write; she writes the first three letters and, like, she doesn't, she can't even tell you what some pictures are. Like, she doesn't know, she, I mean, but she's very ADHD, she's looking at you while I'm talking to her. Anyway, like, when they come in and work with her, they just give her, they just say "Do this, do that." They don't try to challenge her and say, you know, "Tell me what this is. You do know what this is." Like, and give her examples. Like, they do it for her.

Waverly: Yeah.

Evelyn: Hmmm (pause) that's sad. I just remember, like, in my first student teaching class my teacher always said, like, you know, if you (pause) like, raise the bar to a certain level and you don't accept anything below, like, those students are going to reach your expectations, so.

These participants were taking the ideas from the article and considering actual classroom experiences that the author's statements could support, thus showing evidence of a higher level of critical thinking.

Other

As the researcher was analyzing the discussion transcripts, there were several instances when participants' discussions were off-topic. Sometimes these extra conversations revolved around other aspects of the course, such as assignments and upcoming assessments; others concerned more social topics.

While 28.9% of the statements that occurred during face-to-face discussions were coded as other, these irrelevant discussions varied in length as well as in number of participants who

engaged in them. Some groups seemed to get off-topic more often than others, and some participants seemed not to want to participate in these extra discussions.

Through the data analysis process, the researcher also noted that if there were fewer participants engaged in a discussion, they seemed to stay on task more often. This was only observed in Section 1 of the course, as there were no absences during face-to-face discussions for analyzed groups in Section 2. This may be due to the time of day that each class met. Section 1 met at 8:00 am, while Section 2 met a little later at 9:30 am. Table 4 indicates the percentage of off-topic statements for each discussion and each group in Section 1 of the course. Groups A and B were the purposefully selected groups, while Group C was the randomly selected group for each discussion. Therefore, Group C represents a different group of participants for each discussion. The table also indicates the number of participants engaged in the discussion.

Table 4

Participants' Off-Topic Statements During Face-to-Face Discussions

Discussion	Number of Participants	Percentage of Off-Topic Statements
Are Rules Interfering with Children's Mathematical Understanding (Behrend, 2001)		
Group A	4	37.0%
Group B	4	20.2%
Group C	2	16.2%
Promoting Communication in the Mathematics Classroom (Whitin & Whitin, 2002)		
Group A	4	28.3%
Group B	4	40.8%
Group C	3	23.8%
Tools of Classroom Talk (Chapin, O'Connor, & Anderson, 2003)		
Group A	4	30.9%
Group B	4	27.8%
Group C	2	17.3%

It should also be noted that the group of participants that had the most integration and resolution statements also had the least number of other statements.

Online Discussions

Online discussions took place within the established groups described previously. In order to build a foundation for online discussions to occur, participants were expected to submit a minimum number of posts for each online discussion (see Appendix C). Each member of the

group was asked to post one original response to each discussion prompt as well as reply at least once to each member of the group. Since groups consisted of at most four participants, this was established in order to aid in creating an atmosphere for discussion to occur while not overloading the teacher candidate with an extensive amount of online posts to read and respond to. The majority of participants followed these minimum guidelines and did not post additional statements. Five of the 16 participants that were followed throughout the semester did not submit the minimum expected posts. There was, however, one of these 16 participants that did supply more posts than the minimum expectations.

Once all transcripts had been collected, approximately two weeks after discussions ended, the researcher coded the posts using the practical inquiry model (Garrison, et al., 2001). Since online statements were categorized in their entirety, there were significantly fewer coded statements than in face-to-face discussions. Online discussion analysis included 658 statements that will be described by level of critical thinking in the paragraphs that follow.

Triggering events

Online discussions were focused around discussion prompts posted by the instructor. Since these discussion prompts were not initiated by the participants, very few triggering events were evidenced during online discussions. A total of seven triggering events were found across all online discussions. Two of the seven triggering events initiated by participants were posted by Jana, the same teacher candidate that had posed triggering events during face-to-face discussions. The other five were posted by participants in the randomly selected groups.

Four of the triggering events that emerged during online discussions were from discussions around Reinhart's (2000) article titled "Never Say Anything a Kid Can Say!" Three of these triggering events are shared below.

Jana: I wonder if there is a good reason to ever use product questions.

Jana: What would be a benefit of using product questions, or when would they best be utilized?

Amy: What about those situations that actually benefit with rote memorization. Those situations such as memorizing multiplication facts help students with frequency in math.

None of these triggering events received responses from other group members. Thus, the discussions did not develop. One triggering statement did receive a response.

Jayme: How do product questions check for involvement?

Amy: I feel that product questions also check for involvement because they at least show that the students are listening even if the answer is simple recall or yes/no. However, I do not feel that product questions are engaging or even invoke a lot of critical thinking.

It is unfortunate that the participants did not respond to each others' questions. In particular, Jana responded to two different group members with basically the same question and neither replied with an answer to her question.

Exploration

Exploration statements accounted for 29.8% of the online discussions that were analyzed. As in face-to-face discussions, these statements were those in which participants either shared information directly from the assigned reading or offered personal experiences as a way to answer the question but without completely developing or justifying their argument. Approximately 60% of these exploration statements were participants' initial responses to the discussion questions, while the rest were replies to their group members. Since the online statements tended to be much longer than face-to-face statements, there were times when these statements contained several ideas, but never fully developed any of those ideas. These types of statements also fell into the exploration category. An example of this type of exploration statement follows.

> Charlotte: Teachers should act as a guide in the classroom discussion. The teacher should feed off the students' ideas. The teacher should ask questions in order to further the thinking of the students. This way the teacher is never providing direct instruction during the discussions but only working with the thoughts of the students. The teacher needs to provide information that will allow the students to think more critically about the math topic.

In this excerpt, Charlotte provides several ideas in response to a prompt asking about how teachers should facilitate mathematics discussion. However, she simply lists things that teachers can do without any explanation about why these actions may be helpful, nor does she reference any readings, discussions, or personal experiences to back up her statements.

Exploration-agreement

Since online statements were always complete sentences and many times several sentences, there were no posts that showed agreement with a simple "yeah" or "uh-huh," as was the case with face-to-face discussions. There were, however, several agreement statements during online discussions. Participants that agreed with a statement made by one of their group members would state that they agreed and then proceed to restate what was said. The researcher recognized these types of agreement statements more often than the exploration statements described previously. Of all online statements posted, 36.0% were categorized as exploration-agreement. Two examples of these statements, along with the statement that prompted the reply, are provided below.

> Kim: To facilitate mathematical discussion, the teacher could give the students a problem that can be solved in many different ways. Effective questions for students are questions such as reversibility, flexibility and generalization questions. Instead of asking "What is ten times three?"; the teacher should ask, "What are two numbers whose product is thirty

six?" Being able to solve the question with several different answers is more effective and leads to student communication. The teacher could also have the students come up with their own word problem and discuss the problem and method of solving with other students.

Melanie: I absolutely love the points you made. I agree with the idea that it is beneficial for the teacher to give students problems that can be solved in multiple ways. I also think flexibility and reversibility questions are beneficial. Having students create their own problems is also a great way to facilitate instruction.

Melanie's response to Kim simply restates the main ideas of Kim's statement. Melanie does not add any new information nor offer additional evidence to support Kim's statements.

Rosie: I think the teacher wants students to explore problems individually first because the teacher wants everyone to think and use their own thoughts because if they start out in a group then a student might change their strategy or answer because theirs is different from the other group members and their process is just as important as the other group members. Also, if they start out in groups sometimes only one student ends up doing all the thinking and problem solving.

Beverly: I couldn't agree more. The students tend to let one person solve the problem and the rest of the group agrees just to move on with the problem.

Again, Beverly restated Rosie's argument to show agreement with Rosie's statement. This type of reply to group members did not further the discussion and therefore did not show evidence of critical thinking.

Integration

Integration statements found during online discussions, which represented 29.6% of all online statements, contained many of the same characteristics as those found in face-to-face

discussions. The majority of integration statements were described as extending or adding additional information in response to another participant's statements. Other integration statements included referencing other sources, challenging ideas and presenting well developed, justified arguments. Examples of these different statements are provided below.

The excerpt that follows consists of two integration statements. The first was an initial response by Kaitlin to the discussion question and exhibits references to in-class discussions. Amy then extends Kaitlin's ideas with her response.

> Kaitlin: "Transitional thinking" is the step between introducing a concept and the student completely understanding the concept. This might lead to mistakes being made by the student, but as we stated in class the other day mistakes are not always a bad thing. Students should always understand what they are doing and not just do what they are told and it takes several steps between introducing the topic and understanding with complete comprehension of what is being done and why it is being done.
>
> Amy: I really like the fact that you pointed out that students should "understand" because so often in math classes students do not understand a topic. Instead, they are merely doing what's "told" without actually "learning." I feel with these courses we can move our society of teachers toward Teaching For Understanding instead of rote memorization and following these set patterns like what was taught in the past in order to gain true comprehension.

Both of these statements showed a high level of engagement in the topic and, thus, a higher level of critical thinking. In the next excerpt, however, only the response to the initial post was categorized as integration. April's initial post fell into the exploration category, but by challenging April's statement, Christy's comments fell into the integration category.

April: Problem performers are students focusing on an end or completion of a problem. These students don't have too much of a broad mind set when it comes to mathematics because they are always presented with problems that require less cognitive thinking and have a more short term memory with problems. Problem solvers on the other hand are long term problem solvers and think more cognitively.

Christy: [April], I disagree slightly with your statement about problem performers being presented with less cognitively challenging problems. I feel most of the time these students are presented with cognitively challenging problems, but at times not encouraged to discuss and communicate with their peers. The teacher should be feeding the questions in this situation, and stimulate talking among students. If the teacher presents the problem properly (without specifying a correct answer from the start), any problem can be increasingly difficult for students.

This example of challenging another participant's response did not occur very often. In fact, this represented one of only four occasions that participants challenged the ideas of another. In two instances, Jana challenged the ideas of her group members, and on the other occasion, Melanie challenged the author of the assigned reading by disagreeing with part of the author's arguments.

In the next excerpt, Jayme presented a well-developed, justified idea about transitional thinking based on the article "What Nathan Teaches Us about Transitional Thinking" (Taylor, Breck & Aljets, 2004). This is followed by Amy's response that extends Jayme's ideas while referring to earlier in-class discussions.

Jayme: Transitional thinking is the step between not understanding a new concept and having complete understanding of a concept. It is when a student is learning something new, but does not quite have total understanding of the concept. In the article, the boy

used transitional thinking when he understood the 16 to be 16 ones and not as the teacher saw it. He did not get the full picture of the ones and the tens. This thinking does have a role in the classroom. It is part of the process of understanding [what] students go through. Teachers need to respect transitional thinking and [not] be quick to say that [the] child is doing the problem incorrect.

Amy: I liked the fact that you brought up that this is part of the process students go through. I feel that this relates to what we were talking about in class the other day about mistakes and if mistakes are necessarily a "Bad" thing. Mistakes are part of life and part of the learning process. Thomas Edison made some thousand light bulbs wrong before he got it correct. He learned, therefore, some thousand ways to incorrectly build a light bulb. Everyone can – and should – learn through mistakes. If people continue to make the same mistake, then something is wrong with them. So, just like how mistakes are a part of learning and growing and developing concepts, transitional thinking is very much a part of that process. It may not be the beginning or the end of the process, but it's a VERY important part of the process. It helps explain how a student can get from one concept to the other without just stating that they did because "That's how the teacher told them to do it." For this reason, teachers should tread lightly and not step on the learning process.

These examples provide a sampling of the integration statements that the researcher observed in the online discussions. By extending, justifying and challenging their peer's statements, these participants exhibited high levels of critical thinking.

Resolution

Similar to face-to-face resolution statements, online posts that described hypothetical classroom applications were categorized as resolution statements. Eighteen statements fell into this category, representing 2.7% of all online posts. Of these, seven resolution statements arose

out of discussions around Whitin and Whitin's (2002) article titled "Promoting Communication in the Mathematics Classroom." Resolution statements from these discussions are shared below.

> Anita: Communication is useful in the mathematics classroom for many reasons. I know from experience that if I am having an issue with a particular problem and I begin to talk aloud about the problem to someone else then I begin to understand it. For some reason when my thoughts are put into words I understand them better. This could also be the same for a student in my classroom. If I allow them to communicate their thought processes to me in mathematical terms then hopefully they will have a break through and have a better understanding of the concepts. Whether it be written or oral communication, students will learn from each others comments and ideas in the mathematics classroom. Someone may look at a problem differently than someone else and when they convey their reasoning and understanding it will help other students to understand it.
>
> Melanie: When conducting a math discussion, the teacher's role is very important, however, the students should be the real leaders. I think teachers should guide the class to explore their mathematical ideas and improve their skills. Just as the teacher did in the article, it is beneficial to provide students with a problem that can be solved in many different ways. I found it effective that the problem was introduced [by] reading a book to engage the students and give the class something to relate the problem to. Having students explore their ideas while the teacher monitors the discussions is also helpful. Teachers should then allow the class to come together to share and model the ideas they came up with. During this discussion, the teacher can have children make predictions, and wrap it up by writing about their discoveries. While teachers are vital to a math discussion, we must realize the students are the ones who truly do the work.

Both Anita and Melanie describe ways that they could utilize mathematical communication in a real classroom setting. This application of ideas shows evidence of the highest level of critical thinking according to the practical inquiry model.

Other

The researcher placed statements that were considered off-topic into the "other" category. While this category accounted for over one-fourth of the statements made during in-class discussion, only two off-topic statements were recognized in online discussions, representing 0.3% of all online statements. Both of these statements were posted by Jana and were related to technical or grammatical issues within the discussion. In the first statement, Jana was informing another group member that her post did not contain any text: "I don't think your answer was submitted or something because I cannot see anything in the text box." The second statement was a reply to her own initial response to the discussion prompt in order to correct an incorrect usage of the word "their." She indicated that she should have used the word "there" instead.

Comparing Online and Face-to-Face Discussions

The first focus of this study was to address the research question "How does the level of critical thinking evident in teacher candidates' responses during online discussions compare to those in face-to-face discussions?" When looking at the levels of critical thinking evident in online versus face-to-face discussions, the researcher noticed that online discussions elicited a higher percentage of integration and resolution statements. Table 5 shows the number and percentage of statements that fell into each category based on discussion format.

Table 5

Comparison of Critical Thinking Levels in Face-to-Face and Online Formats

	Face-to-Face		Online	
Category	N	%	N	%
Triggering Event	146	4.5	7	1.4
Exploration	1342	41.5	196	29.8
Exploration—Agreement	585	18.1	240	36.0
Integration	212	6.6	195	29.6
Resolution	15	0.5	18	2.7
Other	935	28.9	2	0.3

Online discussions revealed a greater percentage of higher levels of critical thinking. Since integration and resolution statements were identified as representing high levels of critical thinking, face-to-face had a combined total of 7.1%, while online had a combined total of 32.3%. This is a very large difference. At first glance, the researcher thought that this difference was due to fewer low-level statements since face-to-face exploration statements resulted in 41.5% compared to 29.8% in online discussions. When all exploration statements, exploration and exploration-agreement, were combined, however, the gap narrowed, with 59.6% for face-to-face discussions and 65.8% for online discussions.

The researcher noticed that participants showed agreement much more often in online discussions, accounting for a large percentage of the lower level critical thinking statements. As stated earlier, very few participants disagreed or challenged the ideas of others during online discussions. This led the researcher to look for other gaps that would account for the difference

between high-level statements in face-to-face and online formats. The researcher came to the conclusion that the "other" category explained the great difference in the percentages. Almost 30% of face-to-face statements were considered to be off-topic, whereas online discussions produced virtually no off-topic statements. Although there was not a large gap in the number of low-level statements, participants did produce a much greater percentage of high level statements in the online format. This was especially true for the integration category.

After noticing these results, the researcher analyzed the levels of critical thinking based on the different readings in each format. Table 6 shows these results. Since integration and resolution statements were determined to show evidence of critical thinking, only these percentages are shared here. The entire analysis can be found in Appendix E.

Table 6

Integration and Resolution Statements by Assigned Reading

	Face-to-Face		Online	
Reading	N	%	N	%
Are Rules Interfering with Children's Mathematical Understanding? (Behrend, 2001)				
Integration	33	6.3	42	44.2
Resolution	2	0.4	4	4.2
What Nathan Teaches Us About Transitional Thinking (Taylor, Breck, & Aljets, 2004)				
Integration	37	8.9	25	34.2
Resolution	2	0.5	3	4.1
Fostering Mathematical Thinking and Problem Solving: The Teacher's Role (Rigelman, 2007)				
Integration	48	8.9	35	22.4
Resolution	5	0.9	0	0.0
Promoting Communication in the Mathematics Classroom (Whitin & Whitin, 2002)				
Integration	54	9.3	27	49.1
Resolution	4	0.7	7	12.7
The Tools of Classroom Talk (Chapin, O'Connor, & Anderson, 2003)				
Integration	9	2.2	16	19.5
Resolution	1	0.2	1	1.2
Never Say Anything a Kid Can Say! (Reinhart, 2000)				
Integration	31	4.1	50	25.4
Resolution	1	0.1	3	1.5

This analysis showed that more critical thinking was evident in online discussions than in face-to-face discussions without regard for the article or topic being discussed. Similar results were found when analyzing this data by participant (see Appendix F).

Prior Experience with Communication Technologies

The second area of interest for this study addressed the question "How does prior experience with using communication technologies impact online class discussions?" To address this question, participants were asked to provide information regarding their use of communication technologies through survey responses. For each of the communication technologies included in the survey, participants were to indicate whether they communicated using these formats daily, weekly, monthly, rarely, or never. Almost all participants indicated that they communicated through email and text messaging on a daily basis. A majority indicated communicating through social networking sites, such as Facebook or MySpace, on a daily basis. Very few participants indicated using online discussion forums on a daily basis and over half indicated that this type of communication was used either rarely or never. Complete results for this survey item are shown in Table 7.

Table 7

Participants' Use of Communication Technologies

Type of Technology	Daily	Weekly	Monthly	Rarely	Never
Email	97.2%	2.8%	0.0%	0.0%	0.0%
Text	98.6%	0.0%	0.0%	1.4%	0.0%
Social Networking Websites	88.9%	9.7%	1.4%	0.0%	0.0%
Online Discussion Forums	9.7%	20.8%	4.1%	38.9%	26.4%

Since participants indicated very similar prior experiences with communication technologies, they were indistinguishable based on this data. Therefore, the data did not provide a means for answering this question.

Interest in Discussion Topics

Finally, the researcher was interested in how existing interest in course topics impacted online discussions. The following paragraphs will address the third research question "How does prior experience with using communication technologies impact online class discussions?"

Sixteen participants' survey responses and transcripts were analyzed to address this area of the study since these participants were in the groups that were followed throughout all discussions during the semester. Through this analysis, the researcher noted two trends within the data. Some participants contributed fewer statements to topics they indicated less interest in, while some participants showed consistent levels of critical thinking across all topics, regardless of their reported level of interest. These two observations are described in detail in the paragraphs that follow.

The researcher administered a survey to determine participants' levels of interest in course topics. The majority of participants expressed that they were very interested in learning about children's mathematical thinking as well as practical teaching tips. Just over half of the participants indicated that they were very interested in learning about mathematics processes. This was also the only topic in which some participants indicated that they were not interested. The results of this item are shown in Table 8.

Table 8

Participants' Level of Interest in Course Topics

Topic	Very Interested	Somewhat Interested	Not Interested
Children's Mathematical Thinking	80.6%	9.4%	0.0%
Mathematics Processes	55.6%	40.3%	4.1%
Practical Teaching Tips	83.3%	16.7%	0.0%

Lack of participation

Two participants stood out during this analysis due to their lack of participation in topics in which they indicated little interest. Evelyn indicated that she was very interested in children's mathematical thinking and practical teaching tips, but only indicated that she was somewhat interested in mathematical processes. During online discussions, she submitted the minimum required posts for both of the discussions around her topics of interest, but did not participate at all in the discussion on mathematical processes.

Candice showed a similar trend in that she indicated the same levels of interest in the three topics as Evelyn; however, she exhibited low participation throughout all online discussions. During the first online discussion around children's mathematical thinking, Candice posted an initial response to each of the two discussion prompts; however, she only replied to one of three other group members for each discussion prompt. The minimal expectations stated that participants were to post an initial response as well as a reply to each group member for each question. Candice did not participate in the second discussion around mathematical processes. During the third discussion, practical teaching tips, she provided initial responses to the

discussion prompts, but no replies to group members. Candice also showed low levels of participation in face-to-face discussions, whereas Evelyn contributed just as much as the other members of her group during face-to-face discussions.

Although these two participants did not participate in the online discussion focused around the topic in which they indicated less interest, this does not indicate that a lack of interest will typically result in a lack of participation. Other participants also indicated less interest in mathematics processes, but participated in these discussions at the same levels as other topics. Based on the analysis of topics of interest and online participation, there is not a relationship between interest and level of participation.

Consistent levels of critical thinking

Some participants showed consistent levels of critical thinking in online discussions regardless of the topic being discussed or their indicated interest in each topic. Two participants, Hannah and Alice, posted very few integration or resolution statements throughout all online discussions. In fact, Hannah, who participated in all discussions by posting the minimum expected number of posts, only had one statement that was categorized as integration and no resolution statements across all three discussions. Alice, who participated fully in the last two online discussions, but only provided initial responses to discussion prompts during the first discussion, had two statements categorized as integration statements and no resolution statements throughout the three online discussions. It should be noted that these participants also contributed very few critical thinking statements during face-to-face discussions as well, with only two integration statements for Hannah and three integration statements for Alice. Neither participant contributed any resolution statements during face-to-face discussions.

Alternatively, there were four participants that showed high levels of critical thinking throughout all three online discussions. Their integration and resolution statements are presented as a total in Table 9.

Table 9

Participants Exhibiting High Percentage of Critical Thinking in Online Discussions

	Children's Mathematical Thinking		Mathematics Processes		Practical Teaching Tips	
Teacher Candidate	N	%	N	%	N	%
Christy	6	85.7	10	62.5	6	37.5
Jana	4	50.0	9	50.0	8	50.0
Kathy	5	62.5	6	75.0	1	12.5
Kim	6	75.0	5	62.5	2	25.0

Note. N represents integration and resolution statements combined.

All of these participants indicated that they were very interested in all topics, except Jana who indicated that she was somewhat interested in mathematics processes. This high level of critical thinking was not evident in all of these participants across all topics. Kim, however, did show high levels of critical thinking across all topics in both discussion formats.

It should be noted that the discussion around practical teaching tips that Kathy and Kim were involved in had fewer instances of integration and resolution statements due to the nature of the discussion prompts for that discussion. These participants were discussing the book chapter "Tools of Classroom Talk" (Chapin, O'Connor, & Anderson, 2003). The researcher posed questions that limited the amount of critical thinking required to answer the question. Face-to-

face discussions around this reading showed no integration or resolution statements for two groups and very few for the third group.

Since there were other participants that indicated that they were very interested in all topics, it cannot be assumed from these four participants that there exists a relationship between levels of critical thinking and levels of interest in discussion topics.

Summary

In this chapter, the researcher presented a description of the data that was collected through surveys, face-to-face discussions, and online discussions. A description of how this data addressed the research questions was also provided. The next chapter will focus on discussions around these observations as well as potential areas of future research.

CHAPTER V: DISCUSSION

Introduction

With the rapid growth in online learning opportunities, it is important for university instructors to consider the benefits and pitfalls of this type of learning environment. According to Vygotsky (1978), learning is a social process that requires the sharing of ideas among learners. One aspect of online learning includes asynchronous discussion boards (ADB), which allow learners to share ideas and engage in this social learning process. Based on the data collected during this study, ADB also provides a platform for learners to think more critically about course material than similar in-class experiences.

This chapter will provide a brief summary of the research findings, followed by a discussion of issues that arose during the data analysis. Finally, a discussion of potential areas for future research will be presented.

Summary of Findings

Based on surveys, face-to-face discussion transcripts, and online discussion transcripts for participants enrolled in an elementary mathematics methods course, the online format for discussing course readings produced more critical thinking statements than the face-to-face format. This was true for all discussions and for all participants. While some participants stood out as showing critical thinking regardless of the format used, their online statements represented a higher percentage of integration and resolution statements similar to other participants. In this study, the distribution of statements among the different categories of the practical inquiry model

remained consistent with those found in other studies (Arnold & Ducate, 2006; Bai, 2009; Fahy, 2005), with over 50% of statements being categorized as exploration statements regardless of discussion format.

The other aspect of this study focused on the impact of teacher candidates' interest in course topics on levels of critical thinking evident in online discussions. Based on the analysis of the data, there is not a relationship between a teacher candidate's interest in a topic and level of critical thinking, as these results were mixed and largely depended on the individual. Therefore, no obvious trends were noticed in this area.

Discussion

Although ADB can be beneficial to the learning process and provide opportunities for learners to think critically about the material, the researcher noticed some pitfalls to this learning environment as well. Some aspects of online discussions can hinder the development of ideas among learners. Discussion prompts may or may not lead students to think critically about the material. Also, while online discussions allow learners to share their ideas, it limits the ability of learners to extend one another's ideas or introduce new areas of discussion. Additionally, the time allotted for discussion can impact the level of critical thinking evident in those discussions. Each of these aspects will be described in the paragraphs that follow.

The Role of Discussion Prompts

Throughout all six discussions analyzed during this study, the researcher noticed that some discussions elicited more statements categorized as critical thinking than others. One discussion in particular resulted in the fewest number of integration and resolution statements in both discussion formats. "Tools of Classroom Talk," a chapter from the book *Classroom Discussions: Using Math Talk to Help Students Learn* (Chapin, O'Connor, & Anderson, 2003),

was selected by the researcher and course instructor to address the practical teaching tips theme of the course.

During face-to-face discussions around this reading, only nine integration statements and one resolution statement were found. Seven of these ten statements were the result of a discussion among two participants, as the other two group members were absent during this discussion.

The researcher does not believe that the lack of critical thinking that arose from discussions around this reading was due to the content of the reading but rather a result of the discussion questions posed to the participants. The questions participants were asked to consider included the following:

1. Describe the five talk moves. How does each support communication in the mathematics classroom?
2. What message do teachers send to students when they use talk moves to facilitate classroom discussions?

The first question required participants to list the five talk moves and use information from the chapter to describe what each talk move looked like in a classroom setting. This question required very little thinking from the participants. Many participants simply restated what was in the chapter to address this item. The second part of that question, however, is where most of the critical thinking statements arose in the group described previously. The only resolution statement was a result of this group's discussion around question number two.

During face-to-face discussions, participants were given a limited amount of time to discuss the questions and prepare a poster with their responses. During this discussion, the researcher noticed that most groups spent the majority of their discussion time listing and

describing the five talk moves and therefore ran out of time to discuss the other parts of the discussion prompts. The researcher feels that this may have led to this discussion producing less critical thinking. Since this reading has been used in this course in the past and will likely continue to be used in the future, the researcher suggests amending the first discussion prompt. Teacher candidates could either choose one talk move to focus their discussions around or the instructor could assign groups different talk moves to discuss. This would allow groups to focus their discussions around one idea instead of having so many ideas to address during one discussion.

While the online discussions around this reading did produce more critical thinking statements, 16 integration statements and one resolution statement, it still had the smallest percentage of critical thinking statements compared to other reading discussions. All groups discussing this reading online did produce some critical thinking statements, but again, eleven of the sixteen statements came from responses to the second discussion prompt, and the rest were from participants' responses to the second part of the first prompt.

Another reading discussion, "Promoting Communication in the Mathematics Classroom" (Whitin & Whitin, 2002), was notable for having produced the highest percentage of critical thinking statements in both discussion formats. Participants were to focus on the following discussion prompts for this reading:

1. Why is communication useful in the mathematics classroom?
2. How should teachers facilitate mathematical discussion?

All groups produced some critical thinking statements when discussing these prompts. The nature of these discussion prompts did not allow for participants to simply restate information from the reading but rather consider the information in the reading and develop an opinion about

the use of communication in the mathematics classroom. In addition, participants were asked to consider the teacher's role in facilitating these discussions. The second discussion prompt required participants to consider ideas beyond the reading itself in order to apply the information to a real classroom setting.

Considering both of these discussions, the researcher feels that the discussion prompts played an important role in the level of critical thinking that evolved from classroom discussions. Bai (2009) also stated that the prompt played an important role in eliciting critical thinking. In his study, Bai noted that there were no resolution statements evidenced and attributed that to the fact that the discussion prompts did not lend themselves to real-world applications. Based on the data collected in this study, course instructors should carefully craft discussion prompts in such a way that they can lead to more in-depth discussions among teacher candidates.

Triggering New Discussions

The researcher was surprised to notice that very few new discussions were triggered by participants. One possible reason for this may be that participants were given specific discussion prompts to consider and may have felt that they did not have the freedom to divert from these questions to pursue their own relevant questions. In face-to-face discussions, the researcher noticed several times that participants began discussing new topics, however, these discussions were not related to the reading or the topics that were intended to be the focus of those discussions.

Since participants were given minimum expectations for online discussions, this may have hindered the development of new, related discussions. Very few participants posted online responses beyond those that were required in order to meet the minimum expectations. Therefore, when participants attempted to trigger a new, relevant discussion, other group members did not respond. The researcher contends that these minimum expectations should

either be revised or eliminated. Eliminating minimum participation expectations could lead to two possible outcomes. Either some teacher candidates would choose not to participate at all or a more back-and-forth dialogue may occur. The researcher feels that more research is needed to analyze the impact of minimum participation expectations on online discussions.

Timing of Online Discussions

The data collected during this study showed higher levels of critical thinking emerging from online discussions as opposed to face-to-face discussions. Due to the asynchronous nature of online discussions, participants had time to consider the discussions prompts in relation to the assigned reading and craft well-thought-out responses. The time that was available to consider the question may have led to the increased level of thinking that was shown. While analyzing face-to-face and online transcripts, however, the researcher noticed less interaction during the online discussions. During online discussions, participants crafted their responses and shared them with the group; however, the participants did not establish a dialogue. Arnold and Ducate (2006) describe dialogue as comments posted that lead to responses from other participants. As was outlined in the minimum expectations for online discussions, group members did typically respond to each other members' original posts; but only on rare occasions did the original group member then respond back to what was posted. The online discussions lacked the back-and-forth dialogue that was evident in face-to-face discussions. Thus, the timing of online discussions benefitted individuals' opportunities to think critically about the material, but participants did not take advantage of this additional discussion time to extend one another's ideas.

Alternatively, during face-to-face discussions, participants did not have the opportunity to carefully consider the discussion prompts. Participants that were familiar with the assigned readings began to share initial thoughts after only a few seconds of reflection. While participants did not have the time to develop a complete response individually, they were able to extend one

another's ideas to develop a group response. The time allotted for this discussion by the instructor and the fact that groups were expected to record their ideas on a poster limited the development of these ideas. Also, since group members would often interrupt each other, some participants' ideas were cut short. Thus, the format of face-to-face discussions allows participants the opportunity to engage in dialogue and develop ideas as a group of learners; however, the timeframe in which these discussions must occur limits the level of critical thinking in which participants engage.

Through analysis of the data, the researcher recognized that engagement of teacher candidates in discussions around scholarly articles requires much forethought and planning on behalf of the instructors. Careful attention to discussion prompts, participation expectations, and timing of both online and face-to-face discussions is needed to create an environment for critical thinking to occur. Since the interactions that occur among teacher candidates during online discussions are quite different from interactions during class, instructors should consider the goals of the discussion before determining the format through which discussions will be held. If the instructor's goal is for teacher candidates to think critically about the course material, then based on the results of this study, ADB provides the best platform for that critical thinking to occur. If the instructor's goal, however, is for teacher candidates to work collaboratively toward a shared conclusion, then the researcher contends that an in-class discussion would be more appropriate.

Areas for Future Research

The integration of online learning in post-secondary education will most certainly continue to grow. With this in mind, it is important that research in this area continue as well. Based on the findings of this study, the researcher recognizes specific areas in which additional

research is needed to understand fully the impact of online learning. One area that should be investigated further is the use of minimum participation expectations for online discussions. A better understanding of how minimum expectations impact participation and critical thinking can aid university instructors when designing online learning experiences.

Other forms of communication technology are available to university instructors that were not a part of this study. Technologies such as social networking sites, synchronous discussion forums, and internet blogs are just a few of the platforms available for online learning. Research to determine the impact on learning and critical thinking using these and other platforms should be conducted and compared with research on asynchronous discussion board use to determine the most effective platforms for online learning.

In addition, the impact of group size deserves further investigation. The researcher noted that groups that consisted of only two or three participants had fewer off-topic statements than groups that consisted of four participants. Research to determine the optimal size of groups could be beneficial to university faculty wanting to make efficient use of discussion time.

Throughout this study, the researcher noticed that some teacher candidates demonstrated higher levels of critical thinking than others. One such participant was Jana, who was identified as being a PTC. Therefore, research designed to determine the impact of mathematics course completion on teacher candidates' performances in their elementary mathematics methods courses should be explored. The researcher identified process-oriented teacher candidates (PTCs) who had completed their mathematics content courses in an environment that promoted the themes presented in their elementary mathematics methods course. Researching the relationship between those that have experienced these teaching practices as a learner and learned how to

implement these practices as a teacher can be informative for making decisions around mathematics education course program offerings.

Finally, the sample of teacher candidates that participated in this study had very similar prior experiences with communication technologies. Therefore, the researcher was unable to determine if these prior experiences had an impact on online discussions. Since university campuses serve a diverse population, additional studies should be conducted using a more diverse sample of participants to determine if prior experience with communication technologies impacts online learning and interactions.

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List of Appendices

Appendix A

NAME AGE

1. How would you describe your level of interest in learning about the following topics?

	Very Interested	Somewhat Interested	Not Interested
Practical tips for teaching mathematics	☐	☐	☐
Children's mathematical thinking	☐	☐	☐
Mathematics processes such as problem solving	☐	☐	☐

2. How often do you use each of the following communication technologies?

	Daily	Weekly	Monthly	Rarely	Never
E-mail	☐	☐	☐	☐	☐
Text messaging	☐	☐	☐	☐	☐
Social networking sites (Facebook, Twitter, MySpace, etc.)	☐	☐	☐	☐	☐
Online discussion forums (Yahoo! Groups, Gtalk, AIM, etc.)	☐	☐	☐	☐	☐

3. How comfortable do you feel utilizing each of the following Blackboard features?

	Very Comfortable	Somewhat Comfortable	Not Comfortable	No Experience with this Feature
Announcements	☐	☐	☐	☐
Downloading documents	☐	☐	☐	☐
Submitting assignments (SafeAssign)	☐	☐	☐	☐
Discussion board	☐	☐	☐	☐
Sending e-mail	☐	☐	☐	☐
Accessing groups	☐	☐	☐	☐
Accessing grades	☐	☐	☐	☐

4. Which of the following best describes your learning preference?

☐ I prefer to engage only in classroom learning activities.

☐ I prefer to engage only in online learning activities.

☐ I prefer a combination of classroom and online learning activities.

5. Indicate which of the following teaching experiences you have participated in.

	Yes	No	If yes, what grade level?
Tutoring student in mathematics	☐	☐	
Observation of mathematics lesson	☐	☐	
Teaching a mathematics lessons	☐	☐	
Employed as assistant teacher	☐	☐	

6. What type of internet service do you have regular access to? Mark all that apply.

Dial-up ☐ DSL ☐ Cable ☐ Satellite ☐ Wireless ☐ I do not have regular access to the internet ☐

7. Identify the semester and location that you took each of the following courses. If you have not taken these courses yet, please indicate by marking "N/A":

MATH 245 Semester: Fall ☐ Summer ☐ Spring ☐ N/A ☐ Year: _____

Location: UM ☐ Other ☐

MATH 246 Semester: Fall ☐ Summer ☐ Spring ☐ N/A ☐ Year: _____

Location: UM ☐ Other ☐

Appendix B

Discussion Questions for Assigned Readings

Are rules interfering with children's mathematical understanding? (Behrend, 2001)

1. The author states, "A positive struggle with mathematical relationships is necessary for learning." What is meant by "a positive struggle?" Do you agree or disagree with the author's statement? Why?
2. What is the difference between learning rules and understanding the meaning behind the rules?

What Nathan teaches us about transitional thinking? (Taylor, Breck & Aljets, 2004)

1. Describe "transitional thinking" and its role in the mathematics classroom.
2. Is it important for students to make sense of mathematics or should students focus on procedures that when followed accurately will produce a correct answer? Which of these should be the focus of elementary mathematics instruction? Explain your reasoning.

Fostering mathematical thinking and problem solving: The teacher's role (Rigelman, 2007)

1. Compare and contrast "problem performers" and "problem solvers."
2. Why might a teacher have students explore problems individually before discussing solution strategies in small or large groups?
3. What should problem solving look like in the elementary mathematics classroom?
4. Should ALL students be engaged in problem solving? Why or why not?

Promoting communication in the mathematics classroom (Whitin & Whitin, 2002)

1. Why is communication useful in the mathematics classroom?
2. How should teachers facilitate mathematical discussion?

The tools of classroom talk (Chapin, O'Connor, & Anderson, 2003)

1. Describe the five talk moves. How does each support communication in the mathematics classroom?
2. What message do teachers send to students when they use talk moves to facilitate classroom discussions?

Never say anything a kid can say! (Reinhart, 2000)

1. Describe one of the suggestions that the author poses for improving mathematics instruction. Explain why it can be useful in improving mathematics instruction.
2. Why is it important to plan specific questions along with your lesson?
3. What does the author mean by "Never say anything a kid can say?"
4. What is the difference between process questions and product questions? What are the benefits of each for students? For teachers?

Appendix C

EDEL 403 Section 1 T-Th 8:00 am

Reading Discussions

Throughout this semester, some reading discussions will be held online using Blackboard's Group feature, while others will be discussed in class. For the online discussions you will be placed in a small group and all discussions will take place in your group's area on Blackboard. Each discussion will begin with a discussion prompt. Each member of the group is expected to participate in the discussion as outlined below.

Online Discussion Expectations:

- Each member of the group should respond to the initial discussion prompt
- Each member of the group should reply to each of the other members of the group at least once

These are the minimum expectations for these online discussions. Please take the opportunity to have meaningful discussions around the topics presented. Your participation in the discussion is what makes it a successful learning experience.

****Participation in both in-class and online discussions is required. Failure to participate in discussions will result in deductions to your participation grade****

Below is a schedule of reading discussions and the format of each along with participation deadlines.

		Online Discussion Timeline		
Article	**In Class or Online**	**Discussion Opens**	**Initial Response Due**	**Replies to Group Members Due**
Are Rules Interfering with Children's Mathematical Understanding?	In Class			
What Nathan Teaches Us about Transitional Thinking	Online	9/8	9/10	9/14
Fostering Mathematical Thinking and Problem Solving: The Teacher's Role	Online	9/27	9/29	10/3
Promoting Communication in the Mathematics Classroom	In Class			
Book Excerpt: The Tools of Classroom Talk	In Class			
Never Say Anything a Kid Can Say!	Online	10/13	10/15	10/19

Reading Discussions

Throughout this semester, some reading discussions will be held online using Blackboard's Group feature, while others will be discussed in class. For the online discussions you will be placed in a small group and all discussions will take place in your group's area on Blackboard. Each discussion will begin with a discussion prompt. Each member of the group is expected to participate in the discussion as outlined below.

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****Participation in both in-class and online discussions is required. Failure to participate in discussions will result in deductions to your participation grade****

Below is a schedule of reading discussions and the format of each along with participation deadlines.

		Online Discussion Timeline		
Article	**In Class or Online**	**Discussion Opens**	**Initial Response Due**	**Replies to Group Members Due**
Are Rules Interfering with Children's Mathematical Understanding?	Online	9/6	9/8	9/12
What Nathan Teaches Us about Transitional Thinking	In Class			
Fostering Mathematical Thinking and Problem Solving: The Teacher's Role	In Class			
Promoting Communication in the Mathematics Classroom	Online	9/29	10/1	10/5
Book Excerpt: The Tools of Classroom Talk	Online	10/11	10/13	10/17
Never Say Anything a Kid Can Say!	In Class			

Appendix D

Practical Inquiry Model[1]

Triggering Events		
Descriptor	Indicators	Sociocognitive Processes
Evocative	Recognizing the problem	Presenting background information that culminates in a question
	Sense of puzzlement	Asking questions
		Messages that take discussion in new direction

Exploration		
Descriptor	Indicators	Sociocognitive Processes
Inquisitive	Divergence—within the online community	Unsubstantiated contradiction of previous ideas
	Divergence—within a single message	Many different ideas/themes presented in one message
	Information exchange	Personal narratives/descriptions/facts (not used as evidence to support a conclusion)
	Suggestions for consideration	Author explicitly characterizes message as exploration—e.g., "Does that seem about right?" or "Am I way off the mark?"
	Brainstorming	Adds to established points but does not systematically defend/justify/develop addition
	Leaps to conclusions	Offers unsupported opinions

Integration		
Descriptor	Indicators	Sociocognitive Processes
Tentative	Convergence—among group members	Reference to previous message followed by substantiated agreement, e.g., "I agree because…" Building on, adding to others' ideas
	Convergence—within a single message	Justified, developed, defensible, yet tentative hypotheses
	Connecting ideas, synthesis	Integrating information from various sources—textbook, articles, personal experience
	Creating solutions	Explicit characterization of message as a solution by participant

Resolution		
Descriptor	Indicators	Sociocognitive Processes
Committed	Vicarious application to real world	None
	Tested solutions	Coded
	Defending solutions	

[1]From "Critical Thinking, Cognitive Presence, and Computer Conferencing in Distance Education," by D. R. Garrison, T. Anderson, and W. Archer, 2001, *The American Journal of Distance Education, 15,* p. 15 – 16. Copyright 2001 by Routledge. Adapted with permission of the publisher.

Appendix E

Critical Thinking Levels by Assigned Reading

	Face-to-Face		Online	
Reading	N	%	N	%
Are Rules Interfering with Children's Mathematical Understanding? (Behrend, 2001)				
Triggering Events	39	7.4	1	1.1
Exploration	192	36.5	22	23.2
Exploration—Agreement	114	21.7	26	27.4
Integration	33	6.3	42	44.2
Resolution	2	0.4	4	4.2
Other	146	27.8	0	0.0
What Nathan Teaches Us About Transitional Thinking (Taylor, Breck, & Aljets, 2004)				
Triggering Events	14	3.4	0	0.0
Exploration	183	43.9	24	32.9
Exploration—Agreement	82	19.7	20	27.4
Integration	37	8.9	25	34.2
Resolution	2	0.5	3	4.1
Other	99	23.7	1	1.4

Fostering Mathematical Thinking and Problem Solving: The Teacher's Role (Rigelman, 2007)				
Triggering Events	27	5.0	2	1.3
Exploration	220	40.9	55	35.3
Exploration—Agreement	112	20.8	63	40.4
Integration	48	8.9	35	22.4
Resolution	5	0.9	0	0.0
Other	126	23.4	1	0.6
Promoting Communication in the Mathematics Classroom (Whitin & Whitin, 2002)				
Triggering Events	25	4.3	0	0.0
Exploration	219	37.6	6	10.9
Exploration—Agreement	104	17.9	15	27.3
Integration	54	9.3	27	49.1
Resolution	4	0.7	7	12.7
Other	176	30.2	0	0.0
The Tools of Classroom Talk (Chapin, O'Connor, & Anderson, 2003)				
Triggering Events	12	2.9	0	0.0
Exploration	219	52.6	32	39.0
Exploration—Agreement	58	13.9	33	40.2
Integration	9	2.2	16	19.5
Resolution	1	0.2	1	1.2
Other	117	28.1	0	0.0

Never Say Anything a Kid Can Say! (Reinhart, 2000)				
Triggering Events	29	3.8	4	2.0
Exploration	309	40.9	57	28.9
Exploration—Agreement	115	15.2	83	42.1
Integration	31	4.1	50	25.4
Resolution	1	0.1	3	1.5
Other	271	35.8	0	0.0

Appendix F

Critical Thinking Levels by Participant

	Face-to-Face		Online	
Participant	N	%	N	%
Alice				
Triggering Event	5	7.5	0	0.0
Exploration	23	34.3	14	43.8
Exploration—Agreement	15	22.4	16	50.0
Integration	3	4.5	2	6.3
Resolution	0	0.0	0	0.0
Other	21	31.3	0	0.0
April				
Triggering Event	8	6.3	0	0.0
Exploration	62	48.4	11	27.5
Exploration—Agreement	13	10.2	19	47.5
Integration	6	4.7	9	22.5
Resolution	1	0.8	1	2.5
Other	38	29.7	0	0.0
Beverly				
Triggering Event	11	4.7	0	0.0
Exploration	91	39.1	18	47.4
Exploration—Agreement	39	16.7	5	13.2
Integration	16	6.9	15	39.5
Resolution	1	0.4	0	0.0
Other	75	32.2	0	0.0

Candice				
Triggering Event	5	7.0	0	0.0
Exploration	32	45.1	1	16.7
Exploration—Agreement	13	18.3	0	0.0
Integration	6	8.5	5	83.3
Resolution	0	0.0	0	0.0
Other	15	21.1	0	0.0
Charlotte				
Triggering Event	7	4.4	0	0.0
Exploration	81	50.9	5	33.3
Exploration—Agreement	8	5.0	4	26.7
Integration	5	3.1	5	33.3
Resolution	0	0.0	1	6.7
Other	58	36.5	0	0.0
Christy				
Triggering Event	1	1.2	0	0.0
Exploration	40	47.6	9	23.1
Exploration—Agreement	10	11.9	8	20.5
Integration	5	6.0	22	56.4
Resolution	0	0.0	0	0.0
Other	28	33.3	0	0.0
Evelyn				
Triggering Event	1	1.2	0	0.0
Exploration	32	39.0	5	31.3
Exploration—Agreement	21	25.6	6	37.5
Integration	14	17.1	4	25.0
Resolution	3	3.7	1	6.3
Other	11	13.4	0	0.0

Hannah				
Triggering Event	3	2.8	0	0.0
Exploration	46	43.4	13	33.3
Exploration—Agreement	24	22.6	25	64.1
Integration	2	1.9	1	2.6
Resolution	0	0.0	0	0.0
Other	31	29.2	0	0.0
Jana				
Triggering Event	24	10.4	2	4.8
Exploration	99	43.0	11	26.2
Exploration—Agreement	28	12.2	6	14.3
Integration	5	2.2	19	45.2
Resolution	0	0.0	2	4.8
Other	74	32.2	2	4.8
Kathy				
Triggering Event	7	4.9	0	0.0
Exploration	70	49.3	3	12.5
Exploration—Agreement	32	22.4	9	37.5
Integration	10	7.0	11	45.8
Resolution	0	0.0	1	4.2
Other	24	16.8	0	0.0
Kim				
Triggering Event	2	3.4	0	0.0
Exploration	26	44.1	3	12.5
Exploration—Agreement	8	13.6	8	33.3
Integration	6	10.2	10	41.7
Resolution	0	0.0	3	12.5
Other	17	28.8	0	0.0

Melanie				
Triggering Event	2	1.0	0	0.0
Exploration	62	31.6	3	12.5
Exploration—Agreement	66	33.7	12	50.0
Integration	8	4.1	8	33.3
Resolution	1	0.5	1	4.2
Other	57	29.1	0	0.0
Rosie				
Triggering Event	2	0.9	0	0.0
Exploration	73	34.0	12	30.
Exploration—Agreement	64	29.8	21	52.5
Integration	17	7.9	7	17.5
Resolution	1	0.5	0	0.0
Other	58	27.0	0	0.0
Tiffany				
Triggering Event	2	1.9	0	0.0
Exploration	39	36.1	15	39.5
Exploration—Agreement	14	13.0	17	44.7
Integration	8	7.4	6	15.8
Resolution	0	0.0	0	0.0
Other	45	41.7	0	0.0
Waverly				
Triggering Event	16	8.2	0	0.0
Exploration	72	36.9	8	44.4
Exploration—Agreement	44	22.6	2	11.1
Integration	24	12.3	7	38.9
Resolution	1	0.5	1	5.6
Other	38	19.5	0	0.0

Wendy				
Triggering Event	5	3.7	0	0.0
Exploration	66	48.9	7	36.8
Exploration—Agreement	26	19.3	5	26.3
Integration	10	7.4	6	31.6
Resolution	3	2.2	1	5.3
Other	25	18.5	0	0.0

VITA

Julie Stephens James was born in Dallas, Texas, but moved to Booneville, Mississippi, at a very young age and was raised there by her parents, David and Marylin Jones. After graduating as Salutatorian from Booneville High School in 1996, she accepted a scholarship to Mississippi University for Women where she majored in Secondary Mathematics Education. She graduated cum laude from MUW in 2000.

Shortly thereafter, in September 2000, Julie became the mother to twin boys, Charlie and David, with a third son, Jamie, arriving in February 2002. In August 2002, she began teaching mathematics at North Pontotoc High School in Ecru, Mississippi. While teaching, she began her graduate studies and obtained a Master of Arts in Teaching degree from Grand Canyon University in December 2006. Also in 2006, Julie married William James of Memphis, Tennessee.

In 2007, Julie began her doctoral studies at the University of Mississippi as a fellow with the Center for Mathematics and Science Education. During her time at Ole Miss, Julie gained rich experiences through teaching courses in mathematics education, presenting at state, regional and national conferences, and participating in professional development for in-service teachers. She also served profession organizations as a journal reviewer for the National Council for Teachers of Mathematics, as well as a reviewer for speaking proposals for the Association of Mathematics Teacher Educators' annual meeting. In 2010, Julie was awarded the Outstanding Doctoral Student in Secondary Education Award.