5-2014

Using an online forum to mentor secondary mathematics student teachers toward standards-based instruction.

Landrea Miriti
University of Louisville

USING AN ONLINE FORUM TO MENTOR SECONDARY MATHEMATICS STUDENT TEACHERS TOWARD STANDARDS-BASED INSTRUCTION

By

Landrea Miriti
BA Seton Hall University 1982
MA Montclair State University 1987

A Dissertation Submitted to the Faculty of the
College of Education and Human Development of
the University of Louisville in Partial Fulfillment
for the Degree of

Doctor of Philosophy

Department of Middle and Secondary Education
University of Louisville
Louisville, Kentucky

May 2014

USING AN ONLINE FORUM TO MENTOR SECONDARY MATHEMATICS STUDENT TEACHERS TOWARD STANDARDS-BASED INSTRUCTION

By

Landrea Miriti
BA Seton Hall University 1982
MA Montclair State University 1987

A Dissertation Approved on

April 4, 2014

By the Following Dissertation Committee

Maggie Mc Gatha-Dissertation Director

Jenny Bay-Williams

William Bush

Karen Karp

Carl Lee

DEDICATION

This dissertation is dedicated to my parents,

Dr. Vernon Williams

and

Rev. Doris Leake Williams,

on whose shoulders I stand.

ACKNOWLEDGEMENTS

I want to thank my dissertation advisor, Maggie McGatha for her wonderful support, guidance and encouragement. I would also like to thank all of the members of my dissertation committee, Jenny Bay-Williams, Bill Bush, Karen Karp and Carl Lee, for their constructive feedback.

I want to thank all family and friends who helped to care for my children at times when I needed to focus on course work.

I want to thank my daughters, Ntinyari, Kangai and Kathuure, for taking care of their "baby" sister, Kanario, during the times when I was working on my dissertation.

I want to thank my study pals, Cindy, Mona, Robin, Tiana and Tonja. I could not have made it this far without all of you.

Finally, I would like to thank my husband, Kimathi, for all his support and encouragement during this seven-year long journey.

ABSTRACT

USING AN ONLINE FORUM TO MENTOR SECONDARY MATHEMATICS STUDENT TEACHERS TOWARD STANDARDS-BASED INSTRUCTION

Landrea Miriti

May 9, 2014

Student teaching is the fundamental field experience where pre-service teachers have the opportunity to conceive and develop standards-based instructional practices under the guidance of mentors. Yet, research reveals that mentoring for novice teachers is most often focused on providing technical and emotional support rather than supporting teachers learning to teach with standards-based instructional practices (Wang and Odell, 2002). In addition, university supervisors' efforts to mentor mathematics student teachers toward standards-based instructional practices are hindered by their limited opportunities to meet with their assigned student teachers (Borko & Mayfield, 1995; Frykholm, 1996). Online social networking provides an opportunity for consistent communication between university supervisors and student teachers about student teachers' daily experiences. This study investigated the potential of online social networking as a venue for a university supervisor to mentor secondary mathematics student teachers' toward the following standards-based instructional practices: (a) elevating conceptual understanding and surfacing "big" mathematical ideas, (b) eliciting and attending to students'

mathematical thinking, (c) connecting mathematics to real-life contexts, (d) using and connecting a variety of representations, (e) facilitating active discovery and mathematical investigations, and (f) promoting student collaboration and mathematical discourse. The online mentoring conversations between a university supervisor and four secondary mathematics student teachers were analyzed for content related to standards-based instruction. Qualitative analysis of the online mentoring content revealed that online social networking was an effective venue for a university supervisor to mentor student teachers toward some aspects of standards-based instruction. In addition, online social networking proved to be a site for tracking and documenting student teacher's developing conception and implementation of standards-based instruction.

Keywords: mentoring student teachers, online mentoring, standards-based instruction, university supervisor, secondary mathematics student teachers

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Problem Statement

Student teaching is a pivotal opportunity for learning to teach under the guidance of mentors (Feiman-Nemser & Buchmann, 1987; National Council for Accreditation of Teacher Education (NCATE), 2010; Wilson & Ferrini-Mundy, 2001; Zeichner, 2002). In particular, student teaching presents an opportunity for mentors to help mathematics student teachers connect theory with practice by implementing standards-based instructional practices. Several studies suggest that purposeful and frequent conversations between student teachers and their mentors facilitated student teachers' learning about standards-based mathematics instruction (Bennett, 2010; Blanton, Berenson & Norwood, 2001; Nilssen, 2010; Wang & Odell, 2002 Wang & Paine, 2001). Due to the structure of most teacher education programs, university supervisors visit student teachers only a few times throughout the semester to observe and provide feedback about student teachers' practices. Consequently, university supervisors' efforts to mentor mathematics student teachers toward standards-based instructional practices may be hindered by their limited opportunities to meet with their assigned student teachers (Borko & Mayfield, 1995; Frykholm, 1996). Furthermore, unlike cooperating teachers, who are on-site, university supervisors are often disconnected from the context of student teachers' day-to-day experiences that could serve as catalysts for discussions about standards-based teaching.

Purpose Statement

Online social networking provides an opportunity for consistent communication between university supervisors and student teachers about student teachers' daily experiences. In recent years, various forms of online social networking (e.g., My Space, Facebook, Twitter, weblogs) have emerged and evolved as popular tools for connecting and communicating with others about one's daily life experiences. Similarly, online social networking has the potential to connect university supervisors to student teachers' daily teaching experiences. Moreover, online social networking provides a venue for university supervisors' to help student teachers learn about standards-based teaching practices by communicating with student teachers' about their daily student teaching experiences. The purpose of this study was to investigate the potential of online social networking as a venue for mentoring secondary mathematics student teachers toward standards-based instructional practices.

Research Questions

1) What is the content of mentoring secondary mathematics student teachers for standards-based instruction in an online environment?
    a) What is the content of mentoring in an online environment in relation to the following aspects of standards-based instruction:
        - elevating conceptual understanding and surfacing 'big' mathematical ideas
        - eliciting and attending to students' mathematical thinking,
        - connecting mathematics to real-life contexts,
        - using and connecting a variety of representations,

- facilitating active discovery and mathematical investigations, and
- promoting student collaboration and mathematical discourse,

b) What mentoring processes emerge when mentoring secondary student teachers toward standards-based instruction in an online environment?

2) How are online comments and mentoring conversations related to mathematics student teachers' developing conception of standards-based teaching practices? (Online mentoring conversations are defined as segments of online communications that include at the minimum, a student teacher's initial blog post and a response from the university supervisor. In addition, mentoring conversations could include follow-up responses from the student teachers or the university supervisor.)

a) What do mathematics student teachers' online comments reveal about their developing conception and implementation of standard-based practices?

b) How are mathematics student teachers' self-reported conception and implementation of standards-based instructional practices related to online mentoring conversations about standards-based teaching?

Theoretical Framework

Since the introduction of National Council of Teachers of Mathematics' Standards (NCTM; 1989, 2000) outlining a reform vision of school mathematics programs, mathematics teacher educators have been challenged to create comprehensive teacher education programs to prepare future teachers to enact the mathematics instruction that is central to that vision. Learning about standards-based teaching through field experiences is an essential component of an effective pre-service mathematics teacher education program. Student teaching is the fundamental field experience where pre-service teachers

have the opportunity to conceive and develop standards-based instructional practices under the guidance of mentors. Yet, Wang and Odell's (2002) critical literature review of over 200 studies reveals that the content and processes for mentoring novice teachers is most often focused on providing technical and emotional support rather than supporting teachers' learning to teach with standards-based instructional practices. Moreover, Wang and Odell (2002) conclude that mentoring that focuses on technical and emotional support may promote retention but it does not facilitate student teachers' learning to critically examine their own practice and implement standards-based teaching practices. Consequently, Wang and Odell (2002) assert that researchers need to explore the content and processes of mentoring for standards-based teaching. Furthermore Wang and Odell (2002) assert that case studies can illustrate mentoring practices for novices learning about standards-based teaching. This study addressed Wang and Odell's (2002) assertions by examining the content and processes of cases of mentoring secondary mathematics student teachers for standards-based teaching.

Standards-Based Mathematics Instruction

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM, 2000) outlines the essential components of "high-quality, engaging mathematics instruction" (p.3). In particular, the six principles for school mathematics (Equity, Teaching, Assessment, Learning, Technology, Curriculum) and the five process standards (Communication, Problem-Solving, Connections, Reasoning and Proof, and Representation) are the over-arching themes that inform the classroom practices that compose standards-based mathematics instruction (NCTM, 2000). The over-arching themes of standards-based mathematics instruction are echoed in Wang and

Odell's (2002) description of standards-based teaching practices across all disciplines. Wang and Odell (2002) assert that standards-based instruction is manifested in teachers that

> stress the importance of students' deeper understanding of concepts and relationships of concepts… as opposed to memorization of isolated facts, concepts and theories; challenge students' misconceptions and connect students' learning meaningfully with their personal experiences and real life context; place students' 'active discovery' of important ideas at the center and encourage students to share and examine what they find through discourse" and strive to teach all students and promote excellence for students whatever their gender, race and social, cultural, and economic backgrounds (Wang & Odell, 2002, p. 484).

For this study, I synthesized Wang and Odell's (2002), cross disciplinary description of standards-based instruction above with NCTM's (2000) vision for teaching mathematics to define standards-based mathematics instruction as consisting of the following teacher actions:

- elevating conceptual understanding and surfacing 'big' mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations, and
- promoting student collaboration and mathematical discourse.

This definition of standards-based mathematical instruction served to characterize and delineate aspects of standards based instruction so that they could be easily identified and explored in the context of this study. Active discovery refers to an approach to instruction where students explore and manipulate objects or situations in order to derive patterns, concepts or rules for themselves. Connecting mathematics to real-life contexts refers to linking mathematics curriculum topics to contexts such as science, business, sports, music, current events, health care or personal finance.

Mentoring Toward Standards–Based Instruction

Wang and Odell (2002) reviewed over 200 studies, published after 1995, about mentoring of novice teachers. As previously mentioned, Wang and Odell's (2002) literature review revealed that most mentoring processes for novice teachers are focused on technical/emotional support and on promoting retention rather than supporting novice teachers' learning standards-based teaching. Furthermore, Wang and Odell (2002) assert that mentors and researchers should explore the content and processes of mentoring toward standards-based instruction. Analysis of case study literature where mentors influenced novice teachers' learning to teach in ways consistent with standards-based teaching suggests that mentoring student teachers toward standards-based instruction involves (a) purposefully and consistently using specific teaching events as the catalysts for engaging student teachers in reflection and dialogue about their beliefs, subject matter knowledge, and developing practice; (b) challenging student teachers to reinterpret and reexamine teaching events in light of standard-based teaching practices and (c) offering specific suggestions and reasons for standards-based practices to be implemented in student teachers' current practice (Bennett, 2010; Blanton, Berenson, & Norwood, 2001;

Nilssen, 2010; Wang & Odell, 2002; Wang & Paine, 2001; Wang, Strong, & Odell, 2004). In this study, the university supervisor/researcher employed the processes described above to mentor student teachers toward standards-based instruction.

Significance of Study

This study was significant because it explored the potential of the popular venue of online social networking to address two persistent issues in student teacher education: the need to enhance university supervisor-student teacher mentoring relationships and the need to support student teachers' learning about standards-based mathematics instruction.

According to Feiman-Nemser & Buchmann (1987), mentors must be "actively present in student teaching" (p. 272) to help student teachers become reflective and critical practitioners and to develop dispositions and skills that focus on underlying principles of student learning. Yet, much research points to the fact that mentors, especially university supervisors, often have a limited impact on student teachers' learning of a broad range of skills and dispositions (Borko, & Mayfield, 1995; Feiman-Nemser & Buchmann, 1987; Fernandez & Erbilgin, 2009; Hawkey, 1998; Whitney, Golez and Nagel, 2002). Due to the structure of many teacher education programs, the occasions for interaction between student teachers and their university supervisors are often limited to three or four post-observation conferences throughout a student teaching semester. Both university supervisors and student teachers have expressed dissatisfaction and frustration with these time constraints (Richardson- Koehler, 1988; Borko, & Mayfield, 1995). As a result of limited interactions, university supervisors' feedback and suggestions may be based on insufficient knowledge about student teachers' teaching and thus feedback may be resented or dismissed by student teachers (Richardson- Koehler,

1988). Moreover, minimal interactions between a university supervisor and student teacher contribute to the perception of the university supervisor as an "outsider" and a "threat" in the student teaching triad (Slick, 1997, p. 713). In summary, minimal interaction between university supervisors and student teachers has been a barrier to the development of effective university supervisor-student teacher mentoring relationships. In this study, this barrier was remediated through the use on online social networking as a medium for frequent communication between a university supervisor and her assigned student teachers about their daily student teaching experiences. This study was different from other studies on mentoring student teachers in that mentoring for this study occurred primarily in an asynchronous online environment with limited opportunities for face-to-face observations and feedback. As discussed earlier, limited opportunity for face-to-face observation and mentoring sessions is a prevalent reality in university supervisor-student teacher mentoring relationships. This study was relevant to mathematics' teacher education because it explored the use of online mentoring to guide and monitor student teachers' conceptions and implementation of standards-based teaching practices. In addition, this study addressed the lack of research on the dynamics of online mentoring of secondary mathematics student teachers.

Delimitations

This study examined the online mentoring conversations between one university supervisor who was the researcher for this study and a selected sample of secondary mathematics student teachers enrolled in a Masters with Initial Certification program at a large university in the southeastern United States. Although this research study is limited to a specific mentoring context, the insights gained from this research study can inform

other researchers and teacher educators about the processes involved in using online mentoring to support student teachers' learning about standards-based instruction.

Assumptions

Study participants' online blog posts and responses honestly reflected their experiences with implementing various teaching strategies and their interpretation of those experiences. Study participants answered all interview questions openly and honestly.

Overview of the Following Chapters

Chapter 2 will review literature relevant to the core components of this study:

- teacher educators' efforts to use online communications to enhance pre-service teachers' learning from field experiences,
- university supervisors' role in mentoring student teachers, and
- mentoring practices that support novice teachers' movement toward standards-based mathematics instruction.

Chapter 3 will describe the context for this study, the study participants, the research methodology and the data analysis procedures.

Chapter 4 will describe the findings

of this study as related to the research questions.

Chapter 5 will relate this study's findings to research literature and discuss implications of specific findings of this study for teacher education and future research.

CHAPTER 2: LITERATURE REVIEW

Pre-service Teachers' Online Communications about Field Experiences

Overview

This section will synthesize literature on the use of online communications to enhance pre-service teachers' learning during field experiences. Specifically, this section will

- summarize teacher educators' motivations for incorporating online communications as a component of field experiences,
- highlight the promising outcomes linked to pre-service teachers' communicating online about their field experiences,
- surface the pitfalls and challenges encountered by teacher educators when integrating online communications with field experiences, and
- illuminate factors that promote productive online communications about pre-service teachers' field experiences.

Moreover, this review lays the groundwork for future research on the use of online communications between student teachers and teacher educators about field experiences. Consequently, this review has particular implications for the design of my study.

Motives for and Outcomes from the Use of Online Communications

Teacher educators have introduced online communications as a component of field experiences with the hope that online communications can help pre-service teachers

connect with their peers and instructors, reflect meaningfully about teaching practice and connect concepts learned in coursework to their practicum experiences. Although there are limited number of studies that explore pre-service teachers' online communications during their field experiences, research reveals promising outcomes in relation to the use of online communications to (a) alleviate pre-service teachers' isolation during field experiences(Ben-Peretza & Kupferbergb 2007; Delvin-Scherer& Daly, 2001; Edens, 2000; Fry & Bryant ,Winter 2006-2007; Hsu, 2004; Roddy, 1999; Schlagal, Trathen, & Blanton, 1996; Wright, 2010; Yang, 2009), (b) stimulate pre-service teachers' reflection on field experiences (Levin, 1999; Schlagal et al., 1996; Wright, 2010; Yang, 2009, and (c) support pre-service teachers in connecting theory to practice in field experiences(Barnett, Harwood, Keating & Saam, 2002; Delvin-Scherer 2001; Roddy, 1999; Schlagal et al., 1996; Yang 2009).

Alleviating pre-service teachers' isolation during field experiences.

Isolation from peers and university professors is a common and often frustrating reality for pre-service teachers during their practicum experiences. The innovation of online communication has served to connect those that might be separated by distance or other constraints on meeting face-to-face. Consequently, teacher educators and researchers have explored the use of ever-evolving forms of online communication to address pre-service teachers' isolation during field experiences. Through various online mediums (e-mail, discussion boards, online journals, blogging or weblogs, Twitter), teacher educators have provided opportunities for pre-service teachers to share their descriptions and interpretations of their practicum experiences. No matter the format for online communications, a common finding from research on student teachers' online

communications is that sharing field experiences with peers and mentors online has helped to mitigate student teachers' isolation during their practicums (Ben-Peretza & Kupferbergb 2007; Delvin-Scherer& Daly, 2001; Fry & Bryant, 2006-2007, Winter; Hsu, 2004; Roddy, 1999; Schlagal, et al., 1996; Souviney & Saferstein, 1997; Wright, 2010; Yang, 2009). Furthermore, findings from many studies illustrate that providing a venue for pre-service teachers to discuss their field experiences created online discourse communities where pre-service teachers and teacher educators co-construct meaning about real classroom teaching experiences (Barnett et al., 2002; Ben-Peretza & Kupferbergb 2007; Delvin-Scherer& Daly, 2001; Edens, 2000; Fry & Bryant ,Winter 2006-2007; Hsu, 2004; Roddy, 1999; Schlagal, et al., 1996; Souviney & Saferstein, 1997, Wright, 2010; Yang, 2009). These studies and their implications will be discussed in more detail later is this literature review.

Stimulating pre-service teachers' reflection on field experiences.

Teacher educators are charged with developing teacher candidates who are reflective practitioners. Thus, a second motivation for incorporating online communications as a component of field experiences is to provide a venue for engaging pre-service teachers in reflection about their internship experiences. A variety of definitions of reflection have been embraced by teacher educators and researchers. Discussing the various meanings of reflection is beyond the scope of this literature review. Nevertheless, based on however reflection is conceived by the particular researcher, researchers have identified pre-service teachers' reflective thinking in various forms of online communications. For example, Schlagal, Trathen and Blanton (1996) reviewed the e-mail communications between 16 student teachers and their university

professors and found that “several substantive strands of reflective dialogue emerged during the school year” (p. 178). Levin (1999) examined the purpose and content of different kinds of online communication about field experiences among 28 pre-service elementary teachers enrolled in a teaching program at the University of North Carolina. Levin found that 86 to 100% of pre-service-service teacher asynchronous posts on a threaded discussion board were coded as “reflective in nature” (p. 149). Yang (2009) analyzed the blogging content of 43 secondary student teachers in Taiwan and found that the pre-service teachers’ blog posts about their student teaching experiences included both “descriptive and critical reflections” (p.15). Moreover, the percentage of critical reflections increased when instructors intervened in the blog discussion. Wright (2010) examined the value of using Twitter to generate and develop self-reflection during a teaching practicum for secondary student teachers in New Zealand. Based on her findings, Wright (2010) concluded that Twitter served to chronologically log the reflective thinking of pre-service teachers who were required to tweet two to three times a day during a seven-week teaching practicum. She found that 175 out of 494 total tweets by pre-service teachers in her study were “reflective” (Wright 2010, p.261). Furthermore, the study participants reported that the 140-character limit in Twitter forced them to “focus their thinking to reflect purposefully on their experiences” (Wright, 2010, p. 263). The examples above illustrate that various forms of online communication can be a venue for pre-service teachers’ reflective thinking about their practicum experiences.

Yet, some researchers report that pre-service teachers' online reflections about their field experiences are sometimes limited in scope and depth (Edens, 2000; Killeavy & Moloney, 2010; Schlagal et al, 1996; Wpoereis, Sloepa & Poortman, 2010). For

example, Schlagal et al. (1996) found that some student teachers' e-mail reflections "did not rise above the level of routine uninspired summations of experience" (p.181). In Edens' (2000) study of the online discussions among 90 pre-service teachers, the study participants' reflections on their field observations tended to be superficial and included incorrect or unsubstantiated inferences. Wopereis, Sloepa and Poortman, (2010) found that "thematic, sequential and spiral reflection" was lacking in student teachers weblog posts about their internship experiences (p. 258). Although the student teachers in Woperresis et al.'s (2010) study wrote a considerable number of reflective weblog posts during their 8-week internship, their reflections were mainly focused on single incidents related to classroom management. Finally, Killeavy and Moloney (2010) studied the use of weblogs to support first-year teachers' reflection on teaching practice and found that most of the beginning teachers' weblog posts were classified at a low level of reflection because they involved "descriptions of practice or of current state rather than analysis" (p. 1075) The researchers concluded that they erroneously assumed that the first year teachers were familiar with reflection methods from their pre-service education. Thus, the research above suggests that one potential pitfall in the use of online communications is that pre-service teachers may not routinely reflect in-depth on a broad scope of their field experiences in an online format (Edens, 2000; Killeavy & Moloney, 2010; Schlagal et al.,1996; Wopereis et al., 2010). Consequently, when using online communications as a venue for pre-service teachers' reflective thinking, teacher educators need to incorporate strategies to elicit pre-service teachers' expression of in-depth reflective thinking about a significant range of topics related to teaching. Strategies to promote pre-service reflective thinking in online forums will be discussed later in this review.

Helping pre-service teachers connect theory to practice in field experiences.

Practicum experiences are pivotal occasions for pre-service teachers to connect theory to practice. Thus, a third motivation for incorporating online communications as a component of field experiences is to enhance opportunities for pre-service teachers to apply theory learned in coursework to their real practicum experiences. Only a few studies specifically address findings related to practicum teachers linking theory to practice within an online forum. (Barnett et al., 2003; Ben-Peretza & Kupferberg, 2007; Delvin-Scherer 2001; Edens, 2000; Fry & Bryant, Winter 2006-2007; Roddy, 1999; Schlagal et al., 1996; Souviney & Saferstein, 1997; Yang 2009). In general, research reveals that when pre-service teachers are simply provided with an online forum to share their field experiences, the number of instances where pre-service teachers relate theory to practice are non-existent or small in comparison with numerous communications about other issues such as classroom management, school policies and procedures, and relationships with students, teachers and parents (Ben-Peretza & Kupferberg, 2007; Edens, 2000; Souviney & Saferstein,1997; Yang, 2009). Edens (2000) analyzed the discussion board comments of pre-service teachers during an early field experience and found that while pre-service teachers contributed many discussion board postings about topics and concepts related to university course work, there were "no concrete examples of classroom applications to learning theory" (p. 17). Similarly, Ben-Peretza and Kupferberg (2007) explored the interactive learning process in an asynchronous online forum among 12 female student teachers in Israel, and found that the student teachers' online discussions focused primarily on pedagogical issues and interpersonal relations. Moreover, there was an absence of theoretical considerations or justifications related to

their teaching experiences (Ben-Peretza & Kupferberg, 2007). Souviney and Saferstein, (1997) analyzed the topics of e-mail communications between student teachers and university supervisors across three years and found that the majority were about procedural, academic or personal concerns. E-mail communications focused on clinical inquiries about teaching practice were as low as 7% during the first year of the study and only increases to 32 % by the third year of the study (Souviney & Saferstein , 1997). A similar rate was cited in Yang's (2009) findings about the topics of secondary student teachers weblogs: Only 324 out of 977, about 33%, of student teachers weblog discussions were related to theories of teaching. Thus, opportunities for the student teachers, in both Souviney and Saferestein's (1997) and Yang's (2009) study, to connect theory to practice via online communication were constrained by the limited number of communications relating instructional practical to teaching theories. Thus, another potential pitfall in the use of online communications to help pre-service teacher apply theory to their field experiences is that occasions to discuss theory-practice connections may not surface often in the content of online communications.

Although theory-to-practice connections are not prominent in studies about pre-service teachers' online communications, a few researchers have described some episodes where, in an online forum, pre-service teachers meaningfully applied theory to their field experiences. (Barnett et al. 2003; Delvin-Scherer & Daly, 2001; Roddy, 1999; Schlagal et al., 1996; Yang, 2009). These episodes will be discussed in the next section. Moreover, the next section will highlight the role of the teacher educator in helping pre-service teachers to connect theory to their field experiences.

Factors that Promote Productive Online Communications

Overview.

Online communication has the potential to address the following overarching goals of teacher preparation programs: to create a community of collaborative learners, to engage pre-service teachers' in reflective thinking and to meaningfully ground theory in practice. The challenge for teacher educators is to structure and facilitate meaningful online communications that maximize the possibility of achieving these goals. Research suggests that to promote online communications that (a) build learning communities, (b) elicit reflective thinking and (c) help connect theory to practice teacher educators should

- require frequent pre-service teacher participation in online communications (Delvin-Scherer 2001; Fry & Bryant, Winter 2006-2007; Hsu , 2004; Schlagal et al., 1996; Wright, 2010; Yang, 2009),
- provide structure and guidelines for the content of pre-service teachers' online communications (Delvin-Scherer & Daly, 2001; Edens, 2000; Pena & Amlaguer, 2007; Schlagal et al., 1996; Wopereis et al., 2010; Wright, 2010), and
- actively and consistently respond to pre-service teachers' online communications in ways that probe and challenge pre-service teachers' thinking (Barnett et al., 2003; Roddy, 1999, Schlagal et al, 1996; Yang, 2009).

Frequent pre-service teacher participation.

Requiring pre-service teacher's frequent communication about field experiences is a key factor in promoting effective online communication. In various studies where researchers concluded that pre-service teachers developed a collaborative and supportive community, regular participation in online communication was required. (Delvin-Scherer

& Daly, 2001; Schlagal et al., 1996; Yang, 2009; Wright, 2010). In Schlagal et al.'s (1996) study, student teachers were required to send at least two e-mail messages a week to their peers and university professors. The researchers assert that the use of e-mail helped "teacher educators to maintain vital links with student teachers" and created a "community of discourse" among student teachers and teacher educators (p.181). Furthermore, the researchers observed that connections created via e-mail helped to forge student teacher peer communities that continued beyond their internship year. Similarly, Delvin-Scherer and Daly (2001) found that an online discussion group for university professors and student teachers became a source for ideas and support among student teachers. In their study, student teachers were required to post structured assignments (which included classroom observations, reflections on readings, reviews of on-site curriculum materials and interviews with teachers and students) in an online discussion forum. In addition, they were required to post some other communication at least once a week. The other postings could relate to assignments or readings, respond to another student teacher's reflection, or present a concern, question or accomplishment related to their student teaching. Yang (2009) describes the online blogging among a group of 43 student teachers as "a community of practice" because it became a forum for student teachers and their university professors to reflect on issues related to teaching (p. 18). The student teachers in Yang's (2009) study were required to write a reflective blog post after every practical teaching experience during a nine week internship. In addition, student teachers made elective comments about other student teachers' posts. In Wright's (2010) study on the use Twitter among student teachers, each study participant was required to tweet at least 3 times a day about their daily student teaching experiences. She found that

all her study participants valued the regular contact with their fellow student teachers. Moreover, the study participants indicated that communicating through Twitter helped to mitigate feelings of "isolation and emotional overload" (p. 262). In summary, the examples above illustrate that supportive and collaborative online communities emerged in various online formats where pre-service teachers were required to participate in online communications on a regular basis.

On the other hand, in studies where pre-service teachers' participation in online communications about their field experiences was optional, online communications were infrequent and of little value to pre-service teachers (Fry & Bryant, 2006-2007; Hsu, 2004). For example, Fry and Bryant (2006-2007) found that despite the fact that the elementary student teachers in their study were in rural and isolated field placements, only 4 out of 15 student teachers participated in discussion board conversations more than four times throughout the semester. Consequently, the student teachers in Fry and Bryant's (2006-2007) study did not view discussion board as a venue for support and collaboration because of the scarcity and lack of immediacy of responses from their peers. In Hsu's (2004) study, student teachers were asked to voluntarily post and discuss, in an online forum, case studies based on their reflection about problems encountered during their student teaching experiences. Initially, student teachers did not value online discussions and felt that they were too busy with teaching responsibilities to participate in the online forum. Hsu (2004) found that it took considerable effort to get secondary student teachers to voluntarily post cases and participate in discussions online, so the researcher eventually had to require and prompt participation in order to ensure student teachers' involvement in the online forum. Each student was required to post at least one

case and make at least three comments about other cases each month. Requiring and prompting the student teachers' participation in the online forum seemed to be the catalyst for transforming their initial lack of value for participating in the online discussion forum. Hsu's (2004) analysis of the student teachers' online comments revealed that after two months of participating in online forum the student teachers indicated that the discussion forum provided valuable peer support that was crucial to their enduring the challenges of student teaching. Furthermore, the discussion forum became a learning community where the student teachers learned to consider issues from multiple perspectives, obtained knowledge, received guidance and peer support, and built confidence as professionals (Hsu, 2004). In conclusion, research suggests that ensuring pre-service teachers' regular participation in online communications about field experiences is one factor that facilitates the potential for online communications to foster learning communities among pre-service teachers during their field experiences.

Guidelines for the content of pre-service teachers' online communications.

A second factor in promoting productive online communication is providing prompts and guidelines for the contents of online communications. Prompts for online communications that are too open seem to hinder or limit productive online communications (Edens, 2000; Pena & Amlaguer, 2007). Pena and Almaguer (2007) investigated the use of online discussion board to mentor 22 secondary student teachers. In the online discussion board, student teachers responded to general questions posed by the mentor about their student teaching experiences. Pena and Amlaguer (2007) found that the three questions asked in the initial phase of their investigation–"*What is going well?, What is not going well?, How can I help you?"(p. 107)*

–were too open-ended and simplistic and often generated limited responses. To remedy this problem, the questions were revised to stimulate more reflection and discourse about specific lessons, children's learning and student teachers' understandings about effective teaching practice. (e.g."*What lesson or concept did you or your mentor teach especially well this week? How did the students react to the lesson? Why do you think the outcome was positive?"* (Pena and Almaguer, 2007, p. 109-110*).* The revised questions elicited student teacher responses that included more explicit references to content and more detailed descriptions of instructional strategies. Such responses allowed mentors to provide more effective assistance (Pena and Almaguer, 2007). Edens (2000) reported pitfalls related to providing broad guidelines for pre-service teachers' online discussion board comments about their observations during a field experience early in their program. Edens (2000) found that, in response to instructions to share observations of critical events the pre-service teachers focused on "negative events such as student misbehavior or teacher deficiency, rather than examples of constructive episodes" (p.18). Wopereis et al. (2010) encountered a similar narrow scope of content in pre-service teachers' online communication. In their study, student teachers were asked to post descriptions of classrooms events that they perceived as important and to justify their choices. Although, the pre-service teachers reflected productively about specific teaching incidents, the majority of events were related to classroom management rather than teaching and learning. Thus, results from the studies above suggest that prompts that are too open may not stimulate online communications about meaningful topics related to pre-service teachers' field experiences. Consequently, opportunities for pre-service teachers to reflect on instructional practices and bridge theory to practice in an online forum could be

diminished by the narrow scope of topics that may emerge in online communications when the guidelines for communications are too broad.

On the other hand, appropriate prompts and guidelines for pre-service teachers' online communications seem to increase the probability that pre-service teachers will meaningfully reflect and connect theory to practice when interpreting their field experiences. Researchers have provided specific guidelines for online communications that have effectively prompted pre-service teachers to focus on instruction and connections between field experiences and coursework (Delvin-Scherer & Daly, 2001; Schlagal et al, 1996; Wright, 2010). Wright (2012) provided student teachers with prompts that included specific questions about student learning and plans for teaching and found that, although most student teachers' tweets initially covered a range of categories, their tweets soon concentrated on curriculum and planning, pedagogy and reflections. Delvin-Scherer and Daly (2001) instructed the student teachers in their study to share, in an online discussion group, how specific course readings applied to their student teaching experiences. The researchers were delighted at the large quantity and quality of postings with references to readings and coursework. To guide the content of e-mail communications, Schlagal et al. (1996) provided thematic prompts that encouraged pre-service teachers to look for connections between their observations and what they had learned in coursework. Schlagal et. al (1996) assert that providing thematic prompts was an important factor in eliciting "professional online conversations on important themes" (p. 181). Clearly, the prompts and guidelines given to pre-service teachers have an impact on the content of pre-service teachers' online communications. Therefore, to maximize the potential for online communications to help pre-service teachers reflect and relate

theory to practice during field experiences, teacher educators need to provide prompts and guidelines that direct pre-service teachers to attend to and share observations about experiences that can be fodder for reflection and discussion about teaching and learning.

Teacher educators' active participation in online communications.

A third and perhaps most important factor in promoting productive online communications is the participation and intervention of teacher educators is pre-service teachers' online communication about their field experiences. Effective participation and intervention by teacher educators in online communication is the key to cultivating meaningful online communications where pre-service teachers reflect and bridge theory to practice in relation to their field experiences. Research reveals that effective participation by teacher educators in online communications corresponds to the quality of student teachers reflections about their teaching experiences (Edens, 2000; Yang, 2009). For example, Edens (2000) concludes that the lack of effective intervention by teacher educators in student teachers' online discussions about observations during field experiences, contributed to the persistence of pre-service teachers' superficial, negative and judgmental comments about their field observations. On the other hand, Yang (2009) observed that all of the 43 student teachers in her study blogged reflectively about their student teaching experiences but their level of reflection increased when university mentors intervened to challenge the student teachers thinking by (a) asking questions, (b) prompting students to reflect and express more, and (c) modeling reflection on their own teaching. Furthermore, Yang (2009) noted that " twenty student teachers reported that due to such challenges set by the instructors their thinking went deeper and became more critical" (p. 17). Thus, the studies discussed above suggest that teacher educators'

participation in online communications can influence the quality of pre-service reflective thinking about their field experiences

In addition to prompting deeper reflection, teacher educators can play a key role in facilitating student teachers' understanding of field experiences in a broader perspective of learning theory. For example, Barnett et al. (2003) analyzed the online communication of 28 pre-service teachers about their observations of inquiry-based science lessons and found that the online discussions with the most depth were those in which teacher educators were actively involved. Furthermore, Barnett et al. (2003) report that in post-course evaluations, 26 of the 28 pre-service teachers commented that "the participation by the teacher educators in online discussions about observed science lessons helped them to understand better what inquiry-based teaching is within the context of a real classroom" (p.306). Similarly, other researchers recount salient episodes where, in an online forum, teacher educators facilitated student teachers' interpretation of their teaching experiences in the light of learning theories presented in their course work (Roddy, 1999; Schlagal et al., 1996). For example, Schlagal et al. (1996) describe e-mail exchanges between a student teacher and university supervisor where the student teacher raised questions about strategies for helping third graders with editing. According to Schlagal et al. (1996), the university supervisor's responses helped the student teacher "shape her understanding by expanding her ideas and intuitions and placing them in a larger context of developing strategies with strong theoretical underpinnings" (p. 179). Roddy (1999) recounts an extensive, over the course of two weeks, discussion, via e-mail, among student teachers and teacher educators, about using a whole language approach to teach literacy. The discussion was initiated by one student teacher's message

about his encounter with opposition to using the whole language approach at his field experience site. Several other student teachers and two teacher educators joined in the e-mail discussion about the pros and cons of the whole language approach. In particular, the teacher educators' messages served to shift the discussion from a good- vs.-bad debate to a nuanced examination of the theory underlying the whole language approach and thus how the approach can be flexibly adapted to meet the needs of various learners (Roddy, 1999). In summary, the studies discussed above illustrate how teacher educators played a key role in helping pre-service teachers reconcile theory with practicum experiences through online communications.

Implications for My Study

Research on pre-service teachers' online communications about their field experiences has several implications for my study. First of all, research has shown that online communication is a viable tool for listening to pre-service teachers' perceptions of their field experiences (Barnett, Harwood, Keating & Saam, 2002; Ben-Peretza & Kupferbergb 2007; Delvin-Scherer& Daly, 2001; Edens, 2000; Fry & Bryant ,Winter, 2006-2007; Hsu, 2004; Pena & Amlaguer, 2007; Roddy, 1999; Schlagal, Trathen, & Blanton, 1996; Souviney & Saferstein, 1997; Wright, 2010; Yang, 2009). My study seeks to use online communication to selectively listen to how secondary mathematics student teachers interpret field experiences that are related to standards-based instruction. To date, I have not uncovered literature by any other author that focuses on student teachers' online communications about teaching mathematics. Secondly, researchers have sought with some success to use online communication to not only listen to but to facilitate student teachers' reflection and ability to connect theory to practice (Barnett et al. 2003;

Delvin-Scherer 2001; Roddy, 1999; Schlagal et al., 1996; Yang, 2009). Similarly, my study seeks to facilitate and examine student teachers' reflection and learning to apply the principles of standards-based mathematics instruction in the context of their own student teaching practice. Finally, research clearly points to the key role of teacher educators in actively prompting and responding to student teachers' online communications in ways that promote learning. The active role of the university supervisor/researcher as an attentive teacher educator who probes and responds to student teachers' online communications about their student teaching experiences is crucial to my study.

Mentoring Student Teachers: University Supervisor's Role

Overview.

This section will describe the role and impact of university supervisors in teacher preparation programs and highlight efforts to enhance and reframe the university supervisor's role as a mentor to student teachers

University Supervisors' Role in Mentoring Student Teachers.

University supervisors are responsible for observing student teachers in the field, providing student teachers with feedback and assessing student teachers' progress. Historically, as representatives of teacher education programs, university supervisors' perspectives when mentoring student teachers have been distinct from those of cooperating teachers (Guyton, & McIntyre, 1990; Hawkey, 1997). Guyton, & McIntyre (1990) and Hawkey (1997) reviewed research on mentoring student teachers, published prior to 1998, and found that university supervisors and cooperating teachers often have differentiated mentoring goals and roles. For example, Guyton, &McIntyre (1990), summarized a study that found that for cooperating teachers, the development of student

teachers' self-confidence was most important while for university supervisors, the application of theory was most important. Hawkey (1997) described a study that found that when mentoring student teachers, cooperating teachers "concentrate on areas such as teaching dimensions, curriculum knowledge and subject matter" whereas, university supervisors focus more on "children's learning and, theories and research on the teaching process" (p. 326). In summary, past research suggests that, in student teaching triads, university supervisors have particularly attended to helping student teachers connect theory to practice.

Recent studies confirm university supervisors' distinct focus on bridging theory to practice and as well as highlight university supervisors' distinct efforts to elicit pre-service teacher's reflection (Fernandez & Erbilgin, 2009; Paquette & Tochon, 2002; Tsui, Lopez-Real, Law, Tang, & Shum, 2001). Fernandez and Erbilgin's (2009) analysis of the post lesson conference communications in various mathematics student teaching triads revealed that the university supervisor tended to ask open-ended questions related to observed classroom events, probed student teachers' thinking about teaching mathematics and helped student teachers connect ideas from their mathematics education program to their classroom practice. On the other hand, the cooperating teachers tended toward a more "evaluative supervision"–affirming what the cooperating teachers thought the student teacher did well and giving direct suggestions in areas they judged that student teachers could do differently (p. 106). Tsui, Lopez-Real, Law, Tang, and Shum (2001) reported similar findings when they analyzed discourse data from six tripartite post lesson conferences between university supervisors, cooperating teachers and student teachers supervisors. They found that the university supervisors mostly focused on "*eliciting"*

reflection, analysis and evaluation while cooperating teachers' discourse most often involved "*offering*" teaching suggestions and providing information about the school context, the curriculum and the students (p. 325). Tsui et al. (2001) asserted that their findings suggest that university supervisors' *eliciting* approach to mentoring student teachers complemented the cooperating teachers' *offering* approach. Similarly, Gwyn-Paquette and Tochon (2002) found that the contrasting expertise of supervisors and cooperating teachers colluded to effectively impact student teachers' growth. They analyzed the dialogue between university supervisors and student teachers during collaborative planning and reflective feedback sessions and found that university supervisors provided essential moral support, and expertise needed to help student teachers navigate through the difficulties of introducing cooperative learning strategies during student teaching. On the other hand, the cooperating teacher in each student teaching triad had little experience with cooperative learning strategies, yet the researchers observed that cooperating teachers provided valuable contextual information and helped with management issues that supported their student teachers' efforts to implement cooperative learning strategies. In conclusion, university supervisor and cooperating teachers play distinct and potentially complementary roles in mentoring student teachers.

According to the National Research Council (2010), the primary reason for field supervision is to ensure that student teachers apply the knowledge they have learned from their university preparation to classrooms in which they are placed. The research discussed above illustrates instances where university supervisors have particularly attended to helping student teachers connect theory to practice and reflect on their student

teaching experiences. Thus, university supervisors who focus on prompting student teachers to reflect on their practice and connect course work and theory play an essential role in supporting the overarching goals of teacher preparation programs to develop reflective practitioners and ground theory in practice. Likewise, in this study, the university supervisor/researcher will focus on helping student teachers reflect on and apply the tenets of standards based mathematical instruction in the context of their student teaching practice.

Impact of University Supervisors on Student Teachers' Learning.

Although university supervisors aspire to facilitate student teachers' reflective, theory-based practices, the impact of university supervisors' on student teachers' development is often hindered by university supervisors' limited interactions with student teachers. Due to the structure of many teacher education programs, university supervisors' interactions with student teachers are often limited to only three or four post-observation conferences. Researchers who have explored the role of the university supervisor in mentoring student teachers, have found that university supervisors' desires to meaningfully impact student teachers' learning were thwarted by such time constraints (Borko and Mayfield, 1995; Bullough and Draper, 2004; Fryholm, 1996; Richardson-Koehler, 1988; Whitney, Golez and Nagel , 2002). For example, Fryholm's (1996) two-year study of the instructional practices of 44 secondary mathematics student teachers, revealed that university supervisors' three or four visits during the semester were ineffectual in supporting the student teachers' implementation of the standards-based instructional practices advocated by their teacher education program. Similarly, the university supervisors in Borko and Mayfield's (1995) study lamented that meeting with

student teachers on only three or four occasions for a limited time frame inhibited them from engaging student teachers in more in-depth reflection and scrutiny of observed student teacher practices (Borko, & Mayfield, 1995). Based on her research on student teaching supervision, Richardson- Koehler (1988) asserts that university supervisors' "rare appearances" in student teachers' classrooms "do not lend themselves to the type of trust-building and reciprocity necessary for collaborative reflective feedback or for the "rigorous analysis of teaching" needed to further student teachers' development (p. 33). Furthermore, she concludes that university supervisors' feedback and suggestions may be based on insufficient knowledge about student teachers' teaching and thus feedback may be resented or dismissed by student teachers. Richardson-Koehler's (1988) conclusion is supported by Bullough and Draper's (2004) analysis of the mentoring relationships between a student teacher and her assigned cooperating teacher and university supervisor. The student teacher in Bullough and Draper's (2004) study concluded that although her university supervisor was an expert in his field, he was "out of touch with the realities of classroom teaching" and thus his ideas were impractical and irrelevant for her particular teaching situation (p. 415). Similarly, Whitney, Golez, Nagel and Nieto (2002) surveyed and interviewed 900 practicing teachers in California to determine the impact of teacher education program on their teaching practices. They found that many of the study participants did not feel that their university supervisors, who visited at most once a week, were really knowledgeable about their student teaching experiences. Moreover the data that Whitney et al (2002) collected revealed that university supervisors had little influence on the study participants' current practice. In conclusion, university

supervisors' cursory connection with student teachers' daily experiences may inhibit university supervisors' impact on student teachers' learning and instructional practices.

Teacher educators have made a variety of efforts to mitigate the peripheral status of university supervisors and thus increase impact of university supervisors on student teachers' learning. Some teacher education programs have implemented structural changes to increase the frequency and opportunities for interactions between university supervisors and student teachers (Blanton, Berenson & Norwood, 2001; Cuenca, Schmeichel, Butler, Dinkelman & Nichols, 2011; Frykholm, 1998) Cuenca, Schmeichel, Butler, Dinkelman and Nichols (2011) described the outcomes of modifications on a teacher preparation program at a large publically funded research university in the United States. In addition to the standard three to four observation visits during the semester, university supervisors met with assigned student teachers bi-weekly in small groups of three to ten for breakout sessions to discuss their student teaching experiences. The data analysis of break-out conversations revealed three major benefits: (a) University students teachers had access to new and more meaningful conversations with their assigned student teachers; (b) Information discussed during breakout sessions provided a more refined focus for university supervisors' observation visits, and (c) Meeting together in breakout sessions cultivated deeper relationships between university supervisors and students teachers. Cuenca et al. (2011) were careful to note that, although break-out sessions had the positive benefits listed above, based on their research study, they could make no concrete claims about the impact of break-out sessions on student teacher learning. On the other hand, Frykholm (1998) found that implementing a revised supervision model did have an impact on mathematics student teachers' learning. In

response to Frykholm's (1996) findings that mathematics student teachers had difficultly implementing standards-based instruction practices due in large part to lack support from student teaching setting, Frykholm (1998) developed a supervision model where university supervisors met regularly with student teachers to discuss their student teaching experiences. Expanding from the typical three to four visits a semester, in Frykholm's (1998) model, university supervisors visited student teachers weekly for pre- and post-observation conferences. In addition, groups of three university supervisor-student teacher dyads met biweekly in community meetings to discuss student teachers' concerns. Guided by open-ended questions, the community meeting discussion topics included curriculum, classroom management and mathematics pedagogy. According to Frykholm (1998), the numerous interactions between university supervisors and their student teachers served to bridge the gap between classroom theory and practice by providing multiple opportunities for student teachers to reflect on theory and standards-based teaching in relation to their daily student teaching practices. Similarly, the university supervisor in Blanton et al.'s (2001) study met with her student teacher weekly for a 3 hour session that included pre- and post-observation conferences through which the university supervisor facilitated a middle school mathematics student teacher's shift toward standards-based approach of orchestrating classroom discourse when teaching problem solving. A common feature of all three cases discussed above is that university supervision was enhanced by increasing the number and length of opportunities for university supervisor and student teachers to discuss the student teachers' internship experiences. In both Frykholm (1998) and Blanton's (2001) studies, the frequent interactions with students teachers about their student teaching experiences facilitated the

university supervisors' ability to support student teachers' learning about standards-based mathematics teaching practices in the context of their 'real' student teaching experiences. Likewise, in this study, frequent online communications between the university supervisor/researcher and mathematics student teachers will position the university supervisor/researcher to play an effective role in facilitating student teachers' learning to implement standards based teaching practices.

As discussed earlier in this literature review, teacher educators have successfully incorporated online communication as venue for pre-service teachers to communicate with teacher educators about their field experiences. This study seeks to expand on previous efforts, discussed earlier in this review, to use online communications as a vehicle for teacher educators to help student teachers reflect on and apply theory to their student teaching practice. In this study, blogging within an online social networking site will be the venue for the university supervisor/researcher to the help mathematics student teachers reflect on and apply the principles of standards-based mathematics instruction. In addition, this study will document and describe student teachers' developing conception of standard-based mathematics instruction as manifested in online mentoring conversations with their university supervisor.

Mentoring Toward Standards-Based Mathematics Instruction

Overview

As previously mentioned, research reveals that mentoring that focuses on facilitating student teachers learning to critically examine their own practice and implement standards-based teaching practices is lacking novice teacher supervision (Wang and Odell, 2002). In their extensive review of literature on mentoring novice

teachers, Wang and Odell (2002) found that most of the mentoring for novice teachers focuses on providing technical and emotional support and promoting retention rather that supporting novice teachers' learning about standards-based teaching. In light of their findings, they call for researchers and teacher educators to explore the content and processes of mentoring for standards-based teaching. Furthermore, Wang and Odell (2002) assert that case studies can illustrate mentoring practices that support novices learning about standards-based teaching. The following section will review case studies where mentors attended to novice teachers (student teachers and first year teachers) learning about standards–based mathematics instruction. The case studies examined in this section will shed light on mentoring practices that seem to support novice teachers' learning to teach in ways consistent with standards-based teaching.

Case studies: Mentoring Toward Standards-Based Mathematics Instruction

As mentioned earlier, for this study, standards-based mathematics instruction is defined as consisting of the following teacher actions:

- elevating conceptual understanding and surfacing 'big' mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations,
- promoting student collaboration and mathematical discourse

A few researchers have explored in-depth the mentoring processes that seem to support novice teachers' (student teachers and first-year teachers) learning in relation to specific

aspects of standards-based mathematics instruction above (Bennett, 2010; Blanton et al., 2001; Nilssen, 2010; Wang & Paine, 2001). For example, Nilssen (2010) analyzed the mentoring processes of a cooperating teacher who effectively cultivated student teachers' disposition and skills for attending to elementary children's mathematical thinking. Sara, the cooperating teacher and mentor in Nilssen's (2010) study, met with student teachers daily to reflect on their observations of children's mathematical thinking that surfaced during the children's work on various activities during the day. During post-lesson mentoring conversations, Sara emphasized the importance of attending to individual student's mathematical thinking, praised the student teachers for their initial observations of children's thinking and challenged the student teachers to listen more carefully to children's thinking in future lessons. In addition to directing her student teachers to attend to children's thinking, she also encouraged them to observe the elementary students' discussions when working on mathematical tasks. She asked the student teachers detailed questions about their observations:

> Did they [the kids] collaborate or was only one of them front and center?...Did someone ever ask the others: What are you doing now? How are you thinking? Or gave the impression that they were not aware of what was going on?...Did anyone argue why they wanted to move [the numbers]? (p. 596)

In addition to asking detailed questions about how children enacted mathematical discourse, Sara asked her student teachers philosophical questions about why student collaboration is important. Sara's questioning prompted her student teachers to examine and reshape their conception about the aim of mathematical discourse in classroom. According to Nilssen (2010), Sara's overarching mentoring goal was to develop her

student teachers' capacity to be "alert and awake" to children's mathematical thinking and discourse (p. 593). Nilssen's (2010) study found evidence that all 5 student teachers mentored by Sara developed the "habit of mind of listening to kids or at least understood the importance of it" (p. 596). In conclusion, Sara, the mentor in this case study, used mentoring practices that supported student teachers' development in relation to aspects of standards-based mathematics instruction defined earlier–attending to students' mathematical thinking and promoting student collaboration and discourse. Sara's mentoring practices included engaging student teachers in reflection and reexamination of specific classroom events.

Bennett (2010) documented the growth of two first-year secondary-mathematics teachers who, in response to feedback from their mentor, progressed in facilitating mathematical discourse in their classrooms. The mentor in Bennett's (2010) study provided the novice teachers with specific feedback about the frequency and types of questions during six observed lessons over the course of 4 months. Both novice teachers were surprised by the feedback about their questioning practices during initial lesson observations Their erroneous perceptions that they were asking questions that provoked their students' mathematical thinking and discourse was not supported by the data from their mentor. Bennett (2010) suggests that the mentor's feedback prompted the novice teachers to increase in asking more questions that probed for understanding. Thus, by attending to their questioning practices, the novice teachers increased the level and frequency of their students' mathematical discourse. Similar to Nilssen (2010) study, discussed above, the mentor in this study employed mentoring practices that supported novice teachers' development in relation to an aspect of standards-based instruction–

promoting mathematical discourse. The mentoring practices employed by the mentor in this study entailed challenging the first-year teachers to reexamine and consequently change their questioning techniques to foster more opportunities for mathematical discourse.

Wang and Paine (2001) traced the growth of a first-year elementary mathematics teacher toward standard-based instruction practices. According to Wang and Paine (2001), the novice teacher's growth was closely linked to her mentor teacher's mentoring practices. Ms. Liu, the mentor, in Wang and Paine's (2001) study believed that in addition to developing calculation skills, teachers should "develop students' ability to discover mathematics knowledge by themselves" and "nurture their thinking abilities" (p.160). Ms. Liu structured her mentoring practices with the aim of moving the novice teacher "from thinking about teaching as structured telling followed by practice toward thinking about it as a support for students to make sense of mathematical ideas and develop their problem-solving ability" (p.171). Ms. Liu's overarching approach to mentoring was to direct the novice teacher to link a vision of standards-based teaching with specific teaching events. When reflecting on observed lessons or planning for future lessons, she consistently reminded her student teacher to look for underlying, standards-based goals and purposes behind teaching activities and materials. For example, to guide her student teacher's lesson planning, she asked questions like, "What kinds of activities will allow students to form mathematics representations of the problem? What are the ways in which students show their understanding? How much time needs to be used here to reach your goals?" (p. 173). In addition, to asking prompting questions, Ms. Liu provided specific suggestions for revising lesson plans to align with standards-based

teaching practices. For example, she suggested that the student teacher revise a lesson plan on addition to include an opportunity for children to separate and combine a given number of chips. Mrs. Liu explained that manipulating the chips would help the children "actively learn for themselves about the meaning of addition rather than the teacher telling" (p. 175). In addition to asking probing questions and providing specific suggestions, Ms. Liu modeled teaching strategies and reflective thinking that were indicative of a standards-based approach to teaching mathematics. Wang and Paine (2001) assert that Ms. Liu's mentoring practices, described above, contributed to the significant changes they observed in the novice teacher's lessons. They observed that initially the novice teacher taught lessons where "all the rules were summarized and dictated to students by the teacher and practiced by students" (p. 164). In contrast, as the school year progressed, lesson observation data revealed that the rules taught by the novice teacher were "the product of student explorations and examination" (p169). Similarly, Wang and Paine (2001) observed that during initial lessons, the novice teacher did not cultivate mathematical discourse. She did not ask higher-order questions or encourage students to explain their thinking. On the other hand, during lessons observed later in the school year, Wang and Paine (2001) noted, about the novice teacher, that "telling and lecturing had almost disappeared from her teaching. Instead, she gave students more carefully designed problems and far more chances to come up with ideas to solve a problem". She "pushed her students to develop, examine and prove their mathematical ideas through guided discussion" (p. 169). In summary, under the guidance of Ms. Liu, her mentor, the novice teacher's teaching practices developed in ways consistent with standards-based mathematics instructions. Moreover, Ms. Liu's

mentoring practices (i.e. linking teaching events to underlying goals, asking probing questions, offering specific suggestions, modeling reflective thinking) seems to have contributed to the first-year teacher's development of standards-based teaching practices

Blanton et al. (2001) analyzed a university supervisor's approach to mentoring Mary Ann, a middle school mathematics teacher during her student teaching semester. The university supervisor met with Mary Ann weekly for a three-hour sequence that began with observing Mary Ann teach a general mathematics class followed by an hour-long post-observation collaborative planning session that was then followed by observing Mary Ann teach another general mathematics class. The sequence provided opportunity for university supervisor to provide feedback about the first lesson and track any changes in teaching that might have occurred in second lessons. The university supervisors observations of Mary Ann's teaching revealed that when teaching problem solving, Mary Ann enacted a step-by-step approach to explaining how to solve problems, asked "cognitively-small" questions that required only one word answers (p. 192) , and conveyed information that students received passively. Thus, the university supervisor decided to focus on helping Mary Ann cultivate a" dialogic classroom discourse" where students had opportunity to "struggle with unfamiliar problems and justify their ideas through mathematical discourse with each other and Mary Ann" (p. 191-192). The university supervisor's mentoring processes centered on asking open-ended questions that prompted Mary Ann to critically examine her teaching practice. The university was careful to avoid using a direct authoritarian or evaluative tone but was persistent in directing and redirecting mentoring conversations toward issues related to the "nature of classroom discourse that emerged after Mary Ann posed a mathematical task or question"

(p. 191). Blanton et al (2001) assert that the university supervisor's approach to mentoring facilitated Mary Ann's shift in thinking about the role that students play in solving a mathematical problem. Mary Ann began, in her own words to "let students figure out the problem in their own style" rather than "throwing out information" (p. 198). In conclusion, similar to the other case studies discussed above, the mentor in Blanton et al.'s (2001) study implemented mentoring processes that supported a novice mathematics teacher's growth in implementing standards-based teaching practices. Her mentoring practices included asking open-ended questions that prompted the student teacher to critically examine her teaching practice.

Summary and Implications for my Study

The case studies discussed above shed light on mentoring practices that seem to support novice teachers' learning to teach in ways consistent with standards-based teaching.

Synthesizing the findings of this case study literature reveals that mentoring student teachers toward standards–based mathematics instruction involves

- purposefully and consistently using specific teaching events as the catalysts for engaging student teachers in reflection and dialogue about their beliefs, subject matter knowledge, and developing practice;
- challenging student teachers to reinterpret and reexamine teaching events in light of standard-based mathematics teaching practices, and
- offering specific suggestions and reasons for standards-based practices to be implemented in student teachers' current practice.

(Bennett, 2010; Blanton, Berenson, & Norwood, 2001; Nilssen, 2010; Wang & Paine, 2001). In this study, the mentor/researcher sought to mirror these mentoring processes in an online environment. Moreover, this study analyzed and described evidence of mathematics student teachers' growth toward standards-based instructional practice that surfaced in online mentoring conversations between the university supervisor and student teachers

CHAPTER 3: METHODOLOGY

Rationale for Study/Purpose Statement

Student teaching is a pivotal opportunity for learning to teach under the guidance of mentors (Feiman-Nemser & Buchmann, 1987; National Council for Accreditation of Teacher Education (NCATE), 2010; Wilson & Ferrini-Mundy, 2001; Zeichner, 2002). Research reveals a vast array of mentoring relationships differentiated by the nature and frequency of communications between student teachers and their mentors (Hawkey, 1997; Odell & Wang, 2002). Several studies link the contents of conversations between student teachers and their mentors to student teachers' learning and practices (Bennett, 2010; Blanton, Berenson & Norwood, 2001; Hawkey, 1988; Nilssen, 2010; Wang & Odell, 2002, Wang & Paine, 2001). Student teaching presents an opportunity for university supervisors to help mathematics student teachers connect theory with practice by implementing standards-based instructional practices. Generally, university supervisors visit student teachers only a few times throughout the semester to observe and provide feedback about student teachers' practices. Consequently, university supervisors' efforts to mentor student teachers toward standards-based instructional practices may be hindered by the limited occasions of mentoring conversations with student teachers (Borko & Mayfield, 1995; Frykholm, 1996; Richardson-Koehler, 1988). Furthermore, unlike cooperating teachers who are on-site, university supervisors are often disconnected from the context of student teachers' day-to-day experiences that could serve as catalysts for discussions about standards-based instructional practices. Online

social networking provides an opportunity for consistent communication between university supervisors and student teachers about student teachers' daily experiences. Thus, online social networking is a potential venue for university supervisors to facilitate student teachers' understanding and implementation of standards-based instructional practices that are grounded in their authentic student teaching experiences. The purpose of this study was to explore the potential of online social networking as a venue for mentoring secondary mathematics student teachers toward standards-based instructional practices.

Definition of Terms

Standards-Based Mathematics Instruction

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM, 2000) outlines the essential components of "high-quality" and "engaging", mathematics instruction" (p.3). In particular, the six principles for school mathematics (Equity, Teaching, Assessment, Learning, Technology, Curriculum) and the five process standards (Communication, Problem-Solving, Connections, Reasoning and Proof, and Representation) are the over-arching themes that inform the classroom practices that compose standards-based mathematics instruction (NCTM, 2000). The over-arching themes of standards-based mathematics instruction are echoed in Wang and Odell's (2002) description of standards-based teaching practices across all disciplines Wang and Odell (2002) assert that standards-based instruction is manifested in teachers that

> stress the importance of students' deeper understanding of concepts and relationships of concepts as opposed to memorization of isolated facts, concepts

and theories; challenge students' misconceptions and connect students' learning meaningfully with their personal experiences and real life context; place students' 'active discovery' of important ideas at the center and encourage students to share and examine what they find through discourse and; strive to teach all students and promote excellence for students whatever their gender, race and social, cultural, and economic backgrounds (p. 484).

For this study, the researcher synthesized Wang and Odell's (2002), cross disciplinary description of standards-based instruction with NCTM's (2000) vision for teaching mathematics to define standards-based mathematics instruction as consisting of the following teacher actions:

- elevating conceptual understanding and surfacing " big' mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations,
- promoting student collaboration and mathematical discourse and,
- attending to equity in mathematics instruction.

This definition of standards-based mathematical instruction serves to characterize and delineate aspects of standards based instruction so that they can be easily identified and explored in the context of this study.

Mentoring Toward Standards-Based Instruction

Case study literature where mentors influenced novice teachers' learning to teach in ways consistent with standards-based teaching suggests that mentoring student teachers toward standards-based instruction involves purposefully and consistently using specific teaching events as the catalysts for (a) engaging student teachers in reflection and dialogue about their beliefs, subject matter knowledge, and developing practice (b) challenging student teachers to reinterpret and reexamine teaching events in light of standard-based teaching practices and (c) offering specific suggestions and reasons for standards-based practices to be implemented in student teachers' current practice (Bennett, 2010; Blanton, Berenson, & Norwood, 2001; Nilssen, 2010; Wang & Odell, 2002; Wang & Paine, 2001; Wang, Strong, & Odell, 2004). In this study, the university supervisor/researcher will employ the processes described above to mentor student teachers toward standards-based instruction.

Research Questions

1) What is the content of mentoring secondary mathematics student teachers for standards-based instruction in an online environment?

a) What is the content of mentoring in an online environment in relation to the following aspects of standards-based instruction:

- elevating conceptual understanding and surfacing 'big' mathematical ideas
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,

- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations, and
- promoting student collaboration and mathematical discourse,

b) What mentoring processes emerge when mentoring secondary student teachers toward standards-based instruction in an online environment?

2) How are online comments and mentoring conversations related to mathematics student teachers' developing conception of standards-based teaching practices? (Online mentoring conversations are defined as segments of online communications that include at the minimum, a student teacher's initial blog post and a response from the university supervisor. In addition, mentoring conversations could include follow-up responses from the student teachers or the university supervisor.)

a) What do mathematics student teachers' online comments reveal about their developing conception and implementation of standard-based practices?

b) How are mathematics student teachers' self-reported conception and implementation of standards-based instructional practices related to online mentoring conversations about standards-based teaching?

Rationale for Research Design

For this study, a collective case study research design was used to investigate the phenomenon of online mentoring toward standards-based mathematics instruction. A case study is an "in-depth exploration of a bounded system (e.g. an activity, event, process or individuals)" (Creswell, 2009 p. 476). Collective case study design is when "multiple cases are described and compared to provide insight into an issue" (Creswell,

2009, p. 477). In this study, multiple cases of online mentoring between a university supervisor and a mathematics student teacher were analyzed for content related to standards-based instruction. Content related to standards-based instruction was analyzed and compared across cases for emerging themes related to various aspects of standards-based instruction. In addition, based on evidence found in online mentoring conversations, individual cases of student teachers' developing conception and implementation of standards-based instruction was described and documented. Findings from this study provide insights into the potential for mentoring student teachers toward standards-based instruction in an asynchronous online environment.

Site Selection

The Master of Arts in Secondary Education with Initial Certification (MIC) program at the university site chosen for this study is an intensive one calendar-year program of 34 credit hours, which leads to both a master's degree and initial teacher certification. During the fall semester, MIC students take courses on campus for eight weeks and work in interdisciplinary cohorts in area high schools full time for a six-week apprenticeship. In the spring, MIC students continue course work, engage in student teaching and meet together twice a month for a subject specific student teaching seminar. Secondary and middle school mathematics teacher candidates enrolled in the MIC program have earned a bachelor's degree in mathematics, mathematics education or a mathematics related field such as engineering or physics. The university supervisors for the MIC mathematics student teachers are former secondary mathematics teachers who have a vast array of experiences in teacher professional development. University supervisors are required to observe student teachers on four occasions throughout the

student teaching semester and provide feedback during post-lesson discussions, complete written evaluations for each observation and provide a midterm and final evaluation.

Study Participants

Five secondary mathematics student teachers enrolled in a Masters with Initial Certification (MIC) program at a large University in the southeast, United States were selected to participate in this study during their student teaching semester. Study participants were selected based on the following criteria: The student teacher exhibited the ability and willingness to reflect on his or her teaching practice; The student teaching setting supported the student teacher's implementation of standards-based teaching practice; The student teacher was willing to participate in the study.

Researcher's Role and Background

The researcher for this study is a former high school mathematics teacher, who has been involved in the professional development of pre-service and in-service elementary, middle and secondary mathematics teachers for over 20 years. She has worked with elementary and middle school teachers in their classrooms to implement standards-based mathematics curriculum, taught mathematics content courses for pre-service teachers and has served as a university supervisor and mentor for secondary mathematics student teachers. For the past 4 years, she has actively mentored MIC secondary mathematics student teachers online.

In this study, the researcher served as the university supervisor for the study participants. As the university supervisor, she observed each study participant teach a lesson on three occasions throughout his or her student teaching semester, provided feedback during post-lesson discussions, completed written evaluations for each

observation and completed a midterm and final evaluation. As the researcher for this study, prior to student teaching, she interviewed study participants about their conception of and goals for standards-based teaching. Throughout their student teaching semester, the researcher used the venue of online social networking to consistently communicate with study participants about their student teaching experiences and attend to opportunities to mentor study participants toward standards-based instruction.

Study Design

Mathematics pre-service teachers enrolled in the Master of Arts in Secondary Education with Initial Certification (MIC) program at a large research university in the southeast of United States were required to keep an online journal of their experiences during their student teaching semester. The MIC mathematics student teachers used the blogging tool within an online social networking site called Ning (www.ning.com) to share their reflections on their classroom experiences with their fellow student teachers and with their university supervisors and mathematics methods instructor. The Ning site was selected because its structure resembles the popular Facebook website where participants can personalize and update their own page. Access to the Ning site was limited to MIC student teachers, their university supervisors and the methods instructors. Student teachers were required to post blogs within their own Ning page three or four times a week that described their student teaching experiences and their personal reflections on those experiences. Research reveals that pre-service teachers' online communications about their student teaching experiences often lack depth of content and reflection without prompts and feedback from teacher educators (Hsu, 2004; Liang, Ebenezer, & Yost, 2010; Pena &Almaguer 2007). Therefore, the MIC secondary

mathematics student teachers were provided with the following initial instructions and guidelines to direct their blog postings about their student teaching experiences:

> You must post journal entries about your student teaching experiences three to four times a week (minimum). Your journal blog posts should include 1) a description of your student teaching experiences, 2) your personal reflection and reaction to those experiences, 3) your observations about students' mathematical thinking and learning, and 4) a discussion of the impact of those experiences on your plans for teaching future lessons and your teaching philosophy or knowledge of teaching. Journals should help you formulate and refine your philosophy of education. In order to keep up with the increasing technology demands of our society, we will be utilizing a blog setting for journals at the NING website. All journal entries will be kept confidential (between university supervisors, methods instructor and student teachers) unless permission is granted by the student teacher. Your supervisor will read and comment on your journal/blog posts. In order to create conversation, you are required to comment back to your university supervisor. In addition, you must comment on at least one other post each week. We will be using the blogging to create a dialogue about the student teaching experience, to help you learn, as well as, to encourage and support you in this very important and exciting adventure.

In addition, ongoing feedback from university supervisors and methods instructors encouraged student teachers to elaborate and expand their blog posts. The university supervisor read and responded to the study participants' blog posts throughout their student teaching semester and particularly attended to opportunities to mentor secondary mathematics student teachers toward standards-based instruction via the NING site. Study participants were interviewed prior to student teaching about their conception of and goals for standards-based teaching practices (See Appendix A). At the conclusion of student teaching, study participants were interviewed about their perception of their development toward standards-based teaching. Furthermore, during the post interview, study participants were asked to recall their interpretation of and reaction to specific online mentoring conversations related to standards-based

instruction (See Appendix B). To help ensure study participants' honest responses, the post interviews were not conducted by the university supervisor/researcher. Finally throughout the study, the university supervisor/researcher maintained field notes about the study participants' developing conception and implementation of standards-based teaching practices. The field notes included the researcher's notes and reflections about face-to-face interactions with study participants (e.g. teaching observations and post observation discussions), as well as her notes and reflections about on-going online communications with study participants.

Data Sources

- Audio tape of study participants' interviews prior to student teaching. The pre-interview provided baseline information about study participants' conceptions of Standards-based instruction as well as the study participants' goal for implementing standards-based instruction
- Audio tape of study participants' interviews at the conclusion of student teaching. The post-interview data provided information about the study participants' perception of how online mentoring conversation were related to their development of standards-based instructional practices.
- University supervisor's field notes about study participants' developing conception and implementation of standards-based teaching practices. The university supervisor's field notes, recorded researcher observations and reflections about her interactions with student teachers online and during face-to-face post- observations conferences. In addition, field notes were a venue for the

researcher to process and interpret student teachers developing conception of standards-based teaching practices as it happens– in the moment.

- Study participants' blog posts about their student teaching experiences
- University supervisor/researcher's online responses to study participants' blog posts
- Study participants' online responses to university supervisor/researcher's blog posts and responses.

Data Analysis

Qualitative analysis procedures were used to investigate the data in this study. According to Creswell (2009) qualitative analysis involves "examining data in detail to form an in-depth understanding of a central phenomenon through description and thematic development" (p. 254). Thus, this methodology was selected for this study, as the goal for this study was to better understand the phenomena of online mentoring of secondary mathematics teachers. Study participants' blog post and interview data were reviewed and analyzed for emerging themes in relation to various aspects of standards-based instruction. The results of data analysis were used to form answers to the research questions for this study. The data analysis procedures for each research questions are discussed below.

Data analysis procedure for research question 1

1) What is the content of mentoring secondary mathematics student teachers for standards-based instruction in an online environment?

a) What is the content of mentoring in an online environment in relation to the following aspects of standards-based instruction:

- elevating conceptual understanding and surfacing 'big' mathematical ideas
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations, and
- promoting student collaboration and mathematical discourse,

b) What mentoring processes emerge when mentoring secondary student teachers toward standards-based instruction in an online environment?

The researcher analyzed study participants' and university supervisor/researcher's blog posts and responses for content related to the aspects of standards-based instruction above. The researcher sorted content from the blog posts into categories aligned with the aspects of standards' based instruction above. The researcher analyzed the blog posts' content under each aspect of standards-based instruction for subcategories and emerging themes. The researcher analyzed the university supervisor's online comments for mentoring moves that emerged in the online format.

Data analysis procedures for research question 2

2) How are online comments and mentoring conversations related to mathematics student teachers' developing conception of standards-based teaching practices? (Online mentoring conversations are defined as segments of online communications that include at the minimum, a student teacher's initial blog post and a response from the university

supervisor. In addition, mentoring conversations could include follow-up responses from the student teachers or the university supervisor.)

a) What do student teachers' online comments reveal about mathematics student teachers developing conception and implementation of standard-based practices?

b) How are mathematics student teachers' self-reported conception and implementation of standards-based instructional practices related to online mentoring conversations about standards-based teaching?

The researcher reviewed the pre-interview audio data of each study participant to gather baseline information about each participants' conception of standards-based instruction and goals for implementing standards-based instruction during his or her student teaching internship (See Appendix A). The researcher reviewed the content of online mentoring conversations across the semester for individual study participants. The researcher tracked and interpreted study participants' developing conception and implementation of standards-based teaching practices as evidenced in the online comments and mentoring conversations. During post interviews, each study participant was asked to recall and reflect on his or her reaction to specific online mentoring conversations that were related to aspects of standards-based instruction (See Appendix B). The researcher reviewed the audio-tapes of pre- and post-interviews to validate and inform the researcher's interpretation of individual study participant's developing conception of standards-based teaching practices as evidenced in online mentoring conversations. Furthermore, the researcher-university supervisor reviewed her field notes for data that might inform her interpretation of online mentoring conversations.

Internal Validity

Internal validity deals with how closely research findings match reality (Merriam, 1998). In this study, internal validity will be addressed through member checks, triangulation and clarification of researcher bias.

In qualitative research, the interpretation of reality is mediated through the researcher (Merriam, 1998). For this study, the validity of the researcher's interpretation of the reality of online mentoring conversations was enhanced by member checks. During post interviews, study participants were asked to recall their interpretation and reaction to specific online mentoring conversations related to standards-based instruction (See Appendix B). To help ensure study participants' responses do not simply reflect what the university supervisor wanted to hear, the post interviews were not conducted by the university supervisor/researcher. Furthermore the researcher's field notes, which may include notes about study participants' references to online mentoring conversations during face-to-face university supervisor-student teacher interactions (e.g. field observations, post observation conferences, other university supervisor-study participant conversations), informed the researcher's interpretation of online mentoring conversations. Thus, the researcher's field notes served as an additional source of member checks.

In this study, the validity of the researcher's findings about online mentoring toward standards-based instruction was enhanced by triangulation. Triangulation is defined as using multiple sources of data to confirm emerging themes (Merriam, 1998). For this study, findings about online mentoring toward standards-based instruction were

supported by three sources of data: the study participants' blog posts and responses, pre- and post-interview data and the researcher's field notes.

Merriam (1998) states that clarification of the researcher's biases–assumptions, worldview and theoretical orientation–at the outset of the study can enhance internal validity. The researcher for this study is a passionate advocate for standards-based mathematics instruction and as mentioned earlier, has worked with teachers at a various levels for over 20 years to implement and understand standards-based teaching practices. Due to her years of experience with site-based professional development, the researcher is deeply aware that enacting the vision of standards-based instruction is complex and thus, may not develop in classrooms without support, feedback, affirmation guidance and frankly, pushing from others. Furthermore, the researcher has come to appreciate that movement toward standards-based teaching often involves incremental steps in thinking and action on the part of the teacher. The researcher believes that her primary role as a mentor is to "tease out", encourage, label and affirm teachers' "incremental steps" toward standards-based instruction. At the outset of the study, during the initial interview with participants, the researcher made it clear that her intention throughout the study was to support the study participants' application and understanding of standards-based teaching practices in relation to their student teaching contexts.

Limitations of this Study

This study examined the online mentoring conversations between one university supervisor who was the researcher for this study and a selected sample of secondary mathematics student teachers enrolled in a Masters with Initial Certification program at a large university in the southeastern United States. Although this research study is limited

to a specific mentoring context, the insights gained from this research study can inform other researchers and teacher educators about the processes involved in using online mentoring to support student teachers' learning about standards-based instruction.

CHAPTER 4: FINDINGS

Overview

As stated in Chapter 1, this study investigated the potential of online social networking as a venue for mentoring secondary mathematics student teachers' toward standards-based instructional practices. This chapter is organized with respect to the two specific research questions posed in Chapter 1. The first part of this chapter describes (a) the content of online mentoring conversations related to the specific aspects of standards-based instruction as defined by this study and (b) the mentoring moves that emerged in this study. The second part of this chapter describes (a) what online mentoring conversations reveal about the development of individual study participants' conception and implementation of standard-based practices and (b) how individual study participants' self-reports of their conception and implementation of standards-based instructional practices are related to online mentoring conversations about standards-based teaching. Note that the online posts quoted in this section are excerpted from actual blog data and thus include misspellings and typographical and grammatical errors which are typical in the casual and often hasty writing style found in online social networking media.

Study Participants

The study participants for this study, Kathy, Christy, Jake, Sam, and Roger (Roger did not participate in pre and post interviews.) were secondary mathematics

student teachers enrolled in the Masters with Initial Certification Program (MIC) at a large research university in the southeastern United States during the spring 2013 semester. Three to four times a week, study participants posted online journal entries about their student teaching experiences on an online social networking site designated for MIC student teachers and their university supervisors. The university supervisor (US) and researcher for this study read and responded to the study participants' online journal posts. The university supervisor participated in online conversations with the study participants about their student teaching experiences. She particularly attended to using online conversations as a venue for mentoring study participants toward standards-based instructional practices.

Findings Related to Research Question 1

Online Mentoring Content Related to Standards-Based Instruction

The following part of this chapter addresses the findings in relation to research question 1. In particular the following section describes the content of online mentoring conversations related to the following aspects of standards-based instruction:

- elevating conceptual understanding and surfacing 'big' mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations, and
- promoting student collaboration and mathematical discourse.

Online mentoring in relation to elevating conceptual understanding.

Online mentoring conversations related to elevating conceptual understanding were venues for the US and the study participants to (a) spotlight the pedagogical challenges involved in focusing on underlying mathematical concepts, (b) unpack the mathematical concepts that justify particular procedures and (c) discuss instructional moves that might help to promote students' conceptual understanding of particular topics.

Pedagogical challenges involved in elevating conceptual understanding.

In online conversations, Jake and Sam recounted similar outcomes from their efforts to teach a lesson with an emphasis on helping students understand the underlying mathematical concepts. Both Jake and Sam were disappointed that taking the time to teach for conceptual understanding took more class time than anticipated which resulted in not covering or getting behind in the required curriculum.

> Posted by Jake on February 4, 2013 at 10:49pm:
>
> After my conference with [my US] last week, I was really amped up and focused on trying to lead these students on a path of understanding rather than memorization. So, throughout the shortened class period. I was working to try to get them to understand what was really going on when they are finding both real and imaginary roots. Why might only one root show up on a graph when there are 8 other imaginary ones? Where do these imaginary roots come from? etc. These are questions I was asking and I thought we were having good conversation about, until the inevitable happened. The classic, only 5 minutes left. I had gotten nowhere near what I needed to get through to allow them to do their homework. Because of my quest towards understanding, they were now lost and short on time. I doubt any of them really understood what I was talking about. I felt like the whole class was a giant step back in the progression I had made thus far.
>
> Sam' response posted on February 5, 2013 at 10:23am
>
> I had a similar experience last week when I taught an intro to Trig lesson. I felt like the students needed to really understand the concepts in the lesson and I emphasized the concepts. Like you, I got to the end of the lesson with about ten

> minutes left in class and the students did not have nearly enough information to complete the homework assignment. In fact, I had an activity prepared and we could not even get to it successfully. It was unbelievably frustrating and I also felt like I was experiencing the first day of teaching all over again! It literally took me 20-30 minutes to calm down enough inside to think about what had just happened. After talking with my teacher I realized that I do not yet have enough experience in the classroom to truly understand where common misconceptions or misunderstanding will occur in the curriculum.

Jake and Sam's posts about their attempts to focus on underlying concepts revealed that they lacked the pedagogical skills needed to balance time constraints with their quest to teach for conceptual understanding and that they lacked the knowledge of common student misunderstandings necessary to facilitate their students' conceptual understanding. Jake's frustration with his inability to effectively teach concepts and cover the required curriculum in the allotted time frame was compounded by his perception that the required curriculum and standardized exams seem to provide no incentive to really teach for understanding.

> Posted by Jake on February 4th on February 4, 2013 at 10:49pm
>
> More than anything, I was frustrated that I took the time to really "teach" rather than show, and it came back to bite me in the butt. I couldn't help but think of how little incentive there is now for students to actually understand what they are doing, because that is not what they are tested on. They are tested on what they can memorize and do, not what or how they understand

In response to Jake's frustration, the US concurred that there are real pedagogical challenges to teaching for understanding and she acknowledged that some assessments may not measure conceptual understanding.

> US' response posted on February 5, 2013 at 12:03am
>
> I am really impressed that you took on the challenge/risk to teach for understanding. There is a lot to glean from your experience today. First of all, teaching for understanding takes time, and sometimes involves leading students

> through some confusion on the way to clarity and yes, the assessments given to students may not test for particular understandings that you take the time teach

The US conceded that, due to time constraints, it is impossible to completely teach underlying concepts for every topic in the curriculum. Yet, she insisted that it is possible to significantly focus on elevating concepts. She encouraged Jake to envision his potential to more effectively help students understanding underlying concepts in the future, when he will have more experience/knowledge of students' misconceptions, more autonomy to design assessments and more than just a few weeks to cultivate students' conceptual understanding.

> US' response posted on February 5, 2013 at 12:03am
>
> Time is real hurdle, so we have think about what depth of understanding we can achieve within a limited time frame. You have to choose your "teach-for-understanding" battles wisely. It is impossible to teach everything for complete understanding but we can certainly do some significant things with conceptual understanding…. Also remember you are starting from scratch. If you had been teaching these students since the beginning of the year with the intent on teaching for understanding, things may not take as much time because your students will be used to grappling with concepts … Also, after some years of experience, you will better be able to anticipate students' misconceptions and you will have a better sense of how long things will take to teach for understanding… You might feel like you were fighting a losing battle today, but there are battles to be won in the future.

Thus, online mentoring conversations provided an opportunity to spotlight various pedagogical skills – balancing time constraints, anticipating students' misconceptions, choosing which concepts to emphasize, cultivating classroom culture where students consistently examine underlying concepts– that teachers need to develop in order to effectively teach with a focus on elevating the underlying concepts. Online mentoring conversations also provided an opportunity for the US to support one study participant's initial efforts to focus on teaching underlying concepts and to provide encouragement

about his trajectory for developing the necessary pedagogical skills to effectively teach with a focus on underlying concepts.

Unpacking the important concepts underlying mathematical procedures.

The online mentoring forum provided an opportunity for the US to highlight some of the mathematical concepts underlying particular procedures taught by two study participants. Both Jake and Sam posted explanations about their decisions to teach a particular procedure that they anticipated would facilitate their students' ability to correctly complete certain problems. Jake chose to teach a certain procedure for simplifying radicals that involves making factor trees and circling pairs of factors. Jake admitted that the procedure involved simply completing the steps, without attending to mathematical concepts. Jake felt that the procedure would be easier for his students who had limited multiplication knowledge and would be the "most effective way to keep students working on problems."

> Posted by Jake on February 23, 2013 at 9:18am
>
> I introduced simplification, addition and subtraction of radicals. The route that I took in explaining the process I gathered from my time observing at … the spring of my senior year of college. There, they taught students to make trees and circle pairs of factors. For each pair, you write the number represented outside of the radical. Multiple numbers outside are multiplied together while multiple prime numbers left inside are multiplied together and kept under the radical. I realize this may simplify the "simplifying" process to a point that mathematicians might cringe, but from what I have seen, it is the most effective way to keep students working on problems. The other way I have seen it taught is finding the largest perfect square factor and simplifying from there. Obviously the answer will be the same, but for a class of students with limited multiplication knowledge (some not all), this process seemed like a reach.

The US responded to Jake with a rather long and emphatic commentary about the mathematical concepts behind the procedure that he chose to teach. Her rhetorical

questions suggested that a teacher should highlight these concepts when teaching the procedure.

> Posted by US on February 23, 2013 at 12:55pm
>
> …Usually, students are just taught how to make the trees but do not understand the meaning of the numbers at end of each branch. So, I think the process of using prime factorization to simplify radicals can be very powerful if we point out what all those numbers at end of the tree roots mean. Do we as teachers point out what it means when we see two of the same number or doubles or do we just tell students to just circle pairs and write number outside the radical? Do they understand that the doubles indicate perfect square? Do the students know that all the numbers at end of the tree can be multiplied together to get the original number.

The US also included an anecdote from her own teaching experience to illustrate the limitations of students' learning the procedure without understanding the underlying concepts

> Posted by US on February 23, 2013 at 12:55pm
>
> My student, who showed me this method, was able to use this method effectively to simplify radicals with an index of 2 (Square roots) but she did not know what to do when the index higher than 2. For example for cube roots, she actually could use the same method- just look for triples (three of the same numbers at the end of the branches) but she did not know what the numbers in the tree meant so she did not know that you she could look for triples to find perfect cubes.

Thus, the US attempted to underscore the important mathematical concepts inherent in the procedure that Jake chose to teach. She also illustrated the potential pitfalls for students who use the procedure without understanding the concepts.

Similarly, Sam's online post about teaching his students to follow a particular procedure when using the volume formula provided another occasion for the US to comment about underlying mathematical concepts. Sam noted that his students had a tendency to confuse 'big' (area of the base) with 'little' (length of the base) when using

the volume formula. To remediate his students' error, Sam decided to instruct his students to use the following procedure: First, write general formula for volume, next, replace B with formula for the area of the base of the figure and then fill in the numerical values for the variables to solve the problem. The US responded to Sam with comments that suggested that students' understanding the role of the B (area of the base) in the formula for finding volume of 3-D figures could be linked to conceptual understanding of meaning of volume as number of cubic units.

> Posted by US February 25, 2013 at 10:17pm
>
> Cool idea to start with general formula and then replace it with area equation for the base … In middle and elementary school, students should learn why the volume formulas for prisms and cylinders work for finding the number of cubic units inside the figure, When students understand that the area of the base simply tells us how many cubes in each layer of the figure and that the height is the total number of layers then the volume formula just makes sense. I am just not sure how much conceptual understanding high school students receive.

Thus, Jake and Sam's online comments about teaching procedures prompted the US to respond by unpacking the mathematical concepts behind those procedures but, neither Sam nor Jake replied to the US' comments. Furthermore, neither Sam nor Jake provided any indication that the US' comments prompted them to consider ways to highlight the underlying concepts for their students. Although the online forum provided a venue for the US to elevate mathematical concepts, her comments did not initiate or stimulate an online dialogue with Jake or Sam about helping students to understand the concepts

Discussing instructional moves that promote students' conceptual understanding

In contrast to the cases above, the US and Kathy *did* engage in an online dialogue about how to enhance students' conceptual understanding of two specific topics:

calculating percent increase or decrease and simplifying exponential expressions. Kathy suggested a way to modify the presentation of a formula so that it requires students to think about concepts and not just plug in numbers. The US responded by applauding and affirming Kathy's attentiveness to elevating conceptual ideas. Kathy responded to the US and extended the conversation to a discussion of importance of helping students see how one equation can be derived from another equation.

> Posted by Kathy on January 16, 2013 at 5:51pm
>
> When calculating percent of change many of the students were confused by the formula they were told to use (big-little/original=%/100). If the problem stated that the original price was $25, but there was a discount of $10, the students would set it up as (25-10)/25=x/100. The were confused when I explained why this wasn't correct because they though they were following the formula correctly. I think it would have been more clear if they were told to use increase or decrease/original price=%/100. I didn't feel like it was my place to suggest using a different formula, but it made it difficult to explain to kids when the terms "big" and "little" were unclear.
>
> US Response to Kathy s post above:
>
> I am impressed by how often your blog posts address your thinking about how to best teach math specific concepts. Our primary purpose as mathematics teachers is to effectively teach mathematics concepts. ... The problems your students were having using the formula also reflect a bigger issue in teaching mathematics- plugging numbers into formula without understanding the whole situation or big idea. I very much agree with you that "increase or decrease/ original price = % /100" is a formula that would serve students for broader range of percent change problems (given original and new price **or** given original price and discount or mark-up amount) and using the word increase or decrease forces students to think about the increase or decrease and how to find it- either finding it in the information given or by calculating it from the information given. Even though it may not have been your place to suggest a new formula in your current teaching situation, all of your thinking about how to teach math concepts triggered by your student teaching experiences now will certainly benefit your preparation for teaching in the future. Keep it up!
>
> Kathy's response to US's response above
>
> I definitely see formulas becoming an issue. Students use them mindlessly and often do not understand what is going on what so ever. I feel like its important to

> explain to students where the formulas come from even if they will not be expected to recall this later on a test etc. I actually saw a good example of this last week when she was explaining how to get the point slope formula from the slope formula. Even though most students will never recall how to do it, I think that they appreciated knowing that its just a different way to write the slope formula.

Thus, in the conversation above, the US and the student teacher not only dialogued about the importance of helping students understand concepts underlying formulas but they also discussed two specific instructional moves for doing so: providing a formula for calculating percent increase/decrease that forces student to think about concepts rather than just plug in numbers and showing students how the point slope formula for an equation of a line can be derived from the slope formula

In another online conversation, the US and Kathy discussed instructional strategies for helping students focus on the concepts that justify rules for simplifying exponential expressions. In an online post, Kathy mentioned her plans to show students how to expand exponential expression in effort to enhance their understanding of concepts underlying the product rule and power rule for simplifying exponential expressions. In response, the US shared her strategy of initially teaching her students to expand exponential expressions before simplifying in order to help her students understand the concepts that justify the rules for simplifying exponential expressions.

> Posted by US on February 26, 2013 at 6:12am
>
> I have found that my remedial college mathematics students cling to trying to using the rules, often incorrectly, and refuse to check answers by expanding and multiplying, I changed my teaching strategy so that now I teach the topic of simplifying exponents by expanding first and actually give quiz on simplifying by expanding before I teach the rules. I want students to find that they can be successful with simplifying by simply using their knowledge about meaning of base and exponent before I introduce the rules so that if they mix up the rules they will know and feel confident enough to fall back on " common sense"- expanding into multiplication.

Kathy tried to implement the US' idea about teaching students to expand exponential expressions but Kathy found that after her students had been taught the rules for simplifying exponents, students did not have much interest in doing the alternate method of expanding the expressions. Kathy's experience seemed to prompt her to ask the US a more detailed question about the US' strategy for having students expand exponential expressions. She asked the US if she required students to expand expression when the exponents are large.

> Posted by Kathy on February 26, 2013 at 5:07pm
>
> Today, I showed a few problems worked out by expanding, but most of them didn't seem interested. Do you have them do problems by expanding where the exponents are large?

The US confirmed that she had a similar experience of students' resistance to expanding once they have been taught the rules. She shared, in an earlier post, how she has attempted to remedy this problem by teaching expansion before rules and quizzing students on simplifying by using expansion. The US also answered Kathy's question about requiring students to expand expressions with large exponents.

> US response to Kathy's February 26, 2013 at 7:41pm
> Good question about expanding when the exponents are large. I start out having students expand - write out all the factors with no exponents- where the exponents are not very large then when we get to examples with large exponents , I say "so expand it in your head , tell me what you see e.g x^ 26 * x^ 32 would look like 26 x's in a row(being multiplied together) times 32 x's in row (being multiplied together) so when you " squish it back together" it equals x^56. So with large exponents, I ask them to visualize the expansion

Kathy liked the US' idea about having students visualize the expansion and indicated that she will keep this strategy in mind the next time she teaches the topic. Thus, Kathy and the US engaged in an online dialogue about specific instructional moves that could serve

to enhance students' attention to the concepts underlying the rules for simplifying exponential expressions. The dialogue also touched on strategies for addressing the common occurrence that students may be less motivated to attend to conceptual approaches for solving problems after having been taught 'quicker' rules or shortcuts. In summary, online mentoring conversations provided opportunities to expose and address various issues, inherent to teaching mathematics with a focus on underlying concepts, as they surfaced during the study participants' student teaching experiences. Specifically, the online conversations provided a forum to acknowledge the "real" pedagogical challenges to elevating concepts encountered by study participants, to delineate underlying mathematical concepts that were perhaps overlooked by study participants and to discuss some instructional strategies, proposed by a study participant, for enhancing her students' conceptual understanding.

Online mentoring in relation to eliciting students' mathematical thinking.

Online conversations related to eliciting students' mathematical thinking were prompted by study participants' experiences with (a) facilitating students' solution presentations and (b) presenting new material.

Facilitating students' solution presentations.

Online content related to eliciting students' mathematical thinking were initiated by study participants' online posts about their experiences with allowing individual students to present problem solutions. For example, Sam and Kathy described their initial experiences with having individual students present solutions to the rest class. Both Sam and Kathy expressed their delight with having the opportunity to observe how individual

students were thinking about problems and to address students' misconceptions where necessary.

> Posted by Kathy on February 27, 2013 at 2:53pm
>
> Instead of doing another boring worksheet 1 though whatever number, I cut up the questions and put them in a cup. I put the worksheet on the board with the document camera. I asked for volunteers to pick a problem from the cup and come work it on the board in front of the class…Even though it took longer than just working through the problems, it was more fun and it let me see how students were thinking about things and the little mistakes they were making. Even when students made mistakes, we helped them work through it and we made sure to tell every student good job and thank you for participating
>
> Posted by Sam on January 25, 2013 at 4:25pm
>
> I introduced a wrinkle into the flow of the class. I offered individual students, on a volunteer basis, an extra-credit opportunity for presenting problems to the entire class on the board…. I only had one student take advantage of the extra credit opportunity during the A1 class but it was a significant occurrence… Following this I had an even better experience with the review time with A3 geometry. In this class I had three students volunteer to present problems on the board

The US applauded both Kathy and Sam's decisions to take the time to allow students to present solutions. In addition, the US made comments and asked questions to bring attention to teacher actions that serve to encourage students to share solution strategies.

> US Response to Kathy's February 27th post above.
>
> I love what you did with the worksheet and having students come up and work problems. Yes, even when students make mistakes, everyone can learn as long as the teacher guides the conversation in positive encouraging manner.
>
> US response to Sam's January 25th post:
>
> Bravo for the" wrinkle". It is great that you had some students who were willing to explain their solutions …Do think that the way you handled Baljeet's presentation will make students feel comfortable with presenting problems even if their answers are not completely correct? How did the other students respond /listen to the presentations? What did you do while the students were presenting- just listen? Interject? Rephrase? Ask questions?

Thus, the US praised Kathy and Sam for providing an opportunity for their students to present their problem solutions and underscored their role as teachers in creating a comfortable environment for students to share their thinking.

In a subsequent online mentoring conversation Kathy described another lesson when students were asked to explain their solutions in class. In her description, she includes examples of questions that she asked to prompt students to explain their thinking.

Posted by Kathy on April 8, 2013 at 5:01pm

> The advanced class also reviewed... Their review sheet consisted of problems that were commonly missed from the radicals test, as well as the polynomials test, and old material from their first trimester in the class. They were allowed to work on this alone for about 30 minutes. Each student was asked to pick several problems out that they would feel comfortable presenting to the class. After the 30 minutes was up, I randomly drew students' names from a cup and asked them to pick the problem they wanted to present as long as it was not already selected. They were asked to explain the solution to the problem. Several students did really well with the explanations, while others wanted to explain little. For those students, I tried to ask them questions to make them explain such as "Why did you do that?" or "how did you know you could do that?". Getting students talking about math and explaining their thinking is really what I am most excited about as a teacher.

Thus, Kathy took on active role to elicit students' thinking by asking her students questions to prompt them to explain their reasoning. The US applauded Kathy for her actions to push her students to reveal their mathematical thinking

> US Response to Kathy's post above, April 8, 2013 at 9:15pm
>
> It's fantastic that you are getting your students to explain problems even those that who want to' explain little. Way to be a teacher that helps /insists that student find their mathematical voices

In summary, study participants' online posts about having individual students present solutions lead to online mentoring responses that highlighted and affirmed the study

participants' active role in eliciting students' mathematical thinking in the context of their students presenting solutions.

Presenting new material

Online content about strategies for eliciting student thinking when presenting new curriculum topics was initiated by Jake's desire to make his lessons more '"interesting" for his students.

> Posted by Jake on February 20, 2013 at 4:55pm
>
> I feel like I have reached the point of comfort-ability, at least in the Algebra II classes, and they seem to be needing something a little different. The problem is my creative juices are not leading me to anything interesting. …I don't know how to mix up presentation techniques to attract to differing types of listeners. I try to be fun and interactive, but math alone has the ability to turn people off. … They are obedient, good kids who don't complain much at all, so for their sake I feel it upon myself to make things more interesting; I just don't know how to do it.

In response, the US provided Jake with some specific suggestions about what he could do to make his presentation of material more interesting to his students by engaging them in doing the thinking.

> US response to posted on February 21, 2013 at 1:33pm
>
> Its great that your have got a comfortable positive atmosphere going in your Algebra 2 classes. Yes it is hard to make algebra 2 content interesting or fun to do. Perhaps you could make things a little more interesting (intellectually engaging) by doing some things that I have read from other student teachers: For example, 1) do a find the error activity. 2) Show three examples of how to do something without explaining and see if students can discover what you did 3) a group quiz- pair a stronger student to tutor weaker student for 15 minutes then quiz the weaker student reward both students if weaker student improves. 4) show examples and counter examples for students to derive definitions or procedures 5) perhaps even a jigsaw activity. These are just rough suggestions and need to be tweaked for your particular class.

About a week later, Jake described his experiences implementing one of the suggested strategies in his Algebra class.

> Posted by Jake on February 28, 2013 at 10:09pm
>
> Today is a day I will never forget. .. I took some risks in the way I presented adding and subtracting rational exponents today…on the document camera as we went through the lesson. I didn't do groups or anything like that, but I did use some ideas from some other blogs, namely not saying anything, showing them examples and asking them if they could spot the pattern. Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked…. I forced students to walk the class through the concepts, rather than giving them the steps myself, … It was the teaching day I had been waiting for**.**

The US applauded Jake for implementing a different teaching strategy that yielded rewarding results. She encouraged Jake to continue to try new strategies and to expand on his efforts to elicit students in thinking.

> Posted by US in response to Jake's February 28th post above:
>
> **Yeah! …** I am so impressed that you were able to turn things around in your class so quickly by doing something a little different to engage your students and that you found it rewarding. Keep it up and don't limit or doubt your ability to try **all kinds** of different things somewhere along the line.

In subsequent posts, Jake described his success with implementing other instructional activities designed to elicit his students' in thinking when he presented new content in both his Algebra 2 and Geometry classes.

> Posted by Jake March 7, 2013 at 10:51pm
>
> In Algebra II, we learned about multiplication and division of higher ordered radicals, multiplying by conjugates, and multiplying and dividing fractional exponents… I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner. I

> really enjoy this style better than what I was doing because it is more interactive and it forces them to think on their own
>
> Posted by Jake on March 20, 2013 at 11:47pm

> In Geometry, theorems are obviously what most of the teaching centers around, so I was tired of just giving students the theorem and having them memorize (what my CT typically does by PowerPoint), so today I switched things up a little bit. Much like I have been trying with my Algebra 2 classes, I tried to get them to discover the theorem on their own, still in a discussion type setting. In this case, though, I gave them a diagram of what the theorem stated (in this specific case, it had to do with central angles, arc measures and chord lengths). From the diagram, I asked the students to infer as to what the theorem was going to establish. B1 worked like a charm, so much so that a student who is typically lost and frustrated with a crap ton of questions along the way, was excited because he/she "understood something on their own." (he/she was the one that was able to state the theorem to the class in her own words
>
> Posted by Jake on April 8, 2013 at 11:16pm

> Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. In the past, what I have done when introducing new theorems is given them the picture and had them give the words of the theorem. Today I switched it up. The definition of the theorem would come on the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem. … I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed to understand the material. Instead, I was able to focus more on classroom management, controlling and incentivizing positive dialogue.

In summary, Jake developed a variety approaches to introducing new material in ways that engaged his students in mathematical thinking- using inductive and deductive reasoning to make inferences about aspects of the new content. Jake's new teaching strategies reflected and elaborated on suggestions provided by the US and strategies described by his peers in the online forum The US responded to Jake's embrace of new teaching strategies with elation and affirmation. Thus, online conversations provided a venue for the US to "hear" Jake' struggles, provide Jake with suggestions and ideas

posted his fellow student teachers and confirm Jake's progress in relation to implementing instructional strategies that elicit students' mathematical thinking.

Online content in relation to attending to students' mathematical thinking

Prompting study participants to attend to their students' mathematical thinking yielded few and often vague responses from the study participants. In the beginning of student teaching internship, study participants were given guidelines that their online posts should include observations about their students' mathematical thinking (See Methods section.). In addition, on several occasions in the online forum the US asked questions to prompt study participants to articulate their observations of their students' mathematical thinking. Despite the initial guidelines provided and the US' online prompting, only a few of study participants commented explicitly on their students' thinking. In all of those cases, the study participants' comments did not reflect any in-depth analysis of their students' mathematical thinking.

> Posted by Kristy on March 17, 2013 at 4:50pm
>
> We worked on Algebraic Rational Functions, which was basically just introduction to polynomials. … Their mathematical thinking is well developed but I think they need to be pushed more
>
> Posted by Jake on January 16, 2013 at 10:37pm
>
> Since the underclassmen are advanced, there is a bit of difference in their math thinking. They are a little bit quicker, ask more questions, and generally seem more interested

Vague comments like those above did not result in online mentoring conversations about students' mathematical thinking.

Some study participants shared a more detailed analysis of students' thinking when asked by the US to describe their students' misconceptions.

Comment by US on January 10, 2013 at 8:14pm

Did any interesting mathematical misconceptions come up when you were circulating around the room or when you were working with students after school?

Response by Kathy on January 10, 2013 at 8:48pm

One of the biggest things that the students were having trouble with was differentiating between a negative and positive slope. They could count the rise and run, but would often go in the opposite direction of what was indicated. For instance, they would be graphing a negative slope, but their graph would depict a positive sloping line. Part of this stemmed from them being unsure where to put the negative (in the top or bottom)

Comment by the US on February 25, 2013 at 10:34am

Tell me about some of the specific student misconceptions about the volume of 3-D figures that you discussed with your CT or that you anticipated or that you encountered during your teaching.

Response by Sam on February 25, 2013 at 2:49pm

My CT and I discussed how difficult it is for students to separate the general volume equation of V=B*H from the equation for the area of a triangle A=1/2bh because they become confused as to why a triangular prism has two b's and two h's. Additionally, the students commonly struggle with the idea that the "B" represents the entire base area. Many of them want to take a side length of the base and use it for the "B" value instead of calculating the base area. Finally, some students struggle even identifying the base unless the figure is drawn with the base oriented on the bottom.

Yet, the study participants' analysis of their students' misconceptions did not generate significant online discussions about students' mathematical thinking. Most often, the study participants' comments in relation to their students' misconceptions focused on how to remedy students' errors more so than on how to address students' underlying thinking. Furthermore, the US online responses did not effectively move study participants to consider and address the gaps in their students' underlying thinking such as students' limited understanding of slope as the formula "rise-over-run" or students' lack

of understanding of why the volume formula includes finding the area of the base. In summary, in this study, online mentoring did not seem to be an effective venue for generating conversations that involved in-depth examination of students' mathematical thinking.

Online mentoring in relation to connecting mathematics to real-life contexts

Online mentoring conversations related to connecting mathematics to real-life contexts centered on one study participant's (a) initial expectations, (b) disappointing experiences and (c) future plans in relation to incorporating real-life connections in his teaching.

Initial expectations.

At the outset of student teaching, Jake had great expectations about how real-life applications could enhance and motivate students' learning of mathematics. Consequently, he hoped to focus on infusing real-life applications in his teaching, yet he acknowledged that time and curriculum constraints might limit his ability to do so.

> Posted by Jake on January 12, 2013 at 12:06am
>
> Over the course of my early lesson presentation, I want a significant portion of my focus to try to be real world application. To be honest, I am not sure how much time in each block I will be able to devote to such, but it has been something over the last semester I have felt quite passionate about when running a classroom. With Trig and the Pythagorean Theorem coming up in Geometry, it shouldn't be all too hard. The most difficult part will be finding the time. The curriculum is so crunched, lateral thinking seems to be an afterthought, but if at all able, I would like to bring some of that real world problem solving, even if only a pinch.

The US affirmed that time and curriculum constraints might not support the infusion of extended real-life lessons but encouraged Jake to pursue his goal to make real-world

connections in his teaching. The US also provided some general suggestions about how Jake could integrate some real-world connections into his lessons.

> US response posted on January 13, 2013 at 2:28pm
>
> Time constraints and curriculum constraints often hinder the possibilities of doing "lengthy big" real world projects but I think you are right on target to be determined to do something "if only a pinch"(like introducing a topic in a real-world context, doing a few meaningful real-world application problems, using or collecting real-world data or measurements to solve problems...) You will no doubt learn a great deal from trying about what it may take to effectively integrate real-world applications in the future.

In addition, the US probed Jake to articulate more about his conception of real-world mathematics for his students.

> US response to Jake's January 12th post:
>
> What is the real-world for your students?' What in the real-world do they care about? Jake's response reveals his ideals about how real-world connections could engage students in thinking and questioning.
>
> Jake's response posted on January 13, 2013 at 6:21pm
>
> My aim isn't necessarily to find questions that apply to the world they currently live in, rather spark their interest into the world they are about to be apart of. I aim for students to be thinking about things way higher and more advanced than they are at. Things they want to do with their lives and how simple math principles apply to their aspirations. Maybe how it relates to music, athletics, architecture, or technology design. The youth should be asking questions they have no business solving in the short term, but desire to solve in the long term.

In summary, initial online conversations unveiled Jake's ideals about the efficacy of helping students connect mathematics to real-life contexts yet both Jake and US acknowledged the potential roadblocks to incorporating real-life activities in classroom teaching. Despite the reality of time and curriculum constraints, Jake planned to find

ways to infuse real-life applications in his mathematics teaching. US encouraged Jake to pursue his aspirations to include real-life connections in his lessons

Disappointing experiences.

During the course of his student teaching internship, Jake described several occasions where he carefully planned ways to incorporate real-life connections in his lessons. Jake's first attempt involved connecting a current sky-diving event with a velocity equation involving radicals. Jake was disappointed that real-world connections did not seem to motivate his students' enthusiasm for learning about radicals.

> Posted by Jake on February 26, 2013 at 11:58pm
>
> > This time, I started class with an example of where we would use radical simplification in the real world. I showed a video of a skydiver, then talked about how the formula for final velocity uses radical simplification. From there I went into my lesson, but still the interest was not there. … how interesting can you really make radical multiplication? …It seemed like they understood mildly what was going on, but they looked miserable, and I am not in this occupation to pull student's teeth

In response to Jake's finding that presenting a real-world connection did not magically motivate his students to want to learn about radical multiplication, the US suggested that Jake focus on adopting more engaging approaches for presenting the math topics required in the curriculum. The US did not comment on the efficacy of real-world application in the lesson but rather redirected Jake to enact instructional strategies that might involve students in thinking, collaborating and communicating about mathematics curriculum topics. To illustrate, the US referred Jake to online posts where other student teachers' described how they successfully implemented various strategies that engaged students in learning curriculum topics. Thus, the US directed Jake to teaching strategies that might

achieve the student mathematical engagement that he had failed to garner by connecting mathematics to real-life events.

Jake described another occasion where he attempted to connect mathematics to a real-life context. Jake carefully prepared a lesson where students had to use linear functions to make predictions about real events. Jake was excited about the opportunity to finally involve his students in a real-life problem-solving lesson but never got around to doing the real-world activity part of the lesson. The progression of the lesson was derailed when he had to spend more time than he anticipated, on reviewing the pre-requisite skills necessary for completing the real- world application activity. Jake was disheartened and "blindsided" by the outcome of the lesson.

> Posted by Jake on March 5, 2013 at 7:30pm:
>
> Today I finally prepared a lesson I was really excited about. It was in advanced geometry and we were "reviewing" linear equations...or at least I thought we were reviewing. What really excited me about the lesson was my real world application activity. I spent a lot of time putting together a sequence of videos, questions and tables to show how we might use linear functions to predict future occurences, in my case the olympic 100 meter race. I had a video of the world record race in 1912, 1936, and 1991 and based on those times, the students in groups were going to predict the current world record time. Their results they were going to record on the board. After each group had written a response on the board, we would watch the video and celebrate the winner (the closest to the right answer) by having them explain how they did it. Like I said in the last post, this is the stuff I am most passionate about, and finally I was going to be able to do it. … I was knee deep in the lesson when I found myself spending time on things I did not plan spending so much time on. The students felt lost because of my pace, but I felt lost because of their current algebra knowledge. Because of this curveball, I wasn't able to do my activity and had to spend all of class going over example problems. After first block I was really disheartened because I ruined my chance to do a real world problem. If I had only known to go slower I think everything would have gone better but I had no idea this wasn't a review session. I felt blindsided. …. I still have plans to throw in some real world stuff in the next lesson, but I question the time constraints allowing me to do so.

The US applauded Jake for planning a comprehensive real-world application lesson. She informed Jake that his experience of students' lacking the pre-requisite skills for completing a real–world activity was not uncommon. The US encouraged Jake to learn from his experience and to not give up on doing real-world application lessons.

> US response to Jake posted on March 6, 2013 at 7:09am:
>
> > The fact is that the "cool" real- life application can get bogged down and buried by the student's lack of facility with doing the necessary mathematical manipulations. Your experience with this lesson is not uncommon- but there is no need to throw out your lesson or others like it. This lesson will rise again, you just need adjust it a little and I am sure that you have already thought about some things to do- ways to review the mathematical skills needed at the beginning of the lesson or perhaps at the end of the lesson before or perhaps through a homework assignment... So don't give up on your application lessons, assume that students that will need to review the prerequisite mathematical skills needed for the lesson.

Although Jake mentioned that he still planned to try to integrate some "real-world stuff" in future lessons, Jake did not have an opportunity to implement another planned real-world lesson during his student teaching internship. Thus, Jake's well-planned real-life activities did not achieve his expected outcomes. Presenting his students with an example of how radicals are used in real-life did not motivate his students to learn about radical operations. His students' unanticipated lack of pre-requisite skills prevented Jake from engaging students in real-life problem solving activity and resulted in a loss of class time for covering the required curriculum.

Jake's most rewarding experience integrating a real-life connection was unplanned. Jake taught a lesson on solving systems of equations. In light of his previous attempts to conduct a real-life lesson, Jake did not plan to include any real-life applications for fear of not covering the required curriculum topics for the lesson. He was

thrilled when a student's question created an opportunity for him to discuss a real-life example of solving systems of equation - finding the market clearing price at the intersection of supply and demand curves.

> Posted by Jake on March 7, 2013 at 10:51pm
>
> > Had I more time, I would have loved to dive into the real world application of solving systems, because there are oh so many, but unfortunately I am finding more and more that there is little room for my passion in this jam packed curriculum. However, one student in the back of the room did ask (almost as if provoked from Heaven) "when will we ever use this in life?" I jumped at the opportunity to explain Supply and Demand curves and how the intersection represents the Market Clearing Price of any good or service (classic Economics). This is what I wanted to infuse from the start, but knowing how the last block went, I knew I wouldn't have time. I do think that question was Heaven sent because I needed a little taste of students really wanting to apply the material.

Thus, at a point where Jake seemed to be resigned to the conclusion that infusing real-life connections may not be plausible, Jake landed on an opportunity to make a real-life connection response to a student's question about real-life applications of systems of equations.

Future plans.

Jake's experiences with attempting to connect mathematics to real-life contexts during student teaching seemed to inform his plans for infusing real-life connections in the future. Jake's experience with his students' lack of prerequisite knowledge made him mindful that he might need to review prerequisite mathematical skills necessary to complete real-life activity.

> Posted by Jake on March 7, 2013 at 10:55p

> …knowing now a slower pace/review is needed. I by no means plan to scrap that real world activity because I enjoyed making it too much. It seems like a good thing to have in my back pocket for who knows when.

Jake's encounter with the reality of time and curriculum constraints seemed to spawn new ideas for connecting mathematics to real-world contexts that circumvent the limitations of time and curriculum content.

> Posted by US to Jake on March 19, 2013 at 8:19pm
>
> Hope that you have not given up on "real life applications in geometry because of your initial experience. Perhaps you can try something "real" again keeping in mind what you learned from your first attempt-
>
> Jake response to US posted March 19, 2013 at 11:12pm
>
> What I might start doing, since my review warm ups just seem to turn people off (i.e. factoring), is do a real world problem warm up. Give them a scenario, maybe with a video or a picture, and ask for a written solution of how you might go about solving the problem and an anticipated answer. Make it out of 10 points and add it to the homework grade. If they did it, because of the subjectivity, it would be easy participation points, plus it gets them thinking outside the box. It doesn't have much content relation, though, which is the obvious drawback, but I think it would be fun, and if we are training kids for the real world, I couldn't see a better application.

In conclusion, online mentoring conversations related to connecting mathematics to real-life contexts traced one study participant's journey from idealistic expectations, through sobering teaching experiences, to reframed plans for connecting mathematics to real-world contexts. The mentoring responses to various stages of the study participant's journey included encouragement and consolation.

Online mentoring in relation to using and connecting representations

Online mentoring conversations that were related to using and connecting a variety of representations involved discussions about representing mathematical concepts with analogies. The conversations centered on two important themes: (a) making sure a

representation is mathematically sound and (b) extending a representation to encompass concepts involved in a mathematical procedure.

Making sure a representation is mathematically sound

Kathy described an entertaining analogy that her cooperating teacher developed to help her students understand the definition of function.

> Posted by Kathy on January 30, 2013 at 10:00pm
>
> Basically there is a "function dance" and there are three rules that you must follow. The first rule is that no one can go alone. The second rule is that good kids (x's) can't go with other good kids (x's) and playas (y's) can't go with other playas (y's). Lastly, good kids can only take one playa, but the playas can take as many good kids as they want. Although it seems quite silly, the kids really understand it like this (and it is completely mathematically sound also).

The US expressed her admiration for the "function dance" and commended Kathy for spotlighting the mathematical soundness of the "function dance" analogy. The US underscored that representing a mathematical concept in a concrete way that is both accessible to students and mathematically sound, is an important pedagogical skill for mathematics teachers.

> US' response on February 1, 2013 at 9:27am
>
> I love the "function dance"! … Translating mathematical concepts to language that is accessible to students is a part of specialized mathematical work that teachers do because, as you noted, the translation must "be mathematically sound".

Thus, the online exchange between Kathy and US about the "function dance" surfaced the importance making sure that representations of mathematical concepts are mathematically sound-that is, they accurately depict the mathematical aspects of the concept.

Extending a representation to encompass concepts involved in a procedure.

In another online conversation about using an analogy to represent a mathematical procedure, Kathy and the US discussed ways to extend the analogy to encompass the concepts inherent in a procedure for simplifying radicals. The online conversation began with Kathy mentioning that she used an analogy of a couple divorcing to represent the first step, writing the radical as product of two radicals, of a procedure for simplifying a radical.

> Posted by Kathy on March 13, 2013 at 8:30pm
>
> Next, we moved on to square roots of non-perfect squares. I used the scenario my teacher came up with (she is so good at coming up with these things), which is talking about the radicand as a couple that splits up and moves into separate houses.

The US questioned Kathy about elaborating the analogy to encompass an important mathematical component in the first step–that is,writing the radical to be simplified as product two radicals where the radicand of one of the radicals is the largest perfect square possible.

> US' response on March 13, 2013 at 10:36pm
>
> I like the analogy of couple spliting up as a way to think about rewriting a radical as the product of two radicals. Does your CT carry the analogy further to steps for simplifying radicals. For example, like the wife gets all the perfect stuff in her house and husband gets the rest in his house ... or something like that :)?

Kathy builds on the US's idea and comments how to further extend the scenario to represent additional aspects of the steps involved in simplifying radicals.

> Kathy's response on March 13, 2013 at 11:04pm
>
> Well the ones that we have been working on were where only one of the radicals would simplify and so we would just say the one person moved on, but I do like how you related it back to perfect squares again by calling it "perfect stuff." And

> you could maybe say that all of the non-perfect or bad stuff gets left behind at the old house.

In the online conversation above, input from the US and the student teacher about an initial idea from the cooperating teacher resulted in the development of a more comprehensive analogy to represent a mathematical process. Thus, the conversation above captures an instance of asynchronous collaborative planning between a student teacher, her university supervisor and her cooperating teacher in an online mentoring environment.

Online mentoring in relation to facilitating active discovery.

Online mentoring conversations addressed three issues involved in designing and facilitating effective discovery activities in the mathematics classroom: (a) teacher-led vs. student-led discovery activities, (b) debriefing discovery activities, and (c) motivating students to work through discovery activities. For the purposes of this study, a discovery activity is an activity in which students explore and manipulate objects or situations in order to derive patterns, concepts or rules for themselves.

Teacher-led vs. student-led discovery activities.

One consideration that surfaced in online mentoring conversations was the efficacy of student-led vs. teacher-led discovery activities. Kathy found that her students' inability and/or unwillingness to work independently clearly impeded the progress of her discovery lessons.

> Posted by Kathy on January 24, 2013 at 7:43pm
>
> I had the students work on an independent discovery activity. It walks students through graphing different lines and seeing how they look when graphed and asking students what they notice about the slopes. Students were supposed to reach the conclusion that parallel lines have the same slopes and that

> perpendicular lines have opposite reciprocal slopes. The students who took the time to read it and follow along reached the appropriate conclusions or something close to it, but there were yet again some students who didn't bother to read it or even try. So when it came to the discussion time for the students to talk about what they found out, there wasn't much discussion at all.
>
> Posted by Kathy on February 5, 2013 at 5:33pm
>
> I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation… Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction and some students were having extreme difficulty progressing through the steps. I kept having to clarify how to do things on the board even though the steps were very explicit- they just weren't reading the steps…. Since there wasn't much progress, I chose to stop them where they were and direct their attention to me at the board. I had them graph several different ones and said "Okay, how does this compare to the parent function?" This seemed to be more effective than what they were doing previously.

Kathy's experiences led her to conclude that leading from the front of the class might be a more effective way to facilitate discovery learning for her students. The US approved of Kathy's decision to stop her students from working independently on the discovery activity. In addition, the US pointed out that Kathy's leading the lesson activity still afforded the students an opportunity to make a discovery.

> Comment by US on February 5, 2013 at 9:32pm
>
> I think that you made a very appropriate adjustment in graphing the functions in the board and asking them to make conclusions. You still got the students to make discoveries (make observations and draw conclusions) without getting slowed down by having to teach them how to read.

So, Kathy found it necessary, in her student teaching context, to shift to a more teacher-directed instructional approach for discovery activities.

On the other hand, although Sam had a positive experience leading a discovery activity for his class, he contemplated enhancing the lesson in the future by shifting from

his teacher-directed approach to the activity to allowing his students to work in pairs to manipulate materials and formulate conclusions.

> Posted by Sam on February 5, 2013 at 9:32pm
>
> I was able to do a really cool demonstration for them that helped us derive the equations for pyramid and cone volume. I took a cone and cylinder of the same base and height and asked them to guess the relationship between the volume of the two figures. … I filled the cone with water and then transferred the water to the cylinder. I did this three times and after each transfer the students were allowed to amend their guesses. Obviously by the third time we discovered that the cone was one third the volume of the cylinder …It was awesome to see the students engage in this activity. They seemed to clearly understand this new relationship and information. I think to extend this investigation I could try to obtain a set of figures for every two students and supply them with something like uncooked rice so that every student could have the opportunity to physically demonstrate this volume relationship independently

The US encouraged Sam to try having his students' work independently to discover the volume relationship but she cautioned Sam to think about how to organize the various aspects of the lesson to facilitate the students' learning.

> Comment by US on March 4, 2013 at 9:59pm
>
> You certainly might want to try one day having students work in pairs to find the relationship independently but you will need to consider how you will set up and introduce the activity and debrief the activity as well as how to handle all the materials.

Thus, Kathy's and Sam's experiences facilitating discovery activities surfaced the important instructional consideration of to what extent students should be asked to work independently, in pairs or small groups, to make mathematical discoveries. In both cases, online mentoring conversations provided a venue for the US to support and encourage the student teachers' quest to find ways to make discovery activities effective for their particular teaching contexts.

Debriefing discovery activities.

Incorporating debriefing activities is another important aspect of designing discovery lessons that emerged in online mentoring conversations. Debriefing activities reinforce or extend students' understanding of the main ideas of a discovery lesson. In her online mentoring responses, the US spotlighted the important role of debriefing activities in both Kathy's and Sam's discovery lessons. In Kathy's case, the US identified how a worksheet activity that Kathy included in her lesson served to debrief the ideas that students discovered about the relationship between graphs and their equations.

> Comment by US on February 5, 2013 at 9:32pm
>
> I think that having the students use the graphing calculator and make predictions and then work individually on worksheets were effective and necessary follow-up activities to reinforce and cement discoveries.…

In Sam's case, the US asked Sam to think about, as well as, provided Sam with examples of some follow-up questions he could have asked to assess and cement students' understanding of the "discovered" relationship between volume of cylinder and cone, or pyramid and prism with the same base and height.

> Comment by US on March 4, 2013 at 9:59pm
>
> I am not sure what follow up questions you asked but I would suggest that you think about what might be effective questions to ask to cement students understanding and debrief the activity. For example, if a cylinder has volume of 24 square inches , what must be the volume of the cone with same height and base?...If pyramid you used in your demonstration has volume of 10 square units, what is the volume of the prism with same base and height... If X represents the volume of the cone and Y represent volume of cylinder with same base and height, write an equation that represents the relationship that we just discovered...

In summary, online mentoring conversations were a venue for US to foreground the role of debriefing activities as an important component of discovery lessons.

Motivating students to complete discovery activities.

Yet another topic that surfaced in online mentoring conversations was instructional strategies that motivate students' participation in discovery activities. Motivational strategies discussed included (a) introducing the discovery activity in an engaging manner, (b) asking students to make and amend predictions about outcomes, (c) incorporating group competition, and (d) giving rewards for completing the activity. Introducing a discovery activity in an engaging manner is particularly appropriate motivational strategy in the context of discovery lessons. In an online exchange between the US and Kathy, the US helped Kathy to consider how she might frame her introduction of discovery activities in a way that might motivate students' participation.

> Comment by US on January 24, 2013 at 11:00pm
>
> Now challenge yourself to think about how to get more students involved in a discovery activity:.. Perhaps the students might be motivated by the way you introduce the activity- perhaps build in some competitive aspect in the discovery activity since the student seem to "feed off of the competitiveness"…
>
> Kathy's response January 25, 2013 at 8:21am
>
> I think I could definitely have sold the activity better. Maybe I'll say something like "So we are going to start something new today and it is kind of tricky, but I know you guys can all figure it out. I'm going to put you in groups so you can work together to figure it out. The first group to figure it out gets candy! Let's Go!"
>
> US Response on January 25, 2013 at 8:48am
>
> Yes! Yes! I like how your ideas about how to introduce a discovery activity. Keep tweaking your pitch (and keep thinking about the details of how you will organize groups rewards, participation). Often in teaching you can motivate students by the way you "sell" an idea with your enthusiasm

In an online conversation between the US and Sam, the US directed Sam to attend to how specific elements of his instruction served to motivate students' participation and engagement in his discovery demonstration. In particular, the US asserted that Sam's

asking students to first make predictions was a key element in "setting up" the activity. In addition, the US' questions and comments nudged Sam to consider the potential benefits of having students record predictions before beginning the discovery activity.

> Posted by Sam on March 3, 2013 at 10:15pm
>
> I took a cone and cylinder of the same base and height and asked them to guess the relationship between the volumes of the two figures. Most students guessed that the cone was about half the volume of the cylinder. A few guessed that it was one third the volume. I filled the cone with water and then transferred the water to the cylinder…

Comment by US on March 4, 2013 at 9:59pm

> It's great that your discovery activity for finding the relationship between the volume of cone and cylinder and pyramid and prism with same height and base worked out so well. …It is worth thinking about what made things work out so well and what you could do better so that you can effectively facilitate similar activities in the future. I was not there to observe but I think that asking students to guess the relationship first key element in setting up the activity. Also allowing students amend their guesses after observation engaged students in thinking and re-thinking. Did students call out their predictions or write down their predictions?

Response by Sam on March 4, 2013 at 11:21pm

> I did not have the students record their predictions. This could have provided written evidence for each student as to how accurate they were at each opportunity

Thus, in the conversations above, the US and student teachers focused on an important aspect of facilitating discovery lessons-introducing discovery activities in a way that creates in students a sense of anticipation and thus motivates students' attention to and engagement in reaching an outcome in the discovery activity.

Online mentoring in relation to promoting student collaboration

Mentoring student teachers toward promoting student collaboration in online conversations was comprised of three major themes: (a) prompting student teachers to

attend to student collaboration, (b) providing detailed suggestions about how to promote productive student collaboration and (c) responding to student teachers' efforts to promote student collaboration.

Prompting student teachers to attend to student collaboration

In online conversations, mentoring student teachers toward promoting student collaboration involved prompting student teachers to attend to the student collaboration that occurred in their classrooms. In several posts, student teachers casually mentioned that students worked in groups during the lessons. In response, the US probed and prompted the student teachers to focus, in more depth, on the nature of student collaboration they observed. The US asked questions to provoke student teachers to describe and thus, reflect on the quality of student collaboration in their classrooms.

> US Response to Sam's January 12th post.
>
> Tell me something about how "well" the geometry students worked together in groups. In our interview, you spoke about the importance of student collaboration. Does the group work you have witnessed so far in the geometry classes live up to your vision about student collaborations? Is there something about student collaboration in the geometry class that could be better? Do they stay focused on mathematics? Do they express their thinking, ask each other questions, do they work independently or interdependently
>
> US response to Kathy Feb 22nd post
>
> Curious to hear about how the group work is going …. I wonder what kind of conversations the student are having about which method to use to solve the systems. I will check your posts later to find out.
>
> US Response to Jake's March 7th post
> How did the students do with the share with a partner part of this lesson? Did most of the students share with a partner?

Student teachers' responses to the US' queries revealed that student teachers were often not completely satisfied with the nature and breath of the student collaborations they observed in their classrooms.

> Posted by Jake on March 7, 2013
>
> The partner sharing portion whenever I choose to institute has not worked well. Very few share with their table partners, maybe because they are not comfortable with who they are sitting beside. Oftentimes, I get asked questions when I tell them to check with their partner. That is not to say it is all bad, and during this time I don't answer their questions. There are students who do collaborate with each other, but it seems as a whole they are content doing things solo. I don't really know what to do in order to help aid this process.
>
> Posted by Sam January 12, 2013
>
> The group work I observed this past week had its strong and weak aspects. First, I noticed that some student groups did not work as intended. These groups usually had a single student completing the bulk of the work while the other group members simply tagged along for the ride. … Further, I observed some groups simply behave as an opportunity to socialize. However, there were also many groups that worked beautifully together. …In all three of these examples I find that group work only partly meets the ideal I brought into the classroom.
>
> Posted by Kathy on February 5, 2013
>
> I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. … I told them to make sure that they help their group members and work together …. Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction.

Thus, prompted by the US' inquiries, the study participants reflected and revealed their disappointments about the nature of student collaborations they observed in their classrooms.

Providing detailed strategies for promoting productive student collaboration.

The US responded to the study participants' lack of satisfaction with the quality of student collaboration by providing detailed suggestions about how to promote more

productive group work. The US emphasized and illustrated the teachers' role in providing specific guidelines and expectations for group interaction:

> US' response to Jake's March 7th post
>
> It is usually not enough to simply tell/ ask students to work with a partner- they have to be taught how to work together and it is best if the teaching begins during the first few weeks of school - so you can think about that when you begin your first teaching job. But there is something you could do now to promote better student collaboration. You will need to 1) be more specific about the collaborate behavior that you expect and 2) you have to reward positive and productive collaborative behavior. . So for instance, when you ask students to work together, you might have to tell them exactly who they should talk with e.g. " … then you have to tell them the exactly what they should do e.g. "… In addition to articulating the specific behavior that you want, you need to highlight and praise good collaborative behavior just like we reward and highlight good mathematical work and thinking.. … My major point is that students do not naturllay know how to work to together, you have teach them about what working together sounds like, looks like and you have to reward them when they do it and you might have to motivate them to do so.
>
> US' response to Kathy's February 7th post
>
> It's right on target to now be thinking about the next level- how to make group work more productive. You mentioned one thing - strategically picking group members. Another thing to consider how you can establish and communicative expectations and guidelines about how you want groups to work together- this could being more specific than just saying you have to work together and help each other- for example " first work on problem individually, then compare and explain your answers, do not move on until everyone in the group understands
>
> US' response to Kathy February 5th post
>
> Perhaps, you could still incorporate a group component by asking group members to discuss their predictions and write them down as a group.- perhaps you could give every group a white board(Are schools still using mini- white boards or perhaps students have an app that lets them write on their IPADS).

Thus, mentoring study participants toward promoting student collaboration in online conversations initially entailed prompting students to notice the quality of student collaboration in their classrooms and subsequently involved providing suggestions about

how to structure and facilitate group interactions to improve the quality of student collaborations.

Responding to student teachers' efforts to promote student collaboration

Finally, mentoring student teachers toward promoting student collaboration in online conversations included responding to study participants' efforts to promote student collaboration during their lessons. In several online posts, study participants described positive outcomes from implementing specific strategies to promote student collaboration. Many of the strategies reflected suggestions provided by the US in previous online conversations.

> Posted by Kathy on March 5, 2013:
>
> We played a game that I made up, which I turned out to really like. I had the class divided into groups of three. Each student had their own whiteboard on which they had to work out the problem I wrote on the board. Then, they had to compare answers with their group and reach a consensus on the right answer and/or help each other figure it out. They could then show me their answer. … The kids were really into it the whole time and I was having fun too. I saw a lot of good discussions going on within the groups. … I like this game because it gives the opportunity to correct mistakes, and that they have to cooperate with their group before answering. I definitely want to do this again, especially when reviewing
>
> Posted by Kathy on February 21, 2013
>
> I had them choose their groups, since they are such a small well-behaved class, for the choosing the method activity. I told them to focus more on talking about what method they would prefer and why rather than actually solving it although I wanted them to do that too if they had time. I heard many good conversations
>
> Posted by Jake on April 8, 2013
>
> Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. … The definition of the theorem would come on the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem. Once the two minutes was up and I everyone had made a solid attempt, they turned to their partner and took another two minutes to converse about the right answer and record a final answer

> on the board (both picture and equation). Once the second two minutes was up, each group would hold up their boards, we would look around at all the submissions, go over the right ones and talk about what happened with the wrong ones. … I like the way it went because it forced them to really understand the words of the theorem in order to draw a picture or formulate an equation. It had a nice group aspect to it as well. Definitely going to keep this in the back pocket for years to come.

The US praised the study participants' efforts to promote student collaboration. Moreover, by underscoring the specific strategy implemented by each study participant, the US once again highlighted the role of teacher actions in promoting student collaboration.

> US' response to Kathy's March 5th post
>
> I love everything you mentioned about your game: individual work first, requirement to check and collaborate with group, emphasis not on getting the answer the fastest, lots of good group discussions…
>
> US′ response to Kathy's February 21st post
>
> It's really great that you gave the group some direction about what you wanted them to focus on in their talking in the groups- what method and why more so than just finding the answer - … stating your expectations for group interaction is a key component in facilitating effective group work.
>
> US response to Jake's April 8th post
>
> What' I love about what you did in geometry today is that you progressed a little further in engaging the students in doing the mathematics- …Also I am really pleased with the group aspect that you introduced today- .. . I love the think- pair share element in this learning approach

In conclusion, the content of mentoring study participants toward promoting student collaboration was manifested in three sequential themes. Initially, prompting study participants to focus on student collaboration, subsequently, providing suggestions about specific strategies to improve productive student collaboration and finally, responding to

and supporting study participants' efforts to implement specific strategies to promote meaningful student collaboration.

Online mentoring in relation to promoting mathematical discourse.

In relation to "promoting mathematical discourse", three themes emerged in online mentoring conversations among study participants and their US. Mentoring conversations involved (a) encouraging study participants' vision for promoting mathematical discourse, (b) highlighting strategies that facilitate mathematical discourse and (c) responding to study participants' efforts to generate mathematical discourse.

Encouraging study participants' vision for promoting mathematical discourse.

During the initial weeks of student teaching, Kathy and Roger commented on their observations of students engaged in positive mathematical discourse. Kathy and Roger were both impressed by what they observed.

> Posted by Kathy on January 11, 2013:
>
> Overall, I really enjoyed watching her class. She asked the students lots of questions and let them do most of the thinking and calculating. The students also asked a lot of questions to her… Part of the reason the class was this way was because it is an advanced class, but I still think it can be done with lower level classes as well. I really want to try to involve the students when I am teaching
>
> Posted by Roger on January 11, 2013
>
> I noticed the personality of the class actually lead to positive aspects of the students learning, because they took the opportunity to talk with their friends and critique each other while reaching a solution. … One of the things this showed me today were the benefits of classroom discussions. Students were engaged and talking

The US responded to Kathy and Roger's comments by applauding their observations and encouraging their vision for promoting classroom discourse experiences in their own

student teaching. In Kathy's case, the US encouraged Kathy to hold on her vision of engaging all students in meaningful mathematical discussions.

> US' response to Kathy's January 11th post
> I impressed that you think that lower level students can also be engaged in classes where there is constructive mathematical discourse and communication like you observed in the advanced class. Try to hold on to that vision of classroom interaction for all students.

In Roger's case, the US engaged Roger in an online dialogue that teased out his belief that teachers are obliged to provide opportunities for mathematical discourse:

> Online mentoring conversation between US and Roger:-January 11-13th
>
> Roger: One of the things this showed me today were the benefits of classroom discussions. Students were engaged and talking. However, this was contrasted with the reserved nature that much of the advanced classes showed
>
> US: I have also noted that sometimes because advanced students are so cooperative and there is so much material to " cover" that we neglect to create opportunities for them to communicate/debate their thinking with each other.- On the other hand its interesting to note that Kathy (See Kathy's January 11, 2013 post above) observed an advanced class today where the students were very engaged discussion- answering and asking questions
>
> Roger: I think the advanced classes have to potential to have very productive conversations about mathematical concepts because of their exhibited understanding of math in both general and technical terms. But I also think you hit the nail on the head when you talked about those opportunities being restricted because of the sheer volume of material to cover…
>
> US: Do you think that as mathematics teachers we are obligated to provide or push opportunities for students to communicate productively about mathematics concepts or is Ok to just make sure we cover the material? Is learning to communicate about mathematics apart of learning mathematics?
>
> Roger: I absolutely believe it is essential that students learn to communicate in mathematical thought. … The mission for us as teachers then becomes finding ways for students to participate in mathematics as a conversation.
>
> US: Yeah! So think about how you can create opportunities for mathematical conversations, even if they are brief, and begin experimenting with little (and maybe big) ways to create mathematical discourse when you start to take over classes. Everything you try may not work but you will no doubt learn a lot from

> trying and that's what student teaching is about- learning to teach by trying stuff. Looking forward to hearing about what you try and what you learn :)

In summary, during the first weeks of teaching study participants' descriptions of the positive mathematical discourse that they observed in classrooms at their student teaching site triggered mentoring conversations, where the US encouraged and prodded the study participants' aspirations to provide similar opportunities for classroom discourse in their own teaching.

Highlighting strategies that facilitate mathematical discourse.

As the student teaching internship progressed, mentoring conversation focused on strategies for promoting mathematical discussion. Study participants' identification of specific teaching strategies that seemed to generate classroom discussion was the springboard for mentoring conversations that focused on the teacher's role in facilitating classroom discussion. The US' mentoring responses served to further underscore and specify the strategies noted by the study participants and to reiterate that the way a teacher structures an activity or facilitates a lesson is critical for generating classroom discourse. For example, Kathy observed that dissonance between students' predictions and calculated outcomes generated a "good discussion" in a lower level class and hoped to use a similar "first-predict-then-compare-to-results" strategy to stimulate discussion in her teaching.

> Posted by Kathy on January15, 2013
>
> Of course, students were tempted to say that having a higher number of successes (quarterback pass completions, correct answers on a test, etc.,) regardless of how many attempts were made, was better (Ex. 42/50 would be better than 22/25). After they calculated the percentages and compared, they realized that this wasn't always true. In 4th block in particular, this generated a good discussion about how much data would be needed to rely solely on this

> percentages etc. This gave me a glimpse of what it could be like to have the lower level students engaged in discussion. I think that having them make predictions and comparing that to results would be helpful in the future.

The US affirmed Kathy's observations about the efficacy of the first-predict-then-compare-to-results" strategy for generating discussion and she generalized that eliciting students' input is a way to bring students into a lesson.

> US response to Kathy's January 15th post.
>
> You make a keen observation about how ' asking students to make a predictions and then comparing the predictions to the results" is nice strategy for engaging the students and perhaps stimulating a conversation. Starting with students' input generally helps to bring students into a lesson.

In another example, Roger observed that what served to generate mathematical discourse throughout all the classes he observed one day, was that students had opportunities to solve and discuss problems that had multiple possible approaches to the final solutions. In response, the US applauded Robert's attention to a specific lesson activity–working on problems with multiple solution paths–that facilitated mathematical discourse. She encouraged him to continue to focus on the teacher's role in structuring lessons that provide opportunities for mathematical discourse.

> US' response to Roger's January 14th post
>
> Well, sounds like it was great day for mathematical discourse. Cool observations and a foreshadowing of great possibilities for the future. Continue to think about the teacher's role in facilitating classroom discourse. It is true that some topics lend themselves better to classroom discussion and it is true that some students are just better and more willing to communicate/collaborate about mathematics but the way a teacher structures the classroom activities and facilitates/demands/expects/affirms conversation is the real key to creating mathematical discourse in classroom.

In summary, the US affirmed the study participants' recognition of specific situations that seemed to stimulate mathematical discourse and emphasized the teacher's role in creating and orchestrating such situations.

Responding to study participants' efforts to generate mathematical discourse.

Finally, online mentoring conversations in relation to promoting mathematical discourse involved responding to study participants' efforts to generate mathematical discourse in their own teaching. In several blog posts, Robert described his efforts to stimulate mathematical discourse during various lessons through his student teaching semester. When Robert described that it was difficult to engage his students in mathematical discussions by simply calling on them randomly, the US responded with encouragement and suggestions about additional strategies for promoting classroom discourse. The suggested strategies included having students "think-pair-share" and asking students questions that would require them to comment on and extend verbal contributions from their classmates. When Roger described his success in creating classroom discussion about various solutions paths to a problem in his pre-calculus class, the US cheered his success but she also pushed Roger to reflect on how to improve discourse to include even more student participation.

> US's response to Roger's February 4th post.
>
> Are all the students participating in the discussion? Are the students doing most of the talking and summarizing during the discussion. You have done so much to facilitate classroom discourse so far. What more do you want to see in your students in this regard. There is always room for improvement and do you think the same level of discussion that you see in your pre-calculus students is also possible with your Algebra 1 students?

When Roger expressed concerns that providing opportunity for student mathematical discourse prolonged his lessons beyond anticipated time limits, the US responded by assuring Roger that with experience, he will learn manage the time by strategically selecting when and how to involve his students in classroom discourse.

> US's response to Roger's February 4th post
>
> Yes I understand about the time issue …. Time is something that you will learn to manage more effectively with experience and it often boils down to strategically choosing when and what math to tell and when and what math to let students do and still feel like you have done justice to teaching mathematics with meaning. I am curious to hear how your efforts to work on mathematical discussions and discourse will work out when you take over Algebra 1.

In summary, the mentoring conversations surrounding Roger's efforts' to implement teaching strategies that promote mathematical discourse addressed the range of implementation issues that surfaced in Roger's students teaching experience. The US' mentoring responses included providing practical suggestions about strategies to encourage more participation, asking questions to prompt Roger to assess the nature of mathematical discourse during his lessons and assuring Roger he will learn to balance time constraints with his desire to provide opportunities for student mathematical discourse.

Summary of Findings for Research Question 1

The findings, discussed above, for each aspect of standards-based instruction, synthesize into (a) findings about the content of online mentoring in relation to the various aspects standards-based instruction as defined by this study and (b) general findings about mentoring moves that emerged in the online forum for this study.

General findings about the content of online mentoring

The following section discusses the general findings about the content of online mentoring toward particular aspects of standards-based instruction: (a) moving beyond the status quo (b) acknowledging the obstacles, (c) unpacking the nuts and bolts of instruction and (d) missing the target about students' thinking.

Moving beyond the status quo.

Study participants' dissatisfaction with the status quo was the catalyst for mentoring study participants toward promoting student collaboration and mathematical discourse and toward eliciting students' thinking. For example, study participants' recognition that the quality of students' interaction during group work activities was less than ideal provided a channel for the US to mentor study participants toward taking actions that promote student collaboration and mathematical discourse. Similarly, a study participant's lack of satisfaction about student engagement with mathematics curriculum topics was the segue way for the US to encourage the study participant to implement strategies that engaged his students' thinking. Specifically, the content of mentoring toward promoting student collaboration, promoting mathematical discourse and eliciting students' mathematical thinking involved the following common sequence of online exchanges between study participants and the US:

1. First, study participants assessed the current realities in their student teaching context,
2. Second, the US suggested strategies that might improve the realities;

3. Third, study participants described their positive experiences implementing new strategies and
4. Fourth, the US provided feedback about study participants' efforts to implement new strategies.

In summary, online mentoring conversations seemed to have moved study participants from observing the status quo to identifying and enacting strategies that enhanced the level and quality of student collaboration, mathematical discourse and mathematical thinking in their classrooms.

Acknowledging the obstacles.

The content of online mentoring toward connecting to real contexts and elevating mathematical concepts was centered on one study participant's disappointing experiences with facilitating both a "real-world" lesson and a lesson where he focused on helping students understand mathematical concepts underlying procedures. In both cases, time constraints, curriculum constraints and lack of knowledge of students' potential misunderstandings impeded the study participant's ability to reach the positive outcomes that he had anticipated. The US supported and encouraged the study participant's foray into designing and teaching lessons that connected mathematics to real-life contexts and lessons that emphasized underlying mathematical concepts. Yet, the US was quick to acknowledge the roadblocks and empathize with the pedagogical challenges that the study participant encountered in the process. Although the study participant did not have successful student teaching experiences in relation to connecting mathematics to real-life contexts or elevating concepts, the online forum was a venue for airing his frustrations and receiving encouragement to adjust his approach rather than abandon efforts to

connect to real-life contexts and elevating concepts. Thus, online mentoring conversations supported the study participant on his journey from idealistic expectations, through sobering teaching experiences, to reframed plans for connecting mathematics to real-life contexts and elevating concepts in the future teaching endeavors.

Unpacking the "nuts and bolts" of instruction.

Online mentoring content in relation to using and connecting representations, and facilitating discovery and mathematical investigations was characterized by attention to delineating key instructional components involved enacting these aspects of standards-based instruction. For example, online mentoring discussions on using representations focused on the following two instructional considerations: making sure a representation is mathematically sound and extending a representation encompasses concepts inherent in a mathematical procedure. Online mentoring conversations related to facilitating discovery and mathematical investigations addressed the following key issues:

- motivating students to persist in working through discovery activities,
- determining to what extent discovery activities to should be teacher led or student led and
- incorporating debriefing discovery activities that reinforce and assess students learning.

Thus online mentoring was a venue for unpacking the "nuts and bolts" of implementation in relation to facilitating discovery lessons and using representations

Missing the target about students' thinking.

Significant conversations that focused on attending to students' mathematical thinking did not occur in the online mentoring conversations in this study. Despite the

fact that study participants were given directions to include observations about students' mathematical thinking in their online posts, the study participants made only a few general comments in which they explicitly mentioned their students' mathematical thinking. In addition, study participants' indirect comments related to students' thinking, which most often involved identifying students' errors, never developed into occasions for analyzing the students' thinking underlying the errors. Thus the study participants' posts did not lead to any in-depth online mentoring discussions about their students' mathematical thinking.

Summary of the general findings about the content of online mentoring related to aspects of standards-based instruction.

In summary, the general findings about the content of online mentoring toward the specific aspects of standards-based instruction defined by this study are the following:

- Online mentoring seemed to help study participants make progress in relation to promoting student collaboration, facilitating mathematical discourse and eliciting students′ mathematical thinking.
- Online mentoring was a venue for the US to acknowledge study participants′ frustrations and to encourage study participants to rethink rather than abandon their prospects for teaching real-world lessons and for teaching lessons that focus on helping students understand the underlying mathematical concepts.
- Online mentoring seemed to be an effective venue for unpacking the key components of instruction in relation to facilitating discovery activities and using effective representations

- Online mentoring did not prove to be an effective venue for study participants to engage in analyzing their students′ mathematical thinking.

General Findings About the Mentoring Moves Manifested in this Study

The next section will discuss the following mentoring moves that emerged in the online forum for this study (a) mining study participants online posts (b) affirming and justifying study participants' efforts (c) nudging participants to consider and enact standards-based instructional strategies.

Mining study participants' online posts.

Integral to the design of this study, the content of study participants' online posts about their student teaching experiences were the catalysts for online mentoring discussions about standards-based instruction. Consequently, the US mined study participants' comments for opportunities to discuss standards-based teaching processes. In some cases, study participants' comments were directly related to aspects of standards-based instruction and the US consequently responded with questions to further extend the discussion. For example, in response to Jake's comment about allowing students in his geometry class to share answers with a partner, the US responded with questions in hopes of prompting a conversation about promoting student collaborations:

> US response to Jake on March 7, 2013 at 11:16pm
>
> How did the students do with the share with a partner part of this lesson. Did most of of the students share with a partner?

Similarly, in response to Kathy's comment that she planned to have students work in groups in an upcoming lesson, the US responded with requests for feedback about the students' of mathematical discourse

US' response to Kathy on February 22, 2013 at 12:32pm

> Curious to hear about how the group work goes or is going on now as I write this posts. I wonder what kind of conversations the student are having about which method to use to solve the systems. I will check your posts later to find out.

In some cases, the US responded to study participants' comments about their lesson topics with questions that could potentially segue way into conversations about aspects of standards-based instruction. For example, in response to Kristy's comments about reviewing probability topics for several days, the US asked questions that could potentially lead to conversations about students' mathematical thinking or about using effective representations.

US response to Kristy on February 12, 2013 at 1:26pm

> During the course of reviewing this material for several days, did you find any ways of explaining things that seemed to have worked for students? Which permuation and combination stories really clicked with your students?

Similarly, in response to Sam's comment that "Today was one more day of new material on the equations of circles in geometry", the US responded with probing questions in hopes of prompting a conversation about elevating concepts or "big" mathematical ideas

US' response to Sam on March 25, 2013 at 7:20pm

> Give me some more details about how you taught equations of circles today to your geometry class. How did you introduce it, what kind of examples did you present... what do you think your students walked away with from the class

Although the US′ responses did not always elicit study participants′ attention to standards-based teaching practices, as documented earlier in this chapter, the US' responses to the study participants' online posts quite often resulted in significant conversations about standards-based instruction. In summary, online mentoring involved

persistently mining study participants' online posts for opportunities to discuss standards-based instructional practices

Affirming and justifying participants' efforts.

The US responded to study participants' efforts to enact standards-based teaching practices with affirmation and with comments that highlighted the mathematical learning opportunities made accessible through standards-based instructional approaches. For example, in addition to affirming Kathy's efforts to facilitate a discovery activity, in the comment below, the US elaborated on inductive reasoning opportunities afforded students through discovery activities.

> Comment by US on January 24, 2013 at 11:00pm
>
> Bravo, for trying a discovery activity! Discovery is **inductive reasoning**- making a conclusion or conjecture based on observations of patterns. Inductive reasoning is an important aspect of doing mathematics and you mentioned in you were interesting in students learning about reasoning

Similarly, in addition to praising Jake efforts to design a real-world lesson, the US listed all the academic virtues involved in the lesson.

> Comment by US on March 6, 2013 at 7:09am
>
> I applaud you for planning such a fantastic lesson plan for Advanced Geometry that would include an opportunity for students to look at real data, think, make predictions collaborate and then calculate.

In the comment below, the US confirmed that Kathy's idea of showing how point-slope formula can be derived from the slope formula could serves to surfacing the "big" mathematical idea of equivalent equations.

> Comment by US on January 20, 2013 at 8:52pm
>
> Yes! Showing how the point-slope formula can be derived from the slope formula is important, even if students cannot recall or replicate the process because doing

> communicates so an important big idea in mathematics - equivalent forms of the same equation. People who know real mathematics understand that all equations can be manipulated into different forms.

Similarly in the comment below, the US cheers Kathy for pushing her students to explain their thinking. Moreover, the US asserted that Kathy's insisting that her students explain is a step toward helping her students develop their ability to communicate about mathematics.

> April 8, 2013 at 9:15pm
>
> Its fantastic that you are getting your students to explain problems even those that who want to' explain little. Way to be a teacher that helps/insists that student find their mathematical voices

In summary, the US coupled her affirmations of study participants' efforts to implement standards-based instructional practices with comments that justified standards-based approaches to mathematics instruction as means for achieving valuable education goals and experiences for students.

Nudging study participants to consider and act.

The US consistently directed study participants to consider, explore and implement teacher-actions that exemplify standards-based instruction practices. For example, in the comments below, the US asks study participants to look beyond their students' natural tendencies to contemplate their part in cultivating students' collaboration and mathematical discourse.

> US' comment to Roger on January 11, 2013 at 10:22pm
>
> It's great that you witnessed first-hand the efficacy of students communicating about mathematics in a classroom but you also noted that you have not witnessed similar discussions in advanced classes at [your high school]. You might want to

think about what teachers can do to cultivate/ motivate/demand mathematical discussions so that it is not just left up to students having the “personality" to talk and critique each other.

US comment to Roger on January 14, 2013 at 9:44pm

Continue to think about the teacher's role in facilitating classroom discourse. It is true that some topics lend themselves better to classroom discussion and it is true that some students are just better and more willing to communicate/collaborate about mathematics but the way a teacher structures the classroom activities and facilitates /demands/expects/affirms conversation is the real key to creating mathematical discourse in classroom

US comment to Sam on January 15, 2013 at 9:08pm:

Think about what other strategies you could use to promote the type of group interaction that you would like to see. Students don't naturally know how to work in groups, sometime it happens but most often students have to be " taught " how to work in groups which mean explaining, modeling and providing specifics about effective/expected group behavior.

In addition to asking study participants to think about effective teaching strategies, the US encouraged study participants to experiment with implementing strategies that might increase the frequency of student collaboration and mathematical discourse in their classrooms. She reminded study participants to embrace the opportunity to learn from their efforts.

US comment to Jake on March 11, 2013 at 9:35am

Challenge yourself to see what progress, you can make in helping your students to work together. There is alot that you can do it does not have to be left to chance. So try to think about what you can do and try it and see what happens. We are always learning to teach.

US comment to Roger on January 13, 2013 at 10:28pm:

Yeah! So think about how you can create opportunities for mathematical conversations, even if they are brief, and begin experimenting with little (and maybe big) ways to create mathematical discourse when you start to take over classes. Everything you try may not work but you will no doubt learn a lot from trying and that's what student teaching is about- learning to teach by trying stuff. Looking forward to hearing about what you try and what you learn :)

Even when study participants experienced some success with standards-based instruction, the US pushed them to also consider what more they could to do improve their effectiveness with facilitating standards-based instruction.

> US comment to Kathy on January 24, 2013 at 11:00pm
>
> It's great that the activity worked for those who were willing to read and do it. Now challenge yourself to think about how to get more students involved in a discovery activity
>
> US comment to Sam on March 4, 2013 at 9:59pm:
>
> It's great that your discovery activity for finding the relationship between the volume of cone and cylinder and pyramid and prism with same height and base worked out so well. … It is worth thinking about what made things work out so well and what you could do better so that you can effectively facilitate similar activities in the future.
>
> US comment to Jake on March 6, 2013 at 7:25am:
>
> It's great that the students so willingly helped each other figure things out. You might want to think about how you might have to adjust the game for students who do not so willing help each other.
>
> US comment to Roger on February 5, 2013 at 12:56pm:
>
> Now, I have to ask questions: Are all the students participating in the discussion? Are the students doing most of the talking and summarizing during the discussion. You have done so much to facilitate classroom discourse so far. What more do you want to see in your students in this regard. There is always room for improvement and do you think the same level of discussion that you see in your pre- calculus students is also possible with your Algebra 1 students?

In summary, the online mentoring toward standards-based instruction in this study was characterized by US comments that nudged study participants to reflect on and take action to implement and refine teaching strategies that were consistent with standards-based instructional practices.

Summary of characteristics of online mentoring.

In conclusion, the general finding about over-arching characteristics of mentoring toward standards-based instruction are as follows.

- The US mined study participants′ comments for opportunities to discuss standards-based instructional practices
- The US′ online mentoring responses both affirmed and justified the study participants′ efforts to implement standards-based instructional practices.
- The US′ online mentoring comments nudged study participants to reflect on and take action to implement and refine teaching strategies that were consistent with standards-based instructional practices.

The implications of the general findings above about the content and characteristics of online mentoring toward standards-based instruction will be discussed in Chapter 5

Findings for Research Question 2

The following section of this chapter addresses findings in relation to research question 2. Specifically the following section describes what online comments and mentoring conversations reveal about individual study participants' developing conception and implementation of standard-based practices. While study participants' online comments revealed evidence of progress in several aspects of standards-based instruction, the following sections describe the most pronounced aspect of development for each study participant. In addition the following section reports how individual study participants perceived that online mentoring conversations were related to their development of standards-based instructional practices.

Kathy's Development

Kathy's development in promoting student collaboration and mathematical discourse is documented in the analysis of Kathy's pre-interview responses, online posts and post interview responses found in Figure F-1 in Appendix F. In summary, Kathy's development in conception and implementation of instructional practices that promote student collaboration and mathematical discourse progressed through the following three stages.

- Stage 1: Kathy had both the **desire and the determination** to provide opportunities for all students to collaborate in groups and engage mathematical discourse
- Stage 2: Kathy's **disappointment** about initial group interactions, led her to **doubt** the possibility of lower level students working independently in groups.
- Stage 3: Kathy 's **deliberate implementation of strategies** that were effective in promoting discourse and collaboration in her advanced class prompted her to reconsider the possibility of facilitating similar productive group interaction in lower-level classes

Stage 1: Desire and determination to facilitate student collaboration.

Kathy's pre-interview responses and her initial online journal posts (See Table 4.1 and Table 4.2) revealed her desire to provide opportunities for all levels of students to collaborate in groups and engage in mathematical discourse. Kathy believed that student collaboration and mathematical discourse are means for enhancing students understanding. Her observations of classes prior to students teaching and during early

weeks of student teaching provided glimpses of the possibilities for facilitating communications and mathematical discourse in her own teaching.

Table 4. 1: *Kathy's pre-interview excerpts (January 14, 2013).*

Pre-interview question	Kathy's responses
What is involved in "good" mathematics teaching?	Having students communicating about math, not just being able to do the steps but really understanding what's going on behind the steps and being about to explain it to someone else in an in-depth manner.
Describe a specific time when you have seen "good" mathematics instruction?	Last semester in an "Algebra 2 class…that had a lot of the lower level kids" where the teachers "incorporated a lot of fun activities and a variety of things where they had group work so the students were getting to communicate with each other about the different things that they were learning about and helping each other to figure out what they are not sure about, to share their strengths and weaknesses"
Which of the NCTM process standards do you specifically want to work on during student teaching?	I like the communication one a lot, communication because, like I said before, I think it's important to have them understand not just procedural also but conceptual knowledge. I want to do more group work and partner activities in first class that I am going to take over because it is taught more traditionally than her other classes and they don't really move around a whole lot

Table 4. 2: *Kathy's online post excerpts (January 11-15, 2013)*

Date	Kathy′s online post excerpts

January 11, 2013 at 9:07pm	Kathy: Overall, I really enjoyed watching her class. She asked the students lots of questions and let them do most of the thinking and calculating. The students also asked a lot of questions to her, which she didn't always immediately give an answer to. Part of the reason the class was this way was because it is an advanced class, but I still think it can be done with lower level classes as well. I really want to try to involve the students when I am teaching….
January 15, 2013 at 5:36pm	Kathy: Students were given different scenarios and asked to determine which was the better situation. Of course, students were tempted to say that having a higher number of successes …After they calculated the percentages and compared, they realized that this wasn't always true. In 4th block in particular, this generated a good discussion …. This gave me a glimpse of what it could be like to have the lower level students engaged in discussion. I think that having them make predictions and comparing that to results would be helpful in the future

Stage 2: Disappointment and doubt about student collaboration.

Kathy's initial attempts at asking students in her lower level classes to work in groups did not generate the student collaboration or mathematical discourse that she had envisioned. Kathy tried two teaching strategies, discovery lessons and station activities that in theory should have been venues for student collaboration and mathematical discourse, but the group interactions and discussions spawned by these strategies do not live up to her expectations. She began to doubt the efficacy of allowing her lower-level students to work independently in groups.

Table 4. 3: *Kathy's online post excerpts (January 17-February 5, 2013)*

Date	Kathy's online post excerpts

January17, 2013 at 7:20pm	Kathy: This Thursday, all four of the classes participated in stations.... For the most part the students took it seriously and were working. The typical students who don't usually participate normally did little of the work.…Also, students were allowed to pick their groups which could have cause the trouble... Overall, the stations were a success … However, there were other students who were off task and who were not paying attention. I had to keep going around to the groups and reminding them of what they were supposed to be doing … It really is very hard to keep these lower level students, many of whom are in special education, to stay focused on their own. …
January 24, 2013 at 7:43pm	Kathy: I had the students work on an independent discovery activity. …. The students who took the time to read it and follow along reached the appropriate conclusions or something close to it, but there were yet again some students who didn't bother to read it or even try. So when it came to the discussion time for the students to talk about what they found out, there wasn't much discussion at all. …. I am not so sure if I want the students to do it independently or not now because most of them didn't do it.
February 5, 2013 at5:33p.m.	Kathy: I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. … Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction

Stage 3: Deliberate implementation of strategies to promote student collaboration.

Kathy progressed in facilitating mathematical discourse within group activities. She established more explicit expectations about the content of group discussion—"I told them to focus more on what method they would use and why rather than solving the problems". She provided explicit guidelines about process for group interactions—"first work individually, then compare with your group and come a consensus, then show me the answer to earn a point." She noted several successes in promoting mathematical discourse—"I heard some good discussions". Kathy's successes in facilitating "good

discussions" occurred in her advanced classes where she specifically directed groups about how to work together. She commented that she was considering trying similar activities with her general level classes in the future.

Table 4. 4: *Kathy's online post excerpts (February 21- March 5, 2013).*

Date	Kathy's online posts excerpts
February 21, 2013 at 6:30pm	Kathy: In advanced, we continued to work on solving systems of linear equations by graphing, substitution, and elimination….Students should be able to choose the method that they feel most comfortable with. Tomorrow we are going to be doing activities that encourages students to do just that. They will be placed in groups and given different systems. They will need to discuss which method they want to use and why and then use it to solve.
February 22, 2013 at 4:56pm	Kathy: I had them choose their groups, since they are such a small well-behaved class, for the choosing the method activity. I told them to focus more on talking about what method they would prefer and why rather than actually solving it although I wanted them to do that too if they had time. I heard many good conversations.
March 5, 2013 at 5:14pm	Kathy: We played a game that I made up, which I turned out to really like. I had the class divided into groups of three. Each student had their own whiteboard on which they had to work out the problem I wrote on the board. Then, they had to compare answers with their group and reach a consensus on the right answer and/or help each other figure it out. They could then show me their answer. If it was right, they got a point. If it was wrong, they got one more try to figure it out. …. The kids were really into it the whole time and I was having fun too. I saw a lot of good discussions going on within the groups.... I like this game because it gives the opportunity to correct mistakes, and that they have to cooperate with their group before answering. I definitely want to do this again, especially when reviewing. I might even try this with the general classes, but I would have to be more careful about the ways I choose the groups.

In summary Kathy's development toward promoting student collaboration and discourse, as revealed in online forum, progressed through three stages. Her desire to provide

opportunities for all students to engage in collaboration and discourse was tempered by her initial disappointing experiences with her lower-level students' group interactions. Her successful implementation of strategies to promote group interaction in her higher level classes prompted her to envision the possibility of using similar strategies with her lower- level students.

Jake's Development

Jake's development in eliciting students' mathematical thinking, is documented in the analysis of Jake's pre-interview responses, online posts and post interview response found in Figure F-2 in Appendix F. In summary, Jake's development in regards to implementing instructional practices that elicit students' mathematical thinking can be summarized as progressing through the following three stages:

- Stage1: Jake felt **obliged to conform to the flow** of his CT's traditional teaching style and felt constrained to "stick to the script" of power point lessons developed by the mathematics department.
- Stage 2: Ideas from his fellow student teachers, critique from the US and Jake's own dissatisfaction with the impact of his traditional teaching practice **pushed** Jake **to turn against the flow** and implement new teaching strategies that elicited students' mathematical thinking.
- Stage 3: Propelled by the positive outcomes of his initial effort to engage his students thinking, Jake **embraced a new flow** by implementing a variety of strategies that effectively elicited his students in mathematical thinking, in both his advanced geometry and general algebra 2 classes.

Stage 1: Obliged to conform to the flow.

During the initial weeks of student teaching, Jake felt constrained to conform to his cooperating teacher's "teach off the document camera" approach to mathematics instruction. Jake was troubled that his mimicking of his cooperating teacher's style failed to engage his students' interest and engagement in learning. In addition, Jake felt obliged to follow the prescribed power point lessons developed and distributed by the school's mathematics department. He observed that the prescribed power point lessons, although "nice, neat and clean," could easily lead to lessons that are boring but for the personality of the teacher who uses them. Throughout stage 1, the US encouraged Jake to "go against the flow" at his student teaching site and try some student engagement strategies that he had learned about in his teacher education program. Jake declared that he wanted to "take a risk" to "do something a little different", to "make things more interesting" but he lamented that his lack of ideas and creativity kept him from doing so.

Table 4. 5: *Jake's online posts excerpts (January 15-Febraury 20, 2013).*

Date	Jake's online post excerpts
January 15, 2013 at 8:13pm	Jake: My cooperating teacher teaches off of a document camera. He writes the notes and the students copy them down. He is the form of engagement and he does a great job at that (something I would like to mimic). It is going to be interesting seeing how they respond to differentiated instruction techniques and whether or not they have gotten to used to simply copying notes
January 22, 2013 at 10:34pm	Jake: All of these geometry lessons are on powerpoints meant to be distributed throughout the geometry teachers for immediate use. They are great at presenting the material in an effective manner. They are nice, neat and clean, but the interaction is left up to the personality of the teacher…but it leaves serious potential for the class to be boring.… I do want to do things differently, but I realize how this presentation style may be critiqued.

January 23, 2013 at 10:54pm	Jake: I feel like whenever I step in, I either have to be like him[CT] or completely different but equally as entertaining.….I will look for little things here and there to throw into presentations because ultimately, the document camera makes things easier when it comes to uploading lessons online, absent students and future planning; but it will take some getting used to…
February 20, 2013 at 4:55pm	Jake: I was thinking today about how it is about time to take a risk. I feel like I have reached the point of comfort-ability, at least in the Algebra II classes, and they seem to be needing something a little different. The problem is my creative juices are not leading me to anything interesting. …I don't know how to mix up presentation techniques to attract to differing types of listeners. I try to be fun and interactive, but math alone has the ability to turn people off…. I don't have bad students,… They are obedient, good kids who don't complain much at all, so for their sake I feel it upon myself to make things more interesting; I just don't know how to do it.

Stage 2: Pushed to turn against the flow.

The US used the online forum to provide Jake with some suggestions about how to engage and elicit his students' mathematical thinking. In her online comments to Jake, she summarized ideas that she had read online from other MIC student teachers. She ultimately copied and pasted excerpts of online posts where various MIC student teachers' described strategies they implemented in their classrooms to elicit students' thinking. Jake eventually took the risk to try one of the strategies in his Algebra 2 classes on February 28th, 2013. Jake was exhilarated by the outcomes. According to Jake, his students were engaged and attentive and for the first time he felt like a "facilitator" of learning as he "forced students to walk the class through the concepts, rather than giving them the steps himself."(See Figure 4.1)

Figure 4.1 Jake's online post about his February 28th Algebra 2 lesson

Jake: Today is a day I will never forget...I took some risks in the way I presented adding and subtracting rational exponents today…I put together a note sheet that to show on the document camera as we went through the lesson. I didn't do groups or anything like that, but I did use some ideas from some other blogs, namely not saying anything, showing them examples and asking them if they could spot the pattern. Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked...The variety of students who I called was much greater than it has ever been. In A1, it is usually hard to keep their attention, seeing they are still half asleep, but today, there was smiling, talking and much interaction. I, especially, got really into it, which is what I had been waiting to do the whole year. I don't know if it was being able to walk around or what, but man I was getting excited because of how engaged the class seemed. I forced students to walk the class through the concepts, rather than giving them the steps myself…It was the teaching day I had been waiting for…

Figure 4. 1: *Jake's online post about his February 28th Algebra 2 lesson.*

Stage 3: Embraced a new flow.

Jake continued to develop and successfully implement a variety of strategies that engaged students' thinking when he presented new material. He developed several variations of his initial find-a-pattern/discovery-the-rule activity and implemented them with success in both his general algebra 2 and advanced geometry classes. Jake found that implementing his new strategies made his lessons "more interactive", "forced his students to think" and increased students "ability to problem-solve". Moreover, as a result of adopting these new teaching strategies, teaching was more "enjoyable" and "fun."(see

Table 4. 6: *Jake's online post excerpts (March 7-April 8, 2013).*

Date	Online mentoring conversation excerpts [a]
March 7, 2013 at 10:51pm	Jake: In Algebra II, we learned about multiplication and division of higher ordered radicals,…I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner. I really enjoy this style better than what I was doing because it is more interactive and it forces them to think on their own, …

March 20, 2013 at 11:47pm	Jake: In Geometry…I was tired of just giving students the theorem and having them memorize (what my CT typically does by PowerPoint), so today I switched things up a little bit. Much like I have been trying with my Algebra 2 classes, I tried to get them to discover the theorem on their own, still in a discussion type setting. In this case, though, I gave them a diagram of what the theorem stated (in this specific case, it had to do with central angles, arc measures and chord lengths). From the diagram, I asked the students to infer as to what the theorem was going to establish.…I really liked how this turned out…I will definitely tailor my lessons whenever possible to showing pictures first, words second to let what is really going on soak in.
March 28, 2013 at 10:48pm	Jake: Today, I honestly had a lot of fun. The Geometry lesson was over circles. The students were active and participating…I really liked how the theorem presentation has been working. By showing them the picture first, I believe they are increasing their ability to problem solve just by looking. This is exciting because this is life around them.
April 7, 2013 at 4:38pm	Jake: Teaching this way is so much more enjoyable than bearing the load like I was…I get to facilitate the learning process rather than feeding them everything they might need to know. I have a lot more fun presenting things
April 8, 2013 at 11:16pm	Jake: Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. In the past, what I have done when introducing new theorems is given them the picture and had them give the words of the theorem. Today I switched it up. The definition of the theorem would come on the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem.…I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed to understand the material. ….

Note: CT= cooperating teacher

In summary, Jake's development in eliciting students mathematical thinking as revealed in the online forum progressed from at first conforming to his cooperating teacher's style of teaching to finding and trying a new engaging presentation strategy, to ultimately adopting a teaching style that elicited his students' thinking

Sam's Development

Sam's development in promoting student collaboration and mathematical discourse, as revealed in online mentoring conversations, is documented in Figure F-3 in Appendix F. Sam's, progression with promoting student collaboration can be summarized in the following three stages:

- Stage 1: Sam **noticed the weaknesses in student collaboration but was not moved to enact strategies** to improve group interactions.
- Stage 2: Sam was **forced by a "challenging" class to consider implementing strategies** that might improve student collaboration.
- Stage 3 Sam **realized the efficacy of establishing guidelines** for improving the overall quality of student collaboration.

Stage 1: Noticed the weaknesses but not moved to act.

Sam's pre-interview comments revealed that Sam envisioned student collaboration as a highly effective means for enhancing students learning about mathematics (see Figure 4.2).

Figure 4.2 Sam's Pre-interview response—January 14, 2013
Describe a specific time when you have seen "good" mathematics instruction? "A lot has to do with a classroom that encourages dialogue between the instructor and students but also between the students about the concepts… Anytime I have seen real effective teaching, it is a back and forth between instructor and the students and between the students with each other… where they are working these concepts out and making them their own and they are doing it with each other ... there are a lot of good things that happen when you work cooperatively and there is dialogue and you learn from another person and the two can come up with new ideas or better ideas…"

Figure 4. 2: *Sam's description of effective student collaboration and discourse.*

When describing how well students worked in groups at his student teaching site, Sam noted that that students' work in groups "only partially met his ideal." According to Sam, some groups worked well together–"In these groups the members fed off of one another. I observed many students explaining reasoning and concepts to other students, leading to deeper understanding". Sam also observed that other groups did not work as team–"a single student completing the bulk of the work while the other group members simply tagged along for the ride" and some groups were off task–"some groups simply behave an opportunity to socialize."(see Figure 4.3)

Figure 4.3 Sam's online post excerpt- January 12, 2013
The group work I observed this past week had its strong and weak aspects. First, I noticed that some student groups did not work as intended. These groups usually had a single student completing the bulk of the work while the other group members simply tagged along for the ride. When the "leader" would finish a problem the rest of the group would copy the information down with little explanation. This was frustrating to observe and in a couple of cases I encouraged these groups to work more as a team. Further, I observed some groups simply behave as an opportunity to socialize. However, there were also many groups that worked beautifully together. In these groups the members fed off of one another. I observed many students explaining reasoning and concepts to other students, leading to deeper understanding. In all three of these examples I find that group partly work only meets the ideal I brought into the classroom

Figure 4. 3: *Sam's initial observations about group work at student teaching site.*

In her online response to Sam's observations, the US asked Sam to think about and try strategies to improve the quality of group work but Sam's subsequent online posts did not include comments about his intentions or his actions to implement specific instructional strategies aimed at enhancing student collaboration. In conclusion, although Sam noticed some weaknesses in students' group interactions during the first weeks of student teaching his online posts did not initially reveal any intentions or strategies to remedy those weaknesses despite prompting from the US.

Stage 2: Forced to consider implementing strategies.

As Sam began taking over classes to teach, he provided several opportunities for students to work in groups. Sam's online comments noted the occurrence of "peer-scaffolding" and "a significant amount of mathematical discussions" within groups but did not highlight any weakness in student collaboration. However, in post observations comments, the US' recommended Sam implement strategies to address the weakness in student collaboration that she observed in his classroom. Eventually Sam's experience with teaching a "challenging" class where students were "only 50 % engaged during the group work time", prompted Sam to consider strategies to improve the quality of student collaboration. Sam speculated that perhaps the way he starts a lesson might improve the quality of student collaboration.

Figure 4.4 Sam's online post excerpt March 18, 2013
"I had planned a little different type of activity… The activity consisted of the students getting into groups of three or four…The groups were asked to plot the points and sketch the graph of the figure. Then they were directed to identify the figure as specifically as possible by using information like the slopes and lengths of the sides and follow up by explaining their reasoning for the identification. Finally, the students were asked to find the perimeter and area of the figure. …For this activity I created eight separate figures…and assigned one figure to one group, making eight groups to work together. The final part of the activity was to have each group present their figure to the class and share how they arrived at the solution. I saw this as an opportunity to vary my instructional strategies and also to hopefully create deeper meaning and conncection for the students. The first block of students seemed to connect to this exercise effectively… The second block of geometry students was another story. Out of the four geometry classes this is the most challenging as far as classroom management.… Then this class was about 50% engaged during the group work time. We were only able to get to one group at the end of class and their presentation lacked a great deal of detail. I believe that the beginning of this lesson was the downfall and that a better start is the answer to a more complete finish.

Figure 4. 4:*Sam's "online post excerpt March 18, 2013*

Stage 3: Realized the efficacy of establishing guidelines.

Sam realized the efficacy of his establishing the guidelines for student collaboration at the start of a group activity. Sam described how establishing clear expectations for group work greatly improved the engagement in student collaboration in his challenging class. In subsequent online posts, Sam discussed implementing another approach to establishing guidelines about student collaboration—Sam and his cooperating teacher acted out/modeled the interactive process students were expected to follow when working in pairs on problems. Sam was elated with the success of the new approach and pledged "to keep looking for new ways to engage [his] students in class" (see Figure 4.5).

Figure 4.5 Sam enacts strategies to promote productive student collaboration

Sam's online posts excerpt—March 24, 2013
What a difference a day makes! In my previous posting I discussed how the group activity I designed… just did not work as well with my B2 geometry class. … After Monday's class and following my experiences from yesterday I was able to get ideas from both my CT and my [US] regarding how to approach the completion of this activity with my classes today. The outcomes were vastly different from Monday (and that is a beautiful thing)! My focus for today was to take a few minutes at the beginning of class and address the issues of last class and then help the students see the purpose of our activity and lay out clear expectations for the group work and the presentations. What resulted was a completely changed environment, particularly in B2. The students were significantly more engaged with the concepts and the activities and the presentations were effective and complete. I was very impressed with the overall performance of my students and my CT noted the improvement as well
Sam's online posts excerpt—April 22, 2013
The next part of my lesson was also new. I gave the students the same set of practice problems as yesterday's class but instead of letting them loose to work the problems I planned to first have them complete a peer-share activity with the first problem. To facilitate this I asked my CT to help me model what I wanted the students to do which was to solve the first problem by alternately completing the steps. The students were able to complete this process with a fair amount of success…. Many of the students were able complete the problems successfully and the level of engagement was high throughout the class.

Today was a great success and a wonderful learning experience. I got to experience trying new strategies and having success with them… today's experience encourages me to keep looking for new ways to engage my students in class.

Figure 4. 5*: Sam enacts strategies to promote productive student collaboration.*

In summary, Sam's online comments revealed that his development toward promoting student collaboration and mathematical discourse progressed through stages. Although Sam observed some weaknesses in the quality of students' work in groups during the first few weeks of student teaching, he was not prompted to consider implementing strategies to improve students group interactions until his experience with a class that was about" 50% engaged during the group work time." Sam's reflection on his experience gave rise to his implementation of a strategy to promote effective student collaboration- establishing specific guidelines about group behavior at the beginning of a group activity.

Christy's Development

Christy's development in attending to student's mathematical thinking, is documented in the analysis of Christy's pre-interview responses, online posts and post-interview responses found in Figure F4 (see Appendix F). In summary, Christy's progress in attending to students' misconception progressed through the following stages:

- Stage 1: Christy was **too preoccupied with students' inadequacies** to attend to their thinking.
- Stage 2: Christy **broadly generalized students thinking** either, "well developed", or "lazy and weak."
- Stage 3: Christy **developed and utilized bell-ringer activities** to head off and remediate specific student misunderstandings and misconceptions.

Stage 1: Preoccupied with students' inadequacies.

During the initial weeks of student teaching, Kristy was pre-occupied with her students' inadequacies. In relation to attending to students' mathematical thinking, Christy initial online comments focused on her general students' lack of prerequisite skills, lack of retention of previous material and struggle to understand new material. Christy's singular strategy for addressing students' misunderstandings was to review material again.

Table 4. 7: *Excerpts from Christy's posts in the initial weeks of student teaching.*

Date	Christy's online post excerpts
January 11, 2013 at 8:35pm	Unfortunatly some of my students still do not know the basics. Like the order of operations or how to type -3^2 iinto the calculator. They do not logically think through the fact that a -*- is always positive.
January 14, 2013 at 10:53pm	My students really seemed to struggle with using the sequence formula to solve a series. Others just didn't like the Sigma that was used to represent the summation of a series. Students don't see the connections between the topics. I don't think they understand that a series is just a summation of a sequence. To me this topic seems really easy. You just plug some numbers in, you just have to know how to use the formula.
January 16, 2013 at 10:43pm	My student's understanding was a little rough. I was expecting them to remember what the different variables meant from the arithmetic series notes. I was wrong. They did not remember anything. So the problems went much slower than expected
February 5, 2013 at 7:14pm	We talked about what a sample space is, what Permutations and Combinations are, factorials and how to do things in your calculator…Prior knowledge was basically zero. They remembered very very little about probability and couldn't even make a fraction into a percent.
February 11, 2013 at 9:30pm	• As far as new mathematical material goes we worked on the same things as yesterday. We worked on multiple events and conditional probability. The students really struggled with the conditional probability. They don't understand what conditional probability is or how you find the probability of two conditional events. I plan on going over this in different ways and reviewing a lot!

Note: US= University Supervisor/Researcher

Stage 2: Broadly generalized students' thinking.

Christy commented that students' mathematical thinking contrasted sharply between her advanced algebra 2 class and her general algebra 2 classes. She described mathematical thinking in her advanced classes as "well- developed" and general classes as "lazy" and "weak". (see Figure 4.6)

Figure 4.6 Christy's generalizations about her students' thinking	
Christy' comments about her general students	
March 17, 2013 at 4:50pm	• Today we went over the rational root theorem. .... The Rational Root Theorem has a lot of steps so the students started to tune me out. … Their mathematical thinking I would say is lazy. It's not that they cannot do the material it's that they are too lazy to try the new material. They don't want to do something if there is more than one step or anything they have to think about.
March 27, 2013 at 8:24pm	• I think my students are struggling because they don't know basic algebra 1 skills. Some of my students can't solve a one or two-step equation. They don't know what x times x is. They can't add two negative numbers. Their mathematical thinking is very weak.
Christy's comments about her Advanced class	
February 26, 2013 at 6:48pm	• Today I taught my Advanced class about Unions, Intersections and Compliments. … I really enjoy that the students seem to remember from previous classes. …They picked up very quickly with the new material. I then gave them a worksheet that used M & Ms to do probabilities. I asked them for things I think they really had to think about sometimes. The students seemed to do pretty well with this worksheet only a few questions gave them troubles.
March 17, 2013 at 4:50pm	• I then had them do a review on factoring and multiplying polynomials. All things they should have seen in Algebra 1. They all seemed to remember everything really well. Then we worked on Algebraic Rational Functions, which was basically just introduction to polynomials. … Their mathematical thinking is well developed but I think they need to be pushed more.

Figure 4. 6*: Christy's generalizations about her students' thinking*

Despite inquiries from the US, Christy provided little information, in the online forum, about the specifics of her students' mathematical thinking and misconceptions. Her

generalizations about her students thinking did not reflect attention to the nuances of her students' mathematical thinking.

Stage 3: Developed and utilized bell ringers to address students' misconceptions.

In Stage 3, Christy's progression to attending to student thinking was triggered by the US' suggestion that Christy use bell-ringers to addressed her students' difficulties. In subsequent online posts, Christy described several occasions where she used bell-ringers in both her general and advanced classes to address students' misconceptions or lack of pre-requisite knowledge. Planning bell ringers that addressed student misunderstanding seems to have prompted Christy to describe her students' misconceptions in more detail than in her earlier online posts. (see Table 4.7)

Figure 4.7 Christy's plans about using bell-ringers	
Date	Excerpts from Christy's online posts
March 27, 2013 at 8:31pm	• Today we worked on Conics. …My students then worked on a worksheet asking them to identify a conic given it's standard equation. Then I asked them to find the center or vertex of each conic. …I also found the students struggled when it had a center or vertex at the origin. They didn't like it when there was no number. They also didn't like it when the formula had a positive but the vertex was a negative. I think I will start doing more misconceptions as bell ringers.
March 27, 2013 at 8:53pm	• Again today we worked on parabolas… This group had a harder time with the example with the distance formula so I did another example of this type. I noticed that they were struggling with the distance formula in general. Tomorrow I think I will do a bell ringer with one problem that is finding the distance given two points and another that is finding the distance given two points that have numbers and variables. I think this will help them understand the problems we did today.

Figure 4. 7: *Christy's plans about using bell-ringers.*

Furthermore, using a "find the error" bell-ringer to address students' misunderstandings in her advanced classes, actively involved students in thinking and was a shift from

Christy's initial efforts to remediate students' errors by simply "reviewing a lot."(see Figure4.8)

Figure 4.8 Christy uses a bell-ringer in her advanced class
Christy's online post excerpt- April 22, 2013 at 3:53pm
Christy: Today I again taught radicals. We started with a bell ringer. The bell ringer was over misconceptions from last class…I then analyzed their answers. I found common mistakes and typed them up as a bell ringer. They had to fix the common mistake. I allowed the students to work in groups for this.… I think this really helped them… I think I will continue doing bell ringers like the one I did today. I really like that and felt it really helped my students

Figure 4. 8: *Christy uses a bell-ringer in her advanced class.*

In summary, Christy's progress in attending to students' mathematical thinking was centered on how Christy's attended to students' misconceptions. She progressed from being overwhelmed by student errors and weaknesses to planning and designing bell-ringer activities to remediate and head-off misconceptions.

In conclusion study participants' online comments revealed their progression through various stages of development in relation to aspects of standards based teaching practices. The implication of this finding will be discussed in Chapter 5.

Study participants' perception of how online mentoring conversations were related to their development toward standards-based instructional practices

All study participants indicated that online mentoring supported their development in effectively enacting aspects of standards-based instruction. In her post interview comments Kathy credited online mentoring conversations with encouraging and affirming her efforts to promote student collaboration and mathematical discourse and for providing suggestions about strategies to improve the nature of collaboration and discourse among her students (see Figure 4.9).

Figure 4.9 Kathy's post–interview comments relating online conversations to her development
"It was originally my idea to have them pick and [discuss] a method [for solving systems of equations] My US [said] it was a good idea for facilitating the communication about math which was one of things I wanted to work on. It was reassuring to hear someone say that you are working toward the goals that you have set." (see Kathy's conversations in Appendix D).
"My US suggested to ask the group members to discuss predictions and then as a group to put forth their predictions to the class instead of them all …working in isolation and then we would, as a class, talk about each prediction, …I feel like that is something I tried to keep with …There was actually a group activity that I created a little bit later where I had the students in groups where they had to reach a consensus as a group before they could presented it. So it (the group activity)kind of stemmed from that online]conversations. (see Kathy's conversation in Appendix D).

Figure 4. 9: *Kathy's post interview comments.*

Jake post-interview comments indicated that in online conversations, the US pushed him to get out of his comfort zone and take some risks about presenting material in ways that engaged his students thinking. In addition Jake found the online conversations to be a venue for positive affirmation from the US about his introduction of a new strategy (completing if - then statements) to elicit students thinking and promote student collaboration

Figure 4.10 Jake's post-interview comments relating online conversations to his development
My US pushed me to do things outside my comfort zone.…. She voiced her displeasure with some things I was doing. And it was like Ok, it's time to do something different because I was tired of not doing things sufficiently …just in her comments she had some good things to say …Take some risks, this is your time to take risks …so I appreciated that about this online stuff. (See Jake's conversations in Appendix D)
It was good to me that my US affirmed my " if then" statements. I appreciated that, otherwise, I might have scraped it…. It gave me another tool that I could use, a different

tool in my back pocket. The positive affirmation was good… I used the " if then statements a couple of other times." (See Jake's conversations in Appendix D)

Figure 4. 10: *Jake's post interview comments*.

Sam's post interview comments indicated that he found that the questions that US asked him in online conversation about student collaboration during group work forced him reflect on aspects of group work that he might have thought about by himself.

Figure 4.11 Sam's post interview comments relating online conversations to his development
The fact that could have this conversation (See Sam's conversation1 in Appendix D) and not be in the same room was fantastic for me because it helped me to formulate even better ideas about what I was doing in classroom, because US asked questions that I might have thought to ask myself. And, her experience in the classroom came out in in her questions because I think US anticipated some of things that I had blogged, things that I was not able to anticipate. ... For me, US asked questions that I may not ever been able to come up with or formulate on my own, which made me think over those posts even more when I did my response. So, I was getting, not just the benefit of reflecting on the activity on my own, but I was then getting a second opportunity to go back and reflect again with additional questions, with another set of lenses. When US keyed in with some of her questions, it gave me, yet, another perspective that allowed me to re-inspect what I had experienced and then talk about it some more."

Figure 4. 11: *Sam's post interview comments*.

Christy credited online conversations with prompting her to think more about students' misunderstandings and what she "could do to fix them".

Figure 4. 12 Christy's post interview comments relating online conversations to her development
"I had not really thought about the misunderstanding too much before this comment (US' comment on February 27,2013 See Appendix D)"I thought more about what I could do with misunderstandings and how I can fix them.
Towards the end, I started making bell ringers, that kind of did some of the stuff before; it was mainly for my other classes because they forgot a lot of math like simple things… so it was more for them(general classes) with their misunderstanding and that helped them."
With this class (the advanced Algebra 2 class), I started doing exit slips ..., and then I graded them and put them in pile and put in piles based on misunderstandings so like, if 5 of them made the same mistake, I would put them together, and then I made that into a bell ringer and then, they had to fix their mistakes on the next day I saw them. That was kind of cool. They got to figure out what they did wrong and that class did very well with that.
I was really exciting because they really did work on bell- ringer and I did not really help

them very much I told them to work with their friends …. I wanted them to get on their own. I had them really think about it for a while and then we did it together … it really helped them not to make those mistakes again. I think they will not often make those mistakes again."

"I learned a new way to help them with misconceptions which was really cool I think if they do it themselves they figure it out on their own instead of me just telling them because if I tell them stuff they don't' really listen but if they figure it out on their own, it's like, 'yes', I did it !"

Figure 4. 12: *Christy's post-interview comments*.

In summary, all participants found online mentoring supported their progress in enacting standards-based instructional practices during their student teaching internship. The implication of this finding will be discussed in Chapter 5.

.

CHAPTER 5: DISCUSSION AND IMPLICATIONS OF FINDINGS

Study Overview

Rationale and Purpose

Learning about standards-based teaching through field experiences is an essential component of an effective pre-service mathematics teacher education program. Student teaching is the fundamental field experience where pre-service teachers have the opportunity to conceive and develop standards-based instructional practices under the guidance of mentors. Yet, research reveals that mentoring for novice teachers is most often focused on providing technical and emotional support rather than supporting teachers learning to teach with standards-based instructional practices (Wang & Odell, 2002). In addition, university supervisors' efforts to mentor mathematics student teachers toward standards-based instructional practices are hindered by their limited opportunities to meet with their assigned student teachers (Borko & Mayfield, 1995; Frykholm, 1996). Unlike cooperating teachers, who are on-site, university supervisors are often disconnected from the context of student teachers' day-to-day experiences that could serve as catalysts for discussions about standards-based teaching. Online social networking provides an opportunity for consistent communication between university supervisors and student teachers about student teachers' daily experiences. Thus, online social networking is a potential venue for university supervisors to facilitate student teachers' understanding and implementation of standards-based instructional practices that are grounded in their authentic student teaching experiences. The purpose of this

study was to explore the potential of online social networking as a venue for mentoring secondary mathematics student teachers' toward standards-based instructional practices.

Participants and Context

The study participants were secondary mathematics student teachers enrolled in the Masters with Initial Certification Program (MIC) at a large research university in the southeastern United States. Three to four times a week, study participants posted online journal entries about their student teaching experiences on an online social networking site designated for MIC student teachers and their university supervisors (US). The US and researcher for this study read and responded to the study participants 'online journal posts and particularly attended to opportunities to mentor study participants toward standards-based instruction via the online social networking site.

Data Collection and Analysis

The online communications between the university supervisor and study participants on the social networking site were reviewed for content related to standards-based instruction. In addition, study participants were interviewed about their perception of how online mentoring conversations were related to their growth in implementing standards-based instructional practices. Blog posts data and interview data were analyzed for emerging themes in order address the following research questions.

Research Questions

1) What is the content of mentoring secondary student teachers for standards-based instruction in an online environment–that is, what is the content of mentoring in an online environment in relation to the following aspects standards–based instruction:

- elevating conceptual understanding and surfacing 'big' mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations,
- promoting student collaboration and mathematical discourse and,
- attending to equity in mathematics instruction.

2) How are online mentoring conversations related to student teachers' developing conception of standards-based teaching practices? (Online mentoring conversations are defined as segments of online communications that include at the minimum, a study participant's initial blog post and a response from the university supervisor. In addition, mentoring conversations could include follow up responses from the study participants and/or university supervisor.)
    a) What do mathematics student teachers' online comments reveal about their developing conception and implementation of standards-based practices?
    b) How are student teachers' self-reported conceptions of standards-based instructional practices related to online mentoring conversations about standards-based instruction?

General Finding

The overarching finding of this study was that online social networking was an effective venue for a university supervisor to mentor student teachers toward some

aspects of standards-based instruction. In addition, online social networking proved to be a site for tracking and documenting student teacher's developing conception and implementation of standards-based instruction. The following section of this chapter will relate this study's findings to research literature and discuss implications of specific findings of this study for teacher education and future research.

Discussion of Findings

Relationship to Literature on Mentoring Toward Standards-Based Instruction

The characteristics of face-to-face mentoring toward standards-based instruction found in research literature were replicated in online mentoring for this study. As discussed in Chapter 2, the face-to-face mentoring processes that seem to support novice teachers' (student teachers and first-year teachers) learning in relation to standards-based mathematics instruction include:

- purposefully and consistently using specific teaching events as the catalysts for engaging student teachers in reflection and dialogue about their beliefs, subject matter knowledge, and developing practice;
- challenging student teachers to reinterpret and reexamine teaching events in light of standard-based mathematics teaching practices, and
- offering specific suggestions and reasons for standards-based practices to be implemented in student teachers' current practice.(Bennett, 2010; Blanton, Berenson, & Norwood, 2001; Nilssen, 2010; Wang & Odell, 2002; Wang & Paine, 2001; Wang, Strong, & Odell, 2004)

As discussed extensively in Chapter 4, in this study, the university supervisor was able to enact the mentoring practices listed above in an online format by

- mining study participants' online posts for material that could segue way to online conversations about standards-based instruction
- affirming, justifying and suggesting strategies that embody standards based instruction
- nudging study participants to consider, explore and implement teacher-actions that exemplify standards-based instructional practices

Similar to findings in researched cases of face-to-face mentoring, the mentoring practices manifested in the online environment of this study, seemed to contribute to student teachers' progress toward standards-based instruction. The results of this study reveal the potential for teacher educators to enact a range of mentoring practices in an online environment and provide impetus for including online mentoring as a component of teacher candidate internship programs.

Implications for Facilitating Student Teachers' Learning

This study was distinct from previous studies about mentoring toward standards-based instruction in that this study examined the *online* mentoring conversations between university supervisors and secondary mathematics students teachers for content related to the following aspects of standards based instruction,

- elevating conceptual understanding and surfacing " big" mathematical ideas,
- eliciting and attending to students' mathematical thinking,
- connecting mathematics to real-life contexts,
- using and connecting a variety of representations,
- facilitating active discovery and mathematical investigations, and

- promoting student collaboration and mathematical discourse.

Analysis of the online mentoring content led to the following findings:

- Online mentoring seemed to help study participants make progress in relation to promoting student collaboration, facilitating mathematical discourse and eliciting students' mathematical thinking.
- Online mentoring was a venue for the US to acknowledge study participants' frustrations and to encourage study participants to rethink rather than abandon their prospects for teaching real-world lessons and for teaching lessons that focus on helping students understand the underlying mathematical concepts.
- Online mentoring seemed to be an effective venue for unpacking the key components of instruction in relation to facilitating discovery activities and using effective representations
- Online mentoring did not prove to be an effective venue for study participants to engage in analyzing their students' mathematical thinking.
- Online mentoring conversations revealed study participants' progression through various stages of development in relation to aspects of standards based teaching practices.
- All study participants indicated that online mentoring supported their development in effectively enacting aspects of standards-based instruction.

These findings illuminate the potential role of online mentoring in helping student teachers learn about standards-based instruction in the context of their internship experiences. The following section will discuss each of these findings and the implications for facilitating student teachers' development through online mentoring.

Online mentoring seemed to help study participants make progress in relation to promoting student collaboration, facilitating mathematical discourse and eliciting students' mathematical thinking.

Online mentoring conversations revealed several study participants' growth in relation to promoting student collaboration and mathematical discourse. Asking students to work in groups is a common instructional practice for novice teachers. Study participants' online comments about group work were likely catalysts for online mentoring conversations about promoting student collaboration and mathematical discourse. The US consistently asked study participants about the group interactions they observed in their classrooms. Based on their responses, the US prompted study participants to implement strategies to improve the quality of student collaboration. Study participants' transitions from simply asking students to work in groups to implementing strategies to promote productive student collaboration and discourse during group work were clearly evident in the online mentoring conversations. This finding suggests that asking student teachers to describe their students' group work interactions might be an effective tactic for initiating online conversations about strategies that promote student collaboration and mathematical discourse.

One study participants' dramatic growth in eliciting students' thinking when introducing new material was facilitated by the online social networking format used in this study. As discussed earlier, in response to Jake's concern that he did not know how to "make things interesting" for his students, the US was able to share several examples from his fellow student teachers' online posts describing their experiences implementing strategies that engaged students in their lessons. Although, the US suggested similar

strategies to Jake in earlier online comments, it seemed that her responding with actual excerpts from fellow student teachers' online posts was pivotal in spurring Jake to take action to implement various strategies that engaged students by eliciting their mathematical thinking. In summary, using the online forum to connect Jake with fellow student teachers' experiences seemed to be an effective strategy for moving Jake toward standards-based instruction. This finding suggests that online social networking could provide an effective forum for teacher educators to facilitate student teachers' learning from each other about how to effectively implement standards-based teaching strategies.

Online mentoring was a venue for the US to acknowledge study participants' frustrations and to encourage study participants to rethink rather than abandon their prospects for teaching "real-world" lessons and for teaching lessons that focus on surfacing the underlying mathematical concepts.

Study participants were frustrated and disappointed by their failed attempts to facilitate lessons that connected mathematics to real-life contexts and lessons that focus surfacing the concepts underlying procedures. Facilitating secondary mathematics lessons where students fully understand the underlying concepts and lessons where students meaningfully connect mathematics to real-life contexts are complicated tasks. In this study, study participants' efficacy in accomplishing these tasks was hampered by their lack of facility at working within time constraints and their lack of knowledge of their student's potential misunderstanding. Such deficiencies are common among novice teachers. Although study participants were not successful in orchestrating the "real-world" lessons or the concept-focused lessons they had envisioned, the US supported

them in their process of learning to do so. Online mentoring made it possible for the US to give buoying feedback– to applaud study participants' initial efforts, acknowledge participants' challenges and assure participants of the possibility of their being more successful in the future. Thus, online mentoring can play a critical role in (a) helping student teachers navigate through unsuccessful attempts to enact standards-based instructional practice and (b) encouraging student teachers to reframe rather than abandon their prospective for future implementation.

Online mentoring seemed to be an effective venue for unpacking the key components of instruction in relation to facilitating discovery activities and using effective representations.

Study participants online posts about their experiences facilitating discovery activities and using representations opened up opportunities to discuss key components involved in these instructional activities. As discussed earlier, online mentoring discussions about using representations focused on the following two instructional considerations: (a) making sure a representation is mathematically sound and (b) extending a representation to encompasses the concepts inherent in a mathematical procedure. Online mentoring conversations related to facilitating discovery and mathematical investigations addressed the following key issues: (a) motivating students to persist in working through discovery activities, (b) determining to what extent discovery activities should be teacher led or student led and (c) incorporating debriefing discovery activities that reinforce and assess students' learning. The instructional components discussed online might have been presented in study participants' previous

coursework. If so, online mentoring provided an opportunity to revisit and reiterate the components. On the other hand, the components discussed online might have simply surfaced as result of study participants' student teaching experiences facilitating discovery activities and using representations. If so, online mentoring provided an opportunity to highlight key instructional considerations that might not have been specifically addressed in previous course work. In any case, the findings of this study revealed that online mentoring is a venue for reinforcing and/or introducing, not just the theoretical ideas, but also practical detail components of standards-based mathematics instruction. Furthermore, the findings suggest that online mentors, like the US for this study, who are not privy to the specific content presented in student teachers' coursework, can nevertheless be helpful in addressing concrete issues involved in enacting aspects of standards-based instruction.

Online mentoring did not prove to be an effective venue for study participants to engage in analyzing their students' mathematical thinking.

The initial guidelines provided to study participants about their online posts included the instructions in the course syllabus that online journal posts should include "observations about students' mathematical thinking and learning." In addition, the US often prompted study participants to describe their observations about students' mathematical thinking. Despite the syllabus guidelines and the US' online prompting, study participants' online blog data did not include much analysis of students' thinking. Findings in relation to Christy's development, suggest that attending to students' errors via bell-ringers might lead to online discussions focused on students' mathematical

thinking. There are several possible reasons for the lack of attention to students' mathematical thinking in the online forum. Perhaps study participants did not have the opportunity to observe individual students' mathematical thinking. Perhaps the syllabus guidelines were too open-ended and study participants needed a specific framework for analyzing student's thinking. Perhaps retaining detailed observations about students' mathematical thinking and recounting them later in the online forum was too arduous for study participants. More research is needed to explore strategies that might increase the occasions of online mentoring discussions focused on analyzing of students' mathematical thinking.

Online mentoring conversations revealed study participants' progression through various stages of development in relation to aspects of standards based teaching practices.

Identifying and characterizing study participants stages of development provides a perspective on the processes involved in student teachers' learning to teach with standards-based instruction. Although it is not possible to conclude that all student teachers will progress through the various stages demonstrated by this study's participants, knowledge of the stages uncovered in this study can help teacher educators to facilitate student teachers' learning. Just like knowledge of common student misconceptions informs teachers about designing lessons, knowledge of stages through which student teachers have progressed toward standards-based instruction, can inform teacher educators' approaches to mentoring and coursework design. For example, teacher educators can anticipate and prepare for the possibility that, like study participants,

student teachers might initially feel inhibited about exploring standards-based teaching or feel disillusioned about efficacy of standards-based instructional practices. Similarly, the finding that study participants' dissatisfaction with student engagement in lesson activities preceded their successful implementation of standards-based strategies suggests that teacher educators could seize on student teachers' dissatisfactions as opportunities to mentor toward standards-based instructional strategies. In conclusion, the cases studies presented in this research could be used as tools for training mentors to support student teachers' development toward standards-based instruction.

All study participants indicated that online mentoring supported their development in effectively enacting aspects of standards-based instruction

All study participants reported that the university supervisor's online comments supported their learning to enact standards-based instructional practices. This finding is in concert with finding from previous research studies that the university supervisor's role in helping student teachers bridge theory to practice was enhanced by opportunities for more frequent communication with student teachers about their internship experiences. (Blanton, Berenson & Norwood, 2001; Cuenca, Schmeichel, Butler, Dinkelman & Nichols, 2011; Frykholm, 1998) In that regard, this finding suggests that university supervisors' participation with student teachers in online social networking is a vehicle for frequent communications that can have an impact on student teachers' learning about standards-based mathematics teaching.

Implications for Future Research

In light of the promising findings of this study, researchers and teacher educators should continue to explore the potential for online mentoring of student teachers. More research is needed to delineate online journal formats and online mentoring strategies that seem to be most effective in facilitating student teachers' learning about various aspects standards-based instruction. Future research could also explore a comparison of and the relationship between online mentoring and face-to-face mentoring of student teachers.

Concluding Remarks

In response to Wang and Odell's (2002) call for researchers to explore the content and processes of mentoring for standards-based teaching, this study examined the use of an online forum to mentor secondary mathematics teachers toward standards-based instructional practices. The overarching finding that online social networking was an effective venue for a university supervisor to mentor student teachers toward some aspects of standards-based instruction unveils the prospect of overcoming two persistent challenges in student teacher education: (a) the challenge to enhance a university supervisor's role as a mentor and (b) the challenge to support student teachers' implementation of standards-based mathematics instruction. Finally, the cases of student teacher development examined in this study contribute to teacher educators' knowledge and understanding of the paths by which novice secondary mathematics teachers come to enact standards-based instructional practices.

REFERENCES

Barnett, M.,Harwood, W., Keating T. & Saam, J. (2002.)Using emerging technologies to help bridge the gap between university theory and classroom practice: Challenges and successes *School Science and Mathematics 102*(6), 299-313

Bennett,C. (2010). "It's hard getting kids to talk about math": Helping new teachers improve mathematical discourse. *Action in Teacher Education, 32*(3), 79-89.

Ben-Peretza, M. & Kupferbergb, I. (2007) Does teachers' negotiation of personal cases in an interactive cyber forum contribute to their professional learning? *Teachers and Teaching: theory and practice, 13*(2), *125–143.*

Blanton, M., Berenson, S., & Norwood, K. (2001). Exploring a pedagogy for the supervision of prospective mathematics teachers. *Journal of Mathematics Teacher Education. 4,* 177–204.

Borko, H., & Mayfield, V. (1995). The roles of the cooperating teacher and university supervisor in learning to teach. *Teaching and Teacher Education,* (*11*)5, 501-518.

Creswell, J. (2008). *Educational Research: Planning, conducting and evaluating quantitative and qualitative research.* Upper Saddle River, New Jersey: Pearson Prentice Hall

Devlin-Scherer, R., &Daly, J. (2001).Living in the present tense: Student teaching telecommunications connect theory and practice. *Journal of Technology and Teacher Education, 9(*4*),* 617-634.

Edens, K. (2000). Promoting communication, inquiry and reflection in an early practicum

experience via an on-line discussion. *Action in Teacher Education, 22(*2A), 14-23.

Feiman-Nemser, S. & Buchmann, M. (1987). When is student teaching teacher education? *Teaching and Teacher Education, (3)*4, 255-273.

Fry, S. & Bryant, C. (2006-2007, Winter) Using distance technology to sustain teacher education for student teachers in isolated areas: The technology supported induction network. *Journal of Computing in Teacher Education, 23(*2), 63-69.

Frykholm, J. (1996). Pre-service teachers in mathematics: Struggling with the *Standards. Teaching and Teacher Education, (12)*6, 665-681.

Guyton, E. & McIntyre, D.J. (1990). Student teaching and school experiences In W.R. Houston(Ed.) *Handbook of research on teacher education* (p. 514-534). New York: Macmillan.

Gwyn-Paquette, C., & Tochon, V. (2002). The role of reflective conversations and feedback in helping preservice teachers learn to use cooperative activities in their second language classrooms. *The Modern Language Journal, 86*(2), 204-226.

Hawkey, K. (1997). Roles, responsibilities, and relationships in mentoring: a literature review and agenda for research. *Journal of Teacher Education (48)* 325-335.

Hawkey, K. (1998). Mentor pedagogy and student teacher professional development: a study of two mentoring relationships. *Teaching and Teacher Education, 14(*6), 657-670.

Hsu, S. (2004). Using case discussion on the web to develop student of personal cases in an interactive cyber forum contribute to their professional learning? *Teachers and Teaching: Theory and Practice, 13*(2), 125–143.

Killeavy, M. & Moloney, A.(2010) Reflection in a social space: Can blogging support reflective practice for beginning teachers. *Teaching and Teacher Education, 26*, 1070-1076

Levin, B. B. (1999). Analysis of the content and purpose of four different kinds of electronic communications among preservice teachers. *Journal of Research on Computing in Education, 32*(1), 139–157.

Liang, L.,Ebenezer, J.,& Yost, D. (2010). Characteristics of pre-service teachers' online discourse: The study of local streams. *Journal of Science Education & Technology,* (19)1, 69-79.

Merriam, S.B. (1998) *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass

National Council for Accreditation of Teacher Education. (2010).*Transforming teacher education through clinical practice: A national strategy to prepare effective teachers.* Retrieved from http://www.ncate.org.

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy.* Washington, DC: National Academies Press.

National Council of the Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston VA: Author.

Nilssen, V. (2010). Encouraging the habit of seeing in student teaching. *Teaching and Teacher Education 26,* 591-598.

Pena, C. & Almaguer, I. (2007). Asking the right questions: Online mentoring of student teachers. *International Journal of Instructional Media, (34)*1, 105-113.

Peterson, B. & Williams, S. (2008). Learning mathematics for teaching in the student teaching experience. *Journal of Math Teacher Education, 11,* 459-478

Richardson- Koehler, V. (1988). Barriers to effective supervision of student teaching: a field study. *Journal of Teacher Education ,39,* 28-34.

Roddy, M. (1999). Using the internet to unite student teaching and teacher education. *Journal of Technology and Teacher Education, 7*(3), 257-67.

Schlagal, B., Trathen, W., & Blanton, W. (1996). Structuring telecommunications to create instructional conversations about student teaching, *Journal of Teacher Education*,47, 175-183.

Slick, S. (1997). Assessing versus assisting: the supervisor's role in the complex dynamics of the student teaching triad. *Teaching and Teacher Education, 13*(7), 713-726.

Souviney, R., & Saferstein, B. (1997). E-mail communication and clinical supervision: the InterNet Project. *Journal of Computing in Teacher Education*, *14*(1), 21–27.

Wang, J. & Odell, S. (2002). Mentored learning to teach according to standards–based reform: A critical review. *Review of Educational Research, (72)*3 ,481-546.

Wang, J. & Paine, L. (2001). Mentoring as assisted performance: a pair of Chinese teachers working together. *The Elementary School Journal, (102)*2, 157-181.

Wilson, S., Floden, R. & Ferrini-Mundy, J. (2001). Teacher preparation research: Current knowledge, gaps, and recommendations. Spokane, WA: Center for the Study of Teaching and Policy.

Wopereis, I., Sloepa, P., &Poortman, S. (2010). Weblogs as instruments for reflection on action in teacher education. *Interactive Learning Environments,.18(*3*),* 245-261

Wright, N. (2010). Twittering in teacher education: Reflecting on practicum experiences. *Open Learning*, *25*(3), 259-265.

Yang, S.H. (2009). Using Blogs to Enhance Critical Reflection and Community of Practice. *Educational Technology & Society*, *12*(2), 11–21.

APPENDICES

Appendix A: Pre-Interview Protocol

Interviewer: "*You have spent the last year learning about how to be an effective mathematics teacher."*

1) What is involved in "good" mathematics teaching?

2) Describe a specific time when you have seen "good" mathematics instruction?

3) Which of the NCTM process standards do you specifically want to work on during student teaching? (Interviewer shows the study participant the NCTM Process Standards Sheet)

Note- The Interviewer asked clarifying questions when appropriate.

Appendix B: Post-interview Protocol

Interviewer read the following note to the participant:

This interview will be audio-taped. Your interview responses will be kept confidential and will not affect your course grade or academic record. Your university supervisor will NOT have access to the post-interview audio until after grades are posted. You are free to decline to answer a question that makes you uncomfortable. Information from this study may be utilized in research reports and presented at professional conferences. No reference to your name or your student teaching placement will be made.

Interviewer*:* In the beginning the semester, the US interviewed you about some of your goals for teaching in relation to NCTM process standards described on this sheet.*(Allow participant to read/skim over the NCTM process standards sheet.)* Can you recall some of the goals you discussed during that first interview? How do you feel you have you progressed during student teaching in relation to your initial goals or any of the other process standards. Can you give specific examples?

Interviewer : "Now, we are going to look back on some of your online conversations with the US (and perhaps other MIC ers) on Ning that are related to various aspects of the NCTM process standards . Take a few minutes to carefully read over the conversation and then talk about your reaction to your conversation when it happened and your reflection on this conversation now in hindsight? How do you think this conversation is related to what you have learned about teaching during your student teaching semester? How do you think this conversation is related to your growth as teacher during your student teaching semester?" *Note : When appropriate the interviewer asked clarification questions, or probing questions to illicit more details or deeper reflection-*
Note to participants- Conversations are in chronological order and copied directly from NING and include spelling/ typing errors. Some irrelevant parts of posts are blacked out to reduce amount participants need to read.

Appendix C: NTCM Process Standards Sheet

NCTM Process Standards

Problem Solving

Instructional programs from prekindergarten through grade 1 should enable all students to—

- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflect on the process of mathematical problem solving

Reasoning and Proof

Instructional programs from prekindergarten through grade 12 should enable all students to—

- Recognize reasoning and proof as fundamental aspects of mathematics
- Make and investigate mathematical conjectures
- Develop and evaluate mathematical arguments and proofs
- Select and use various types of reasoning and methods of proof

Communication

Instructional programs from prekindergarten through grade 12 should enable all students to—

- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Analyze and evaluate the mathematical thinking and strategies of others;
- Use the language of mathematics to express mathematical ideas precisely.

Connections

Instructional programs from prekindergarten through grade 12 should enable all students to—

- Recognize and use connections among mathematical ideas

- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

Representation

Instructional programs from prekindergarten through grade 12 should enable all students to—

- Create and use representations to organize, record, and communicate mathematical ideas
- Select, apply, and translate among mathematical representations to solve problems

- Use representations to model and interpret physical, social, and mathematical phenomena

Appendix D: Post Interview Online Conversation Excerpts

Kathy's post-interview online conversations

Conversation1

Parallel and Perpendicular Lines

- Posted by Kathy on January 24, 2013 at 7:43pm

In 1st block, we started a new lesson on parallel and perpendicular lines. We began class with a bell-ringer which covered finding reciprocals and opposites since that would be need for perpendicular lines. I also put problems on the bell-ringer that students had difficulty with on the test. One of their biggest problems was using point slope formula, and the other was solving an equation for y. I am hoping that after seeing it more and more they will start getting it because these are skills that are going to be important for future topics as well, and especially for this parallel and perpendicular lines section. Although the students know they are supposed to work on their bell-ringer for the first 10 minutes of class, it seems like many of them often goof off and waste time instead because they know they will get the answers in a few minutes. I am thinking that I may have to randomly take them up for a grade (based on effort) one day so that they will take them more seriously.

To jump into the new material, I had the students work on an independent discovery activity. It walks students through graphing different lines and seeing how they look when graphed and asking students what they notice about the slopes. Students were supposed to reach the conclusion that parallel lines have the same slopes and that perpendicular lines have opposite reciprocal slopes. The students who took the time to read it and follow along reached the appropriate conclusions or something close to it, but there were yet again some students who didn't bother to read it or even try. So when it came to the discussion time for the students to talk about what they found out, there wasn't much discussion at all. I had to give the answer so that I was sure the others who didn't participate knew what it was. I have a similar discovery activity planned for graphing absolute value functions next week. I am not so sure if I want the students to do it independently or not now because most of them didn't do it. I might just lead from the front of the class and have the students follow along instead.

Despite the not so successful discovery activity, the clicker questions I had following seemed to go over well. The questions asked the students to identify if the lines are parallel, perpendicular, or neither. At first, they were having a lot of trouble with it, but after a few questions the results improved. I made sure to explain each one after the correct answer had been displayed. Students were having the most difficulty when the slopes were reciprocals,but not

opposites. When this happened, they were very tempted to say that the lines were perpendicular. They also often forgot to solve for y before identifying the slope. I think that incorporating clickers will be a good way to get the class to participate in the future, but I don't want to do them too often. The kids really seem to feed off of the competitiveness of being in teams and trying to be the highest scoring team. I also had an iLearn exit slip quiz prepared, but we ran out of time. I really would have liked to have had that data to see how they were doing individually. Next time, I need to watch the time more closely to make sure I get it in. Tomorrow, we will be writing equations of parallel and perpendicular lines. Since this will use the point slope formula, I am anticipating that they will have difficulty with it.

Comment by US on January 24, 2013 at 11:00pm

Bravo, for trying a discovery activity! Discovery is **inductive reasoning**- making a conclusion or conjecture based on observations of patterns. Inductive reasoning is an important aspect of doing mathematics and you mentioned in you were interesting in students learning about reasoning. It's great that the activity worked for those who were willing to read and do it. Now challenge yourself to think about how to get more students involved in a discovery activity: 1) Perhaps more students might be motivated if they are working in groups and given reward for making a discovery (e.g., the first group to make the discovery gets 10 points or pieces of candy, next group gets 8 points/candy, third group gets, 6 points.. and include in the instructions that you should be able to ask anyone in the group to explain the discovery to make sure that everyone in the group is involved . 2) Perhaps you also want trying lead the activity from the front of the class but insist on everyone write down their observations on small slip of paper that you collect and give a reward to everyone writes down a reasonable conclusion , or maybe you could read some of the conclusions out loud and make big deal about the best conclusions. 3) Perhaps the students might be motivated by the way you introduce the activity- perhaps build in some competitive aspect in the discovery activity since the student seem to "feed off of the competitiveness".. These are just ideas and are not set in stone or perfect but perhaps they can help you come with ideas based on what you now about your students.

Comment by Kathy on January 25, 2013 at 8:21am

Those suggestion sound really good, especially since they seemed to like the competition in the teams with the clicker questions! I will try that when I do the next discovery activity with graphing absolute value functions. I think I could definitely have sold the activity better. Maybe I'll say something like "So we are going to start something new today and it is kind of tricky, but I know you guys can all figure it out. I'm going to put you in groups so you can work together to

figure it out. The first group to figure it out gets candy! Let's Go!" I might also require the group to have someone summarize what they found to the class.

Comment by US on January 25, 2013 at 8:48am

Yes! Yes! I like how your ideas about how to introduce a discovery activity. Keep tweaking your pitch (and keep thinking about the details of how you will organize groups rewards, participation). Often in teaching you can motivate students by the way you “sell “an idea with your enthusiasm. Not only are we entertainers, psychologists, counselors, comedians and actors we are also salespersons. Teaching is such an interesting multifaceted profession. It will be interesting to hear about what happens next time you try to do a discovery. No matter what, you will learn something about teaching that will help you in the future.

Conversation 2

Not According to Plans

Posted by Kathy on February 5, 2013 at 5:33pm

Today in first block we covered graphing absolute value functions. I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. Basically, they would graph various transformations of the parent absolute value function and try to generalize what happens when you add or subtract a number inside or outside of the absolute value bars. I told them to make sure that they help their group members and work together because the first two groups with correct conclusions would get candy. I also told them that I would call on one spokesperson from each group at random to explain their findings to the class which would mean that they would all need to know what was going on. Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction and some students were having extreme difficulty progressing through the steps. I kept having to clarify how to do things on the board even though the steps were very explicit- they just weren't reading the steps. I do think that there was more participation and effort than there was for the last discovery activity, but it did not meet the expectations that I had in mind.

Since there wasn't much progress, I chose to stop them where they were and direct their attention to me at the board. I had them graph several different ones and said "Okay, how does this compare to the parent function?" This seemed to be more effective than what they were doing previously. Then, I gave them graphing calculators, instead of using their iPads, to graph the functions so that they can become more familiar with the graphing calculators. I made them

predict how it would move based off of the equation before graphing it and then check it with the graph. They seemed to be doing fairly well, but the left and right shift was the most confusing, as was expected. Next, we put the calculators away, and I had them completed a 6 problems worksheet without the calculator. Most of the students finished this worksheet very quickly. Since I couldn't give candy to the first groups, I gave candy to the students who were working hard the entire time. I concluded with a one problem exit slip that asked them to describe the shift and graph it. 11/26 students completed the exit slip correctly. Most others made small mistakes. I will be going over this again on the bell-ringer tomorrow, but I think they did quite well under the circumstances. In the future, I am unsure about doing discovery activities. I though for sure that it would go much better this time in groups, but it did not. There is just such a divide between the students who really get it consistently and those who don't-on every new topic. My teacher suggested maybe letting the more advance kids work separately on a discovery while the other kids do something different.

I also picked up 4th block today which is a general Algebra 1 class. It also did not go as well as I had hoped. Although I was able to see my teacher teach it for the 2 blocks prior to it, I was still nervous about it because the plans were changed at the last minute due to the snow days, and I had less freedom in what we were doing. This class moved much more quickly (less students, less IEPS) which was good, but it was also challenging because I had to fill in the extra time. We are really crunched to get in all of the material before the finals next week, so we are really expecting the students to buckle down and work hard the next two weeks. Since we covered so many different topics today (not all new), the students were resistant to keep going even though we still had 20 minutes of class left. I feel like the bad guy because I'm just taking over the class and piling the work on them. This class also talked a lot and was easily distracted. Most of them seemed to understand the material, but just didn't want to work. I am hoping that tomorrow will go better. I don't really think that the class was any more problematic than they normally are, but I had just hoped it would have gone more smoothly. Tomorrow, I am going to give them breaks in between sections of the lesson in hopes that they will be more focused. It's just hard to make it fun when we have so much ground to cover.

Comment by Christy on February 5, 2013 at 7:24pm

Most of the time I start with something different they don't meet my expectations but they always slowly curve the behavior and start doing better. I am sure they more they do it the better it will get! Don't be discouraged. :)

Comment by US on February 5, 2013 at 9:32pm

Cassie, I agree with your words of encouragement. I has really been refreshing to read how much all you (MIC student teachers) respond and support each other in NING
Kristian, congratulations for making some major adjustments to your approach to group discovery activates that probably helped to generate "more participation and effort than there was for the last discovery activity"
So, you are making progress. Remember you are learning to teach and there is a lot to learn from this experience of trying a discovering activity. The major thing that I hear and have experienced myself is that unfortunately, many student are not use to and not proficient at reading step by step directions especially in relation to mathematics and thus they get really bogged down or lazy when asked to do so. And I am sure that your directions were very explicit. So what do you do- I think that you made a very appropriate adjustment in graphing the functions in the board and asking them to make conclusions. You still got the students to make discoveries (make observations and draw conclusions) without getting slowed down by having to teach them how to read. Perhaps, you could still incorporate a group component by asking group members to discuss their predictions and write them down as a group.- perhaps you could give every group a white board(Are schools still using mini- white boards or perhaps students have an app that lets them write on their IPADS).
Also, I think that having the students use the graphing calculator and make predictions and then work individually on worksheets were effective and necessary follow-up activities to reinforce and cement discoveries.
Another thought, perhaps, you could put one strong student in each group who is responsible for doing the reading - but that's kind of tricky and could backfire depending on student personalities.
I can understand your hesitation about doing discovery activities but I believe that you will learn how to design and tweak discovery activities to make them work for your students. You have already learned a lot from just two attempts at discovery activities!

Comment by Kathy on February 6, 2013 at 6:39am

Thanks for the encouragement guys! I think that after I read these and thinking it over last night, it wasn't as unsuccessful of a day as I had thought. I do like the suggestion to have them discuss and make predictions as a groups. I think they'd definitely be more likely to try when they are just faced with one question at a time. We do still use the mini white boards, but they have a whiteboard app as well which is much easier to pull put at a moments notice. They seem to like both versions, but the mini whiteboards seems to still be more exciting for what ever reason, perhaps because they don't get used as often now. Even though they may not be as independent as what I had in mind, I do still like discovery, and hopefully I can at least engage them in this make predictions, see what happens, and make generalizations type activity.

Conversation 3

New Strategies to Add to the Bag of Tricks

Posted by Kathy on February 7, 2013 at 8:58pm

In first block, I tried out some stations. Although I have helped with stations in other classes, this was my first time creating and planning the stations on my own. We needed to cover several small statistics topics before the final, so I decided to make it into stations since students could pick up each concept fairly quickly. There were 5 groups: 1.mean, median, and mode, 2. box and whisker plots, 3. correlations, 4. graphing linear equations, and 5. iLearn quizzes. I included the graphing linear equations station because many of the students performed very poorly on their last test which covered linear equations, and continue to struggle especially with graphing lines. I tried to monitor this station fairly closely and to provide extra intervention to those students who I knew were having extreme difficulty. If they learn one thing, these kids need to be able to graph lines before they leave Aglebra 1! Each station had enough slips of paper for each student to read over the basics of the concept. The students each had a front and back notes sheet where they were required to fill in the blanks and work the corresponding problems for that station. They took that paper with them to each station and turned it in at the end of class. I think it was a really good way for me to keep them accountable for their work because I have seen stations in our class in the past fail. I think that paper really helped them focus a lot, and because I took it up, it allowed me to see how they were doing. Most students did well on the new statistics topics that actually tried, but I was surprised to see that many students were still having trouble with graphing lines. I also had a feedback section on the notes sheet where I asked several questions about what they needed to study for the final if they wanted to review in class. Many of them, those who didn't say everything, said they wanted to do more graphing lines, which is good that they are realizing it because they definitely need it. There weren't too many specific suggestions, but I made them all at least answer the questions before I would accept their paper. Several students wanted to take a practice final, which we will in fact be doing on Monday. Although, I don't think I'm a pro at stations just yet, I was pleased with how this turned out. The notes sheet was definitely a good idea, of which I will continue to use. I also really like having one remedial station to help those who are struggling with a particular topic. This way they are not being taken away from the new material to catch up on the old material. In the future, I might think more about strategically picking groups rather than picking randomly. And even though they do complain, it seems like they are getting more used to working in groups.

I won't go into too many details about 4th block today, but I picked up a new strategy that I like there as well. I actually saw my teacher do it in 3rd block and decided to give it a try. Since we had finally completed all of the laws of exponents, we mixed the different kinds of problems up on wrote some on the board. We let students look them over and pick one they were comfortable with. Then, I called on volunteers one at a time to come up and work a problem of their choice. It really seemed to make them feel comfortable with coming up. Some of the students that volunteered were some of the ones that are typically the least vocal and confident. It helped that some of the problems were much easier than others, but it was a real confidence booster and a good way to make sure they could discriminate between the different types of problems. I will be keeping this strategy in mind for future use.

Comment by US on February 12, 2013 at 1:54pm

Yeah! Two new strategies! I am glad that stations went well- as you have observed in the past, stations can really bomb sometimes. Nice ideas to include a worksheet and review station. It's right on target to now be thinking about the next level- how to make group work more productive. You mentioned one thing - strategically picking group members. Another thing to consider how you can establish and communicative expectations and guidelines about how you want groups to work together- this could being more specific than just saying you have to work together and help each other- for example " first work on problem individually, then compare and explain your answers, do not move on until everyone in the group understands" or person A works and explains the problem, Person B asks questions about the solutions, Person C records the solution. Facilitating productive group behavior also includes affirming and praising students when you see good group behavior, or prompting students to ask someone in their group before asking you.... Students have to be taught how to work in groups like that have to be taught how to do algebra and geometry.

Conversation 4

Getting More Comfortable

Posted by Kathy on February 21, 2013 at 6:30pm

In advanced, we continued to work on solving systems of linear equations by graphing, substitution, and elimination. Today focused more on finding the intersection using the graphing calculator. Most of the student were very familiar with the graphing calculators, but some required a little extra assistance. I think it is very important to teach students how to use the calculators so that they can fully utilize them on tests such as EOC's and the ACT. Even if they don't remember any of the other methods, they should always be able to fall back on solving for y and using the graphing calculator to find the intersection point. We

then moved on to harder substitution and elimination problems. I left some easy problems like the ones we did yesterday at the beginning to build the students confidence. The problems gradually got harder. I had 4 challenge problems for students to work on if they were finished. To my surprise several students attempted the challenge problems. I was very glad I did this so that those students weren't just sitting there waiting. I need to continue doing this so that all students' needs are being met. I felt a lot better about their reactions to substitution today. Even the student who struggled the most yesterday was getting it. Her basic skills are still a little rusty, but she knew how to set everything up perfectly. I also feel like the students are starting to feel more comfortable asking me questions etc. It definitely takes time to get them to trust you enough to let you know they need help. Elimination is something that they are still grappling with, but this is partly my fault since we didn't have enough time to get to the really hard elimination problems where you must multiply both equations by something. However, I am okay with this because I mainly want them to understand what a system is and that the solution is where the lines cross. If students can use any of the methods to find a solution, that works for me. I don't think questions on tests that specifically ask to use a certain method are necessary. Students should be able to choose the method that they feel most comfortable with. Tomorrow we are going to be doing activities that encourages students to do just that. They will be placed in groups and given different systems. They will need to discuss which method they want to use and why and then use it to solve. This is something that I found on Pinterest, so if anybody is looking for activities, give Pinterest a try or check out my teacher board :).

Comment by US on February 22, 2013 at 12:32pm

Cool. seems like things are moving along well with teaching systems of equations. Curious to hear about how the group work goes or is going on now as I write this posts. I wonder what kind of conversations the student are having about which method to use to solve the systems. I will check your posts later to find out.

Comment by US on February 22, 2013 at 1:13pm

Oh. I forgot to ask. You said in post above that "I mainly want them to understand what a system is and that the solution is where the lines cross." This is definitely the big idea about systems of equations. Do you think your students understand this big idea? If you were to ask them what the solution to a system of linear equation means of represents what kind of response will you get? Perhaps you should ask them . We have been talking about making sure your students internalize the" big" ideas (not just how to do something) about a concept. I am just wondering about how you feel like this progressing with your lessons.

Comment by Kathy on February 22, 2013 at 4:56pm

Overall, I feel like they understand the big idea of this pretty well because I keep saying over and over that the answer must be a point. Sometimes, I feel like I'm being too repetitive, but I keep on. And many of them prefer to solve by graphing, so they are visually seeing the intersection of the lines. However, I do think that it would be a good idea to ask them about it on Monday's bell-ringer just to see what they would say.
For the group activities, we were originally going to have four stations one with picking a method, one with creating a foldable, one for application problems, and one for completing iLearn quizzes. The teacher next door taught it like that in 3rd block and said that there wasn't enough time in each group for them to get everything done. Therefore, when I taught it in 4th block, we did not do stations. I cut the applications and iLearn group and led the foldable creation from the front of the room. Then, I had them choose their groups, since they are such a small well-behaved class, for the choosing the method activity. I told them to focus more on talking about what method they would prefer and why rather than actually solving it although I wanted them to do that too if they had time. I heard many good conversations. Some of the systems were obviously easier for a certain method, but others were iffy. Some students really loved graphing and some substitution There were several students who solved every equation for y and graphed it, which is fine with me. Most did not like elimination as much as the others, but I expected that. However, I do think that letting them pick a method for different situations shows them why we need to different methods in the first place, which is to make solving it easier depending on how it is set up. Although I don't think they really liked systems overall for the most part, I think they liked the fact that there was more than one way to do it, which I like as well, because it gives them a choice. But, it is also more difficult to teach students how to approach something that can be done in many different ways. Personally, I don't care how they prefer to do it as long as it is a valid method.

Comment by US on February 22, 2013 at 9:07pm

It’s fortunate that you were able to modify the group activity for your class. Yes often, less is more. It's really great that you gave the group some direction about what you wanted them to focus on in their talking in the groups- what method and why more so than just finding the answer - this is right in line with your goals to help student work on reasoning and communicating about mathematics Also, stating your expectations for group interaction is a key component in facilitating effective group work. I agree that letting them pick a method for different situations helps to teach them about the advantages of each method which is part of what we want students to learn when we teach them how to solve systems of equations In general, when teaching mathematics, we want to students to appreciate there is often more than one way to solve a problem. Sounds like a great teaching day.

Jake's post-interview online conversations

Conversation 1

Week 3 - Post 1

Posted by Jake on January 22, 2013 at 10:34pm

Today felt good getting back into the swing of things after a long four day weekend (seeing that I didn't attend school on Friday due to a student organization). I may have taken a few steps back not being there on Friday, but nothing a little consistency and teaching won't fix.

The day started with Advanced Geometry and their introduction to 30-60-90 and 45-45-90 triangles. The content didn't spark a whole lot of thought, controversy or reflection in my head, but what I do have to say concerns presentation style. All of these geometry lessons are on powerpoints meant to be distributed throughout the geometry teachers for immediate use. They are great at presenting the material in an effective manner. They are nice, neat and clean, but the interaction is left up to the personality of the teacher. Not that I doubt myself in that area or that it isn't an effective way of teaching, but it leaves serious potential for the class to be boring. But I must also say this, sometimes boring isn't bad. If you are serious about school, you have to learn to power through boredom. The workforce isn't always engaging, but that doesn't mean we quit and give up. I don't necessarily have a problem with they way the material is covered. I do want to do things differently, but I realize how this presentation style may be critiqued. My question is simply what to do with it? Should I be nervous about continually teaching like that or is it doing the students a service? Traditionalists wouldn't care, but the new era of engagement tells me otherwise.

In Algebra 2, I gave the lesson on Synthetic Division. The lesson took 45 minutes, so it went quick and it really seemed like most of the students understood. It was straight of the document camera, so the engaging again was left up to my personality. The more comfortable I get, the better that will become, but for right now my lessons remain fairly content focused. I want to get more comfortable and loosen up a little bit, but it will take time.

The day was good and I continue to get more enveloped in the activities of Tates Creek. With PLCs and other lesson planning, it is beginning to become much more real.

Comment by Sam on January 22, 2013 at 10:59pm

Jake, I ponder the same question as you about the engagement of the lessons as they are prepared for general use throughout the department. Like you wrote, this type of delivery leaves engagement up to the personality of the teacher. I have the opportunity to be with a teacher that has a dynamic personality so I am observing how this can work effectively. However, I am looking for ways to incorporate more engagement into the lessons. On Friday I included a short animation from the explore learning website to help drive home the concept of similar right triangles. I think there are different ways to take what is already created and modify it with newer strategies and methods.

Comment by US on January 23, 2013 at 8:40am

Jake, I see that you are conflicted about what to do with the already-prepared math department lessons.

I would encourage you to do as Scott suggested and feel free to incorporate and modify the provided lessons in ways that might stimulate more student engagement. Student teaching is your time to try strategies that you have learned. If you try new strategies and see how they work for you now, it will help you have a few practiced strategies in your teaching repertoire when you start teaching next year. I am afraid that if just go with the flow, you may loose this opportunity to learn at a time when you not trying to handle all the responsibilities of a new teacher. Finally, I think this is an issue to talk over with your CT and in your seminar class. (Perhaps ithis something that Dr. Mohr and I should talk over with your CT. As I think about although, we planned to do so, we (Dr. Mohr and I) have not officially met with Chris together with a team.

Having an engaging personality is an important part of being an effective teacher but when it comes to student learning, effective teachers have large repertoire of intentional teaching practices/ strategies-ways to introduce a concept, questioning techniques, face-lifting discussions, designed activities, discovery episodes, integrating formative assessments…. Implementing these strategies is enhanced by an engaging personality and dependent on fantastic communication skills.

Comment byJake on January 23, 2013 at 10:54pm

Sam

[My cooperating teacher] is the same way. I feel like whenever I step in, I either have to be like him or completely different but equally as entertaining. The middle ground is just simply not going to be good enough. I will look for little things here and there to throw into

presentations because ultimately, the document camera makes things easier when it comes to uploading lessons online, absent students and future planning; but it will take some getting used to.

US

I know it seems like I am stuck on this certain topic of lesson independence, but I guess it is what I have been thinking about as I attend these PLCs and teach lessons nearly the exact why my teacher has taught them the block before. I hope I am not kicking a dead horse or anything, but it continues to come up in my thoughts, thus I type it out. I am sure this question and more will be answered after our next meeting.

Conversation 2

Week 7 - Post 2

Posted by Jake on February 20, 2013 at 4:55pm

I was thinking today about how it is about time to take a risk. I feel like I have reached the point of comfort-ability, at least in the Algebra II classes, and they seem to be needing something a little different. The problem is my creative juices are not leading me to anything interesting. I know the unit coming up is covering radicals, but the theme with so much in Algebra II is wrote. I don't know how to mix up presentation techniques to attract to differing types of listeners. I try to be fun and interactive, but math alone has the ability to turn people off. More than anything, what I have noticed is that my desire isn't necessarily for students to learn math, it is for them to have fun doing math; and whatever we have been doing seems completely opposite of this. I don't have bad students, problem students or students that are resilient. They are obedient, good kids who don't complain much at all, so for their sake I feel it upon myself to make things more interesting; I just don't know how to do it. Add to this their age and anything I come up with seems too childish or gimmicky. I have been reading other posts trying to find ideas, but I am still at a loss.

Today I gave the second Matrix lesson (multiplying, finding inverses and determinants on the calculator). They will have a mini assessment on Friday covering today and last block's lesson. The stuff is very easy and is serving as an ACT review before they all take the test March 5th. In addition to this lesson, we have been doing ACT review. These are always interesting: 1. because they aren't worth points for the time being 2. sometimes the questions are difficult. Needless to say, students aren't always motivated to actually try, rather pushing a random answer on the clicker seems to be a more viable option.

Tomorrow I pick up my two blocks of Advanced Geometry, making it the first time I will be teaching for a "whole" day. I am excited about it. The students are fun and the content is interesting. I didn't infuse any real world problem solving aspects into this lesson, but my aim is to do so in the near future. These kids are hungry to ask questions and learn and I am trying to take advantage of this fact. If only I were able to do this same thing during Algebra II. Right now, I guess I am stuck showing random youtube videos that don't make a lot of sense but are something out of the ordinary (the Matrix clip).

Comment by US on February 21, 2013 at 1:33pm

> Its great that your have got a comfortable postivie atmosphere going in your Algebra 2 classes.Yes it is hard to make algebra 2 content interesting or fun to do. Perhaps you could make things a little more interesting (intellectually engaging) by doing some things that I have read from other student teachers: For example, 1) do a find the error activity. 2) Show three examples of how to do something without explaining and see if students can discover what you did 3) a group quiz- pair a stronger studnet to tutor weaker student for 15 minutes then quiz the weaker student reward both students if weaker student improves. 4) show examples and counter examples for students to derive definitions or proceedures 5) perhaps even a jigsaw activity. These are just rough suggestions and need to be tweaked for your particular class. I am also wondeing how the student the student interaction is progressing your classes. Are you doing most of the talking during class ? It might be worth your while to take risk and try something different- of course it should be well thought out and discussed with your CT - because student teaching is time to try and learn.
>
> Looking foward to hearing how you eventually infuse some real- world application into your advanced geometry classes:)

Comment by US on February 21, 2013 at 1:35pm

> Excuse the spelling and sentence structure in the last post, Have to go to an appointment and have no time to proof or spell check

Comment by Jake on February 21, 2013 at 10:12pm

> I really like the "find the error" because it gives me the ability to highlight common mistakes I am seeing on a daily basis. The more I can show them what they are doing wrong the better; but when correction comes to figuring it out on their own, we have problems.
>
> To answer your question, I am still the one that is leading the lessons, meaning I ask a lot of questions and encourage student dialogue, but

ultimately it all comes back to my voice. I don't think this is the key to success, however I am a little nervous changing it because it is how my CT teaches and the students do deserve a little consistency. I understand I the importance of taking risks, but I also feel like I am doing an "ok" job as it stands right now. If I take a risk with a group activity, it may very well enhance the learning experience, but what scares me is if it fails because the students aren't used to it. I don't want to be unfair by changing styles with only months left in the semester. But on the contrary, maybe I am being unfair by only presenting lessons in one form or fashion? Haha obviously I have it all figured out! (Sarcasm included) Thanks for your advice, I just had to air out some of what I had been thinking about.

Comment by US on February 22, 2013 at 12:17pm

Yes! I am glad that you figured it out! Take the risk!. Make mistakes! . Learn from them! Do more than "OK".

You may want to even tell your students that you are taking a risk to try to something new. You said that they seem to appreciate vulnerability .

Student teaching is about trying out new things - things that you have be taught in your methods class so that you can learn about how to make these strategies work in the classroom.

No matter what happens, I've got your back.

Conversation 3

Week 8 - Post 3

- Posted by Jake on February 28, 2013 at 10:09pm

How can I put this gently... Today is a day I will never forget. For starters, and on the softer side of things, I took some risks in the way I presented adding and subtracting rational exponents today. After having my observation with Mrs. Miriti yesterday, I got a really good idea of where I should direct my emphasis currently to become a better teacher. I need to get the students more involved, and as I thought about it, I think my inability to do this so far has been the reason why I feel such a weight on my shoulder at times. It's as if I am shouldering the load of learning rather than passing it to the students for them to handle.

So in response to our discussion, I put together a note sheet that to show on the document camera as we went through the lesson. I didn't do groups or anything like that, but I did use some ideas from some other blogs, namely not saying

anything, showing them examples and asking them if they could spot the pattern. Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked. Because the sheet was already typed out, I was able to walk around the room, which gave me more spunk and allowed me to be more energetic. The variety of students who I called was much greater than it has ever been. In A1, it is usually hard to keep their attention, seeing they are still half asleep, but today, there was smiling, talking and much interaction. I, especially, got really into it, which is what I had been waiting to do the whole year. I don't know if it was being able to walk around or what, but man I was getting excited because of how engaged the class seemed. I forced students to walk the class through the concepts, rather than giving them the steps myself, something Mrs. Miriti pointed out as a tendency of mine. It was the teaching day I had been waiting for. Students were calling me crazy, and I thoroughly enjoyed it, because I was crazy enough to be worth listening to... while still retaining control of the classroom though (while things did get rambunctious sometimes, its nothing pointing out the noise level and stopping couldn't fix).

I still don't know if I am the creative type that will formulate small group activities and stations that allow kids to master the content and stay engaged for the whole hour on a lesson by lesson basis, but as of right now I am ok with that, because that isn't who I am. If, though, I can continue with what happened today, and demand student involvement in other areas while being engaged and excited, I can feel the same result occurring, just with my own zest.

I am grateful for the words [My US] spoke to me yesterday, because otherwise, who knows what I would have done today. But to get to the good stuff... I said this day was memorable, and when I say memorable, I do mean it. Today, during A2, while the PreCalc students were testing, a student had a seizure. I could go into the long story about what happened, how we responded and so on, but I will spare the details. Fortunately he is ok and in the hospital. Experience is an invaluable asset, and today will be proof. I don't plan on forgetting this experience anytime soon, and though I pray that it never happens again, if it does, I will have seen the way to respond. I guess you never know what is going to happen.

Comment by Sam on February 28, 2013 at 10:51pm

> Jake, I am excited for you that today was such a rewarding experience. I think sometimes to be an effective teacher you have to be willing to be a little "crazy". I believe that part of being an effective teacher is communicating your own passion to the students in an appropriate and constructive way. There are many different methods to accomplish this but I think you nailed it on the head when you talked about engaging more and different students. Ultimately it does not matter whether or not we use every new method or strategy that comes down the pipe in the classroom. What matters is that each and every student is given a real opportunity to learn and find their voice or path in the classroom. Let's face it, sometimes

math can be a tedious and rigorous subject to learn and teach. However, the passion you displayed today and the engagement you accomplished is repeatable no matter how dry the math! As far as your unique experience, it is definitely a valuable lesson you learned today about how quickly a situation can develop with regard to student health and safety. I do not envy what happened but it is definitely advantageous that the situation occurred with another teacher in the room. Keep up the good work and many good things will continue to happen for you.

Comment by US on March 1, 2013 at 6:13am

Yeah! Jake!. I am so impressed that you were able to turn things around in your class so quickly by doing something a little different to engage your students and that you found it rewarding. Keep it up and don't limit or doubt your ability to try **all kinds** of different things somewhere along the line. Don't be afraid to fail, we are always learning to teach. As Scott noted, keep aiming for helping student's to find their voice- to find mathematics inside of them.

Conversation 4

Week 9 - Post 3

- **Posted by Jake on March 7, 2013 at 10:51pm**

In Algebra II, we learned about multiplication and division of higher ordered radicals, multiplying by conjugates, and multiplying and dividing fractional exponents all in the same block. It doesn't take a rocket scientist to realize this much content in a block is not ideal for general students who have little interest in math, but it could have gone much worse. I continued to streak of making a follow along worksheet to put under the document camera, allowing me the flexibility to walk around the room. I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner. I really enjoy this style better than what I was doing because it is more interactive and it forces them to think on their own, assuming they have any desire to do well (its always possible to be lazy...).

Assessments in both Algebra II and Geometry are coming and I don't want to be scared of the results, but in the world of teaching, nothing is guaranteed, student's grades included.

Comment by US on March 7, 2013 at 11:16pm

Very interesting [redacted]

How did the students do with the share with a partner part of this lesson. Did most of of the students share with a partner?

Comment by Jake on March 10, 2013 at 10:52pm

[redacted]

[redacted]

The partner sharing portion whenever I choose to institute has not worked well. Very few share with their table partners, maybe because they are not comfortable with who they are sitting beside. Oftentimes, I get asked questions when I tell them to check with their partner. That is not to say it is all bad, and during this time I don't answer their questions. There are students who do collaborate with each other, but it seems as a whole they are content doing things solo. I don't really know what to do in order to help aid this process.

Comment by US on March 11, 2013 at 9:35am

Ok Got it about the If then statement. Nice! I am going to use this idea in my teaching. I like it because, reasoning with " If then" statements is "big idea" in mathematics.

Now about the working with partner issues: I actually expected that there might be a few hitches with your classes and again your experience is not uncommon in classes where students have not been used to/ pushed /taught to work together with a partner from the beginning of the school year. It is usually not enough to simply tell/ ask students to work with a partner- they have to be **taught** how to work together and it is best if the teaching begins during the first few weeks of school - so you can think about that when you begin your first teaching job. **But** there is something you could do now to promote better student collaboration. You will need to 1) be more specific about the collaborate behavior that you expect and 2)

you have to reward positive and productive collaborative behavior. So for instance, when you ask students to work together, you might have to tell them exactly who they should talk with e.g. " Larry and Omar, you two should work together" then you have to tell them the exactly what they should do e.g. “Larry you explain, not just show, your answer, to the problem first and then Omar should tell Larry what you think about his explanation. Then, Omar should explain his answer and then Larry should tell what he thinks about Omar's explanation. You could also say " I will not answer any questions until both you have discussed your answers- or I will not answer any questions, you must talk to your partner. I will be coming around and checking on how well you are talking and explaining to each other." In addition to articulating the specific behavior that you want, you need to highlight and praise good collaborative behavior just like we reward and highlight good mathematical work and thinking.. e.g. "Larry and Omar you are doing a good job of working together, I like the way you explained your solution to Omar..." also if students’ are working well together, you have to prompt and push them " Omar You've got the right answer on your paper, could you explain what you did to Larry... if you explain something to someone else, you learn it better. or" it seems like both of you have no idea what to do so both of you look over you notes and see if you can find something to help you in your notes, tell each other if you find something... and i will come back and check with you. My major point is that students do not naturllay know how to work to together, you have teach them about what working together sounds like, looks like and you have to reward them when they do it and you might have to motivate them to do so. Once they know what you expect and have done it sucessfully , they will do it more naturally. Challenge yourself to see what progress, you can make in helping your students to work together. There is alot that you can do it does not have to be left to chance. So try to think about what you can do and try it and see what happens. We are always learning to teach.

Comment by Jake on March 13, 2013 at 10:06pm

I completely agree with what you have written. I collected from my failed attempts that it was not a natural tendency for students to be able to collaborate effectively. In fact, while I was at Beaumont for two weeks during the fall, the CT I was with talked about how they had to train their students to work in groups like what is a good group looks like and what a bad group looks like. By the time I was there, I was really impressed by what some of those middle schoolers had to offer. A lot of their class was centered around group work and self investigation which I really liked for the age group. I see what you are saying. Lay it all out there for them, so they know exactly what is expected of them. Students are good at doing

what is expected... well most of the time... I will try this and see if it helps improve the classroom dynamic at all. Thanks for the advice.

Sam's post-Interview online conversations

Conversation 1

Student Teaching Week One - January 11

- **Posted by Sam on January 12, 2013 at 12:14am**

Since this is my first journal entry I will provide a short description of the classes I am working with at Tates Creek high school. Each day (both A and B) consists of three 90-minute courses, two general geometry classes and one college prep class. The geometry classes are mostly made up of sophmore level students while the the college prep classes are primarily seniors. It is nice that the A and B day schedules are so similar. I feel like it will ultimately help me stay consistent when I begin to pick up teaching.

At the beginning of this week the geometry classes began learning about the Pythagorean Theorem while the college prep classes worked on practice for Compass testing. After the initial lesson on the Pythagorean Theorem, my supervising teacher and I decided the student could use an additional day of work with this information before moving to the next concept. To accomplish this we designed a station activity for use with each class. This activity was made up of nine different stations where students would have between four and five minutes to cooperatively work through two problems applying the Pythagorean Theorem. After a warmup and review of homework problems we divided students into groups of three or four and set them into moving through the classroom from station to station completing the activity. Throughout the activity my supervising teacher and I walked around and worked with individual groups. Because the Pythagroean Theorem is also relevant to the Compass, KYOTE, and ACT tests we decided to utilize the same activity with our college prep classes.

This first day of utilizing the station activity revealed some of the misconceptions that students struggled with when completing the problems. We found that many students struggled with problems that require preliminary steps before applying the main concepts. We also found that when the problems presented information in a varied format then students became hesitant or confused. Overall, the additional work with applying the Pythagorean Theorem today seemed to be beneficial. I

will be working through the student work this weekend to determine how well these concepts were applied. We will use the same activity for our classes tomorrow, but we may change the opening to address some of the misconceptions we discovered today.

In addition to working with the actual math concepts I have really enjoyed getting to know the students and becoming more familiar with my school. Today, several students began to call me Mr. Emmons instead of "hey you" or "Mr Student Teacher". I have also learned nearly every student's name which has helped me become more comfortable in the classroom. All of this is making me feel like a real teacher.

Comment by US on January 12, 2013 at 11:42am

Hi Sam

Glad you are enjoying your students, learning names and feeling comfortable in the classroom.

Yeah stations! Station activities do help to reveal individual students' misconceptions. You will no doubt learn a lot about students thinking by looking over their work this weekend and using what you have discovered about students misconceptions to plan for the next lesson. Learning about and addressing students thinking about mathematics is what makes teaching mathematics so interesting/ creative/ challenging and different from using mathematics in other fields. I am looking forward hearing exactly what kind of misconceptions you discovered after you review the student work. (Hint hint respond)

Also tell me something about how " well" the geometry students worked together in groups. In our interview, you spoke about the importance of student collaboration. Does the group work you have witnessed so far in the geometry classes live up to your vision about student collaborations? Is there something about student collaboration in the geometry class that could be better? Do they stay focused on mathematics? do they express their thinking, ask each other questions, do they work independently or interdependently? Have they been given guidelines for group work behavior?

Ok enough questions. Looking forward to your response and hearing more about what happens next week.

Comment by Sam on January 12, 2013 at 9:47pm

I will post another entry when I complete my assessment of the station work I brought home this weekend. With regard to your other questions, I do see student collaboration as an important part of an effective mathematics classroom. I believe students can be a powerful influence (both positive and negative) in the classroom and that collaborative work creates opportunities for accelerated intellectual growth. The group work I observed this past week had its strong and weak aspects. First, I noticed that some student groups did not work as intended. These groups usually had a single student completing the bulk of the work while the other group members simply tagged along for the ride. When the "leader" would finish a problem the rest of the group would copy the information down with little explanation. This was frustrating to observe and in a couple of cases I encouraged these groups to work more as a team. Further, I observed some groups simply behave as an opportunity to socialize. However, there were also many groups that worked beautifully together. In these groups the members fed off of one another. I observed many students explaining reasoning and concepts to other students, leading to deeper understanding. In all three of these examples I find that group work only partly meets the ideal I brought into the classroom.

One thing I really like about how my ST uses groups is the group assignment method. My teacher writes a number for each student on the board (i.e. 1-30) then randomly collects three or four numbers together in a group. The students do not always like this because it may place them in a group not to their liking. However, it appears to reduce the amount of socializing that occurs during group exercises. I will definitely utilize this approach for assigning groups.

Comment by US on January 13, 2013 at 3:33pm

Thanks for such a complete response to my questions about group work and student collaborations. Your observations reflect the variety of things that can happen when students are asked to work in groups. You noted that watching some groups was frustrating and that you "encouraged these groups to work more as a team." Think about what other strategies you could use to promote the type of group interaction that you would like to see. Students don't naturally know how to work in groups, sometime it happens but most often students have to be " taught " how to work in groups which mean explaining, modeling and providing specifics about effective/expected group behavior. Also students often do what they are rewarded for. How do we reward and affirm "good" group behavior? or do we just reward getting to right answer. Fortunately, in your [cooperating teacher's] classes you will probably have many opportunities to **faciliate** students work in groups as you walk around and co- teach so you can begin to experiment with what to say and do the promote more effective

group work. I am curious to hear about what you try to do and what you learn by trying. That's what student teaching is all about: trying stuff and learning stuff :)

Conversation 2

Student Teaching Week Seven - February 22

- **Posted by Sam on February 24, 2013 at 4:09pm**

Today was a challenging but rewarding day. My lesson in geometry was on volume of prisms, cylinders, and combination figures. I knew this would be a tough one for the students because of my discussions with my ST. I also knew that putting emphasis on the equations and process would help to lessen the confusion. I was prepared to do everything I could to help them make clear sense of these concepts. We began class with a warmup that reviewed what we had learned about polyhedra in the last class. This was followed by a short discussion on homework. Once again, I made sure that every student had a 3-D figure in their hands for the entire class period to further connect the concepts to something concrete and real. After the warmup and homework we went directly into new information which include several examples for student engagement. As I introduced the volume formulas and three postulates I fielded several questions and misunderstandings. My ST and I had discussed and planned to try some team teaching and it was during this part of the lesson that we employed this strategy. I thought it worked really well. We both walked through the classroom taking turns working through examples and answering questions or explaining concepts. I was still given full leadership during the lesson but I felt like we were really in sync as we taught together. I think that having two different voices saying the same thing will prove to be an advantage for the students. Despite the difficulty of the material I felt like the students exhibited a good understanding of the concepts by the end of the class. I was able to give an exit slip, so I can use these results to inform my thoughts on this lesson.

One of the cool things that happened in response to this lesson came from one of my students. This student is a library aid during fourth block and she came to the classroom to discuss her grade and what she could do to improve. During our discussion she mentioned that it was funny to watch us teach together because we were both really into what the other was saying. She was able to properly interpret the passion we each had for the material and for the instruction the other was providing. I'm not totally sure she had the same passion but I was pleased to find out that our passion had been communicated to the students during the lesson.

My college prep class today was all presentations. I did have a few seats reserved in the lab for those students that had not yet completed their powerpoints. These students went with my ST to finish at the beginning of class while the other students presented following my initial presentation. This block was very successful as several students were able to share with the class. I am finding that as time passes my students grow more and more accustomed to my presence and teaching style and they are responding positively to me during each lesson.

As I left school today I realized I was tired from the work of the week but at the same time I was filled with joy at the results of my work. I know every Friday may not be this way but I can't help but be optimistic that my satisfaction with my career choice will continue to grow every day and every week I am in the classroom teaching. This is definitely where I am supposed to be, doing what I am supposed to be doing. I look forward to see what next week has in store.

Comment by US on February 25, 2013 at 10:34am

Sam, I have come to anticipate that sometime before the end of the weekend I will get the scoop on what happened during the previous week. I will respond to the past three posts in this one response.

First of all, congratulations on another rewarding week of teaching and learning. Your anxiety attack about your lesson is certainly not uncommon in the world of teaching especially when you have to teach something for the first time, which is the way it will be for you during at least your first few years of teaching. I still have anxiety attacks at the beginning of every semester when I start teaching a new groups of students. I am always anxious about how I will come across to new group of students but not very anxious any more about how I will present the material because I have been teaching the same concepts for so many years and therefore I am really aware of a large array of the possible misconceptions that students can have. I think that you and your CT really hit the nail on the head in deciding to discuss students' misconceptions before you plan lessons. I would like to focus my response on **students' misconception**s. First of all I just want to plant seed about something you have perhaps already heard about in your math methods course- "lesson study" or Japanese lesson study". "Lesson study" is process originated and prevalent in Japan to promote teacher professional development. In the lesson study process a group of teachers meet for a quite bit of time (hours and days) to plan a very detailed lesson together, pooling together every teacher's knowledge about the topic and knowledge **students' misconceptions** about the topic. After the lesson is planned, one teacher teaches the lesson to a class while all of the other teachers as well as

other invited guests observe and take notes about student thinking. After the lesson, the teacher and observers discuss their observations and provide feedback about what they have learned about teaching the topic. The lessons is then refined and taught again by perhaps another teacher in the group and observed... This cyclical process is credited for tremendous teacher growth in teaching mathematics. Now I am not suggested that you start a lesson study group, (Although I did work with some college instructor colleagues to start a lesson study group a few years ago) but I just want to reiterate the importance of anticipating and planning for **students' misconceptions** when planning for a lesson and the power of in-depth collaborative lesson planning among knowledgeable teachers that is focused on analyzing how students' learn. Unfortunately, time for such in-depth planning is not a really built - in part of our current teaching day structure.

Now here is what I really want to talk about:

Tell me about some of the **specific student misconceptions** about the volume 3-D figures that you discussed with your CT or that you anticipated or that you encountered during your teaching? How do you facilitate students understanding in light of these misconceptions? There is one misconception that I have encountered often when teaching this volume. I wonder if it also came up in your discussions with Bo or in your teaching. Looking forward to your response :)

Comment by Sam on February 25, 2013 at 2:49pm

Thank you for your insights. The lesson study group sounds intriguing and maybe worth a try when I have my own classroom. I know that having others' input on my teaching strategies and methods has been the most helpful and effective way of improving these components. To get straight to the misconceptions we discussed. My CT and I discussed how difficult it is for students to separate the general volume equation of V=B*H from the equation for the area of a triangle A=1/2bh because they become confused as to why a triangular prism has two b's and two h's. Additionally, the students commonly struggle with the idea that the "B" represents the entire base area. Many of them want to take a side length of the base and use it for the "B" value instead of calculating the base area. Finally, some students struggle even identifying the base unless the figure is drawn with the base oriented on the bottom.

To deal with these issues, I taught the students how to begin each problem with the general volume equation V=B*H, then identify the base and replace the "B" with the area equation of the base figure. Once this has been completed they can plug in the actual numerical or variable

values to solve the equation. By organizing the problems in this way, it allows the students to clearly see the relationship between the "B" and the base area equation of the polygon figure that makes the base. Also, making sure that they have a 3-D figure in their hands when we are instructing helps to solidify the identification process. Overall, there were a few questions about the equations but it seemed to work pretty well.

Thanks again for your feedback. It really helps me organize my thoughts and reflect on the events of my days.

Comment by US on February 25, 2013 at 10:17pm

Yep, misunderstanding the meaning of big B and confusing big B with little b in volume formulas are common misconceptions

Cool idea to start with general formula and then replace it with area equation for the base .I will try this next time I teach this topic. Actually, the formula for the volume of cylinder V= pi* r^2* h is exactly area formula for a circle which is the base of a cylinder times the height. In middle and elementary school, students should learn why the volume formulas for prisms and cylinders work for finding the number of cubic units inside the figure, When students understand that the area of the base simply tells us how many cubes in each layer of the figure and that the height is the total number of layers then the volume formula just makes sense. I am just not sure how much conceptual understanding high school students receive or retain from middle school.

I have to echo Michelle's comment and say that I also liked that each student had polyhedron in their hand throughout the lesson.

Conversation 3

Student Teaching Week Eight - February 27

- **Posted by Sam on March 3, 2013 at 10:15pm**

It seems like new experiences are coming at least every week, if not every day. Today was my first experience with a substitute teacher. My CT missed today to attend a district math curriculum planning meeting at central office. Because he knew this day was coming he was able to plan for a specific substitute who is familiar with the school, the students, and the classroom. Fortunately the sub is also someone I know and with whom I already have a good working relationship. Despite the comfort I felt with the sub there were a few concerns that crossed my mind. Chief

among these was the fact that I had not yet taught the B-day Geometry classes during my time in the classroom. These are students that I know and have worked with one-on-one, but today would be the first solo lesson with them and that fact had me a bit nervous. Secondly, some of these students do not have a good rapport with the sub. They can be very abrasive with him and he does not always respond professionally. I was concerned that I may have some management issues today.

The great news is that today went extremely well. The geometry lesson was on the volume of a pyramid and cone. This information builds from our last class session where we talked about volume of prisms and cylinders. The lesson was broken into different components (warmup, hw review, volume review with examples, concrete demonstration, new material with examples, exit slip) and therefore kept the students moving and engaged. I was able to do a really cool demonstration for them that helped us derive the equations for pyramid and cone volume. I took a cone and cylinder of the same base and height and asked them to guess the relationship between the volume of the two figures. Most students guessed that the cone was about half the volume of the cylinder. A few guessed that it was one third the volume. I filled the cone with water and then transferred the water to the cylinder. I did this three times and after each transfer the students were allowed to amend their guesses. Obviously by the third time we discovered that the cone was one third the volume of the cylinder. I performed the same investigation with a square prism and pyramid of the same base and height. Again the students were able to see that the pyramid was also one third the volume of the prism. It was awesome to see the students engage in this activity. They seemed to clearly understand this new relationship and information. I think to extend this investigation I could try to obtain a set of figures for every two students and supply them with something like uncooked rice so that every student could have the opportunity to physically demonstrate this volume relationship independently. This is definitely something I will add to my toolbox and use in the future whenever I teach geometry.

Comment by US on March 4, 2013 at 9:59pm

Yeah, you were " teacher in the room"

It's great that your discovery activity for finding the relationship between the volume of cone and cylinder and pyramid and prism with same height and base worked out so well. (The first time I tried the same activity with a class, the water spilt all over and the 1/3 relationship was not very clearly seen because three fillings of the pyramid did not quite fill the prism. It actually worked better when I demonstrated with rice.) It is worth thinking

about what made things work out so well and what you could do better so that you can effectively facilitate similar activities in the future. I was not there to observe but I think that asking students to guess the relationship first key element in setting up the activity. Also allowing students amend their guesses after observation engaged students in thinking and re-thinking. Did students call out their predictions or write down their predictions? I am not sure what follow up questions you asked but I would suggest that you think about what might be effective questions to ask to cement students understanding and debrief the activity. For example, if a cylinder has volume of 24 square inches , what must be the volume of the cone with same height and base?...If pyramid you used in your demonstration has volume of 10 square units, what is the volume of the prism with same base and height... If X represents the volume of the cone and Y represent volume of cylinder with same base and height, write an equation that represents the relationship that we just discovered...)

You certainly might want to try one day having students work in pairs to find the relationship independently but you will need to consider how you will set up and introduce the activity and debrief the activity as well as how to handle all the materials.

Comment by Sam on March 4, 2013 at 11:21pm

Thank you for your comments and insights. The suggestions you make are fantastic. I did not have the students record their predictions. This could have provided written evidence for each student as to how accurate they were at each opportunity. Furthermore, the square prism I used in conjunction with the pyramid did have measurement markings on it up to 1000mL. This allowed us to quickly identify that the pyramid filled up approximately 1/3 of the figure when we observed the water coming up to about 330mL after one transfer. However, it would be even more effective to have the students extend that experience as you suggested by working toward a generalization of the volume formulas for each figure. This is definitely something I will work to add into this particular lesson or concept in the future.

In regard to the logistical challenges of using physical manipulatives, I find that timing and lesson efficiency are the two main concerns when considering hands-on activities. These types of activities can be so rich and effective at cementing understanding in the minds of students while at the same time there can be disasterous results from an activity that does not go as expected. I know it would take a lot of practice and a classroom full of trusted students for me to allow them to work with water and three dimensional figures. However, using something like rice is not at all out of

the realm of possibility for this kind of activity. Thank you again for sharing your ideas. I am grateful to have the feedback.

Conversation 4

Student Teaching Week Eleven - March 18

- **Posted by Sam on March 18, 2013 at 8:09pm**

  Another day, another dollar. Nope, scratch that, I do not get paid (smiles!) A little Monday humor for my loyal readers. Anyway, today was yet another learning experience. I had planned a little different type of activity for both my geometry classes in an effort to create some deeper connections between polygons in the coordinate plane and the idea of parallel and perpendicular lines. I planned a warmup which dealt with the concepts of parallel and perpendicular so that the students would get back into the swing of things. We then dealt with a couple of questions over the homework for approximately ten minutes. The activity consisted of the students getting into groups of three or four and each group was assigned a single sheet of paper which contained an xy-coordinate plane, a set of points (either three or four), and a list of tasks to complete. The groups were asked to plot the points and sketch the graph of the figure. Then they were directed to identify the figure as specifically as possible by using information like the slopes and lengths of the sides and follow up by explaining their reasoning for the identification. Finally, the students were asked to find the perimeter and area of the figure. All in all, the students should have had to use a combination of distance formula, slope formula, Pythagorean Theorem, and counting to find the information required for each figure. For this activity I created eight separate figures (Triangles - scalene, isosceles, right, and equilateral; Quadrilaterals - square, rectangle, rhombus, and parallelogram) and assigned one figure to one group, making eight groups to work together. The final part of the activity was to have each group present their figure to the class and share how they arrived at the solution. I saw this as an opportunity to vary my instructional strategies and also to hopefully create deeper meaning and conncection for the students.

  The first block of students seemed to connect to this exercise effectively. We were only able to have two groups come up and present their solutions but they were able to effectively communicate the outcomes set for the lesson. The second block of geometry students was another story. Out of the four geometry classes this is the most challenging as far as classroom management. This group seems to take longer to do everything and today was not the exception. The opener took longer than the first block which set the stage for struggle. Then this class was about

50% engaged during the group work time. We were only able to get to one group at the end of class and their presentation lacked a great deal of detail. I believe that the beginning of this lesson was the downfall and that a better start is the answer to a more complete finish. The good news is that I had two days set aside for working with polygons in the coordinate plane and so my plans are not ruined by the lack of speed today. I sat down with my CT and we discussed some additional strategies for managing this particular classroom. He noted that I have already earned their trust but now I must leverage that when I am instructing and put the onus back on the students to take responsibility for their learning. Everything he said was spot on and I have a better feel for how to approach this lesson with tomorrow's classes as well as revisiting the lesson on Wednesday with the B-day students.

Overall, today was another valuable learnng opportunity for me. It was not the smoothest day of my student teaching experience, but I still learned and grew from what happened and that makes it a successful day. I am excited to try this same lesson again tomorrow with the A-day students.

Comment by US on March 18, 2013 at 11:25pm

As one of your loyal readers, I thank you for your detailed description and your humor:)

Bravo for trying an ambitious group activitiy!. It will interesting to hear or perhaps see how things go tomorrow

Student Teaching Week Eleven - March 20

- **Posted by Sam on March 24, 2013 at 11:42pm**

What a difference a day makes! In my previous posting I discussed how the group activity I designed to work with graphing polygons in the coordinate plane just did not work as well with my B2 geometry class. This was mostly due to the issues of classroom management I am experiencing with this particular group. After Monday's class and following my experiences from yesterday I was able to get ideas from both my CT and my UK ST regarding how to approach the completion of this activity with my classes today. The outcomes were vastly different from Monday (and that is a beautiful thing)! My focus for today was to take a few minutes at the beginning of class and address the issues of last class and then help the students see the purpose of our activity and lay out clear expectations for the group work and the presentations. What resulted was a completely changed environment, particularly in B2. The students were significantly more engaged with the concepts and the activities and the

presentations were effective and complete. I was very impressed with the overall performance of my students and my CT noted the improvement as well.

The opportunity to start fresh the next day is one of the major components of teaching that is so appealing to me. I believe it the reason why teaching is one of the best jobs out there even though it is one of the most challenging. I fully understand that there are opportunities to grow and learn in other fields and other careers, but in teaching that is the name of the game! I am almost guaranteed that everyday will be a new experience and a new opportunity to produce a unique result. This is both exciting and a little scary at the same time. As a person that relishes being a lifetime learner I could not be more satisfied with the idea of being a teacher. It sounds clichéd but I feel like I was born to be a teacher and it is experiences like today that encourages this feeling. Let me also say, I am surrounded by a wonderful collection of colleagues, instructors, supervisors, and classmates. I have never been more impressed with a group of people than I am with this group of MICers and others. It is amazing for me to watch the dedicated professional educators day in and day out express their talents and skills in an effort to change the future for the young people sitting in their classrooms. Additionally, I am a part of a group of pre-service educators that I would put up against any others anywhere in the country. The men and women in this program have played a significant part in my development and growth as an individual and professional that I could never properly thank them. Not to mention, they are all amazing teachers in their own right. Finally, the supervisors and instructors have provided the type of leadership and guidance that has allowed all of us to grow to our full potential. I am bordering on waxing nostalgic at this point so I will bring this post to end by simply saying, thank you and let's do it all over again tomorrow.

Conversation 5

- **Posted by Sam on March 25, 2013 at 3:24pm**

Ah, the week before spring break and it's snowing outside! This crazy Kentucky weather will keep you on your toes. Despite it not being related academically, I would like to talk a little bit about the weather. Last night as I tried desperately to find the most reliable information regarding what was going to happen (or not happen) today I found myself very worried about the possibility of missing a day of school. While you may think it has to do with not wanting to extend the school year, may I remind you that I do not have to go until the end of the school year, so that is not my issue. Instead, my concern really focused on the fact that we are scheduled to test in Geometry at the end of this week and a missed day

would wreak all kinds of havoc on my best laid plans. I was really excited and happy to get up this morning and see that school was in session. Then I realized I am now one of those weird and strange people called teachers that look forward to school and don't want to miss any days. I find myself missing my classroom and constantly thinking about ways to teach concepts and knowledge.

This week is the beginning of my last solo teaching week. However, the week will be light on new material and instead most of the time will be spent either reviewing for a test or taking a test. Today was one more day of new material on the equations of circles in geometry and adding and subtracting rational expressions in college prep math. Overall the lessons in both classes went very well. These are the A-day classes and since I missed the previous A-day classes on Thursday of last week, I felt like I had not seen these students in a while. In fact many of them asked me why I missed last class which was kind of nice to hear that they actually noticed I was gone! Every day and every week I feel like I grow closer and closer to being a "regular" teacher and the students seem to interact with me in that way as well.

This week we are retroactively celebrating Pi day and cone day with all of our classes on Tuesday and Wednesday. This will conincide with the test review for the geometry classes and just be a Pi and cone day with the college prep classes. The students are very excited for these days and I am hoping the novelty of sharing some pie and ice cream will provide additional encouragement for these students to stay engaged with the review session. The last two days of the week will be unit testing for the geometry classes. At any rate, I am hoping we have a successful and complete week

Comment by US on March 25, 2013 at 7:20pm

Yep, you got that teacher geek thing real bad when you find yourself thinking about ways to teach math concepts at times when you are not necessarily intentionally trying to plan for lesson. I must confess, I do the same thing myself, even after all these years: Often when I am in the shower, more often when I am driving, unfortunately sometimes when I should be listening to my kids and God forgive me , sometimes when I am in church. I do have a life outside of teaching math but for me thinking about to how teach something never gets old. I am a teacher gee which brings me to my questions. Give me some **more details** about how you taught equations of circles today to your geometry class. How did you introduce it, what kind of examples did you present... what do you think your students walked away with from the class? Looking forward to your response, soon :)

Comment by Sam on March 26, 2013 at 6:02pm

For the lesson on equations of circles I used a powerpoint presentation and guided notes for the students. This was followed by a set of practice problems, which many students finished by the end of class.

I began by introducing the two components that are necessary to build the equation of a circle; the radius and the center point. I then introduced the students to the general form of the equation $(x - h)^2 + (y - k)^2 = r^2$. After introducing this equation we went directly into applying a given center coordinate and radius. During this first example I asked the students if they recognized the equation in any way. I was excited when several students responded with the idea that it looked like the distance formula. This allowed me to lead them in a discussion about how the equation actually is an application of the distance formula which results in the distance value of the radius of the circle. This initiated a short conversation about the fact that this formula can be used to identify all the points on the circle that are exactly a radius-lengthed distance from the center of the circle. The next concept I introduced dealt with circles that have the origin at the center and how the equation takes the form of $x^2 + y^2 = r^2$. This lead to a question from one of my students asking why this looked like the Pythagorean Theorem. Obviously this allowed me the opportunity to discuss the fact that the difference in the x-values can be treated like the horizontal leg and the difference in the y-values can be treated like the vertical leg while the radius can be treated as the hypotenuse in a right triangle, which makes the equation of the circle an application of the Pythagorean Theorem. These connections seemd to amaze the students, which was very cool. To finish up I had them find the equation by providing an example with the center and a point on the circle. Many of them simply plugged in both points and solved for the radius and then went back and created the equation. To finish the new information portion we did an example where they were given the equation and asked to identify the center and radius. The last part of class was used to allow them an opportunity to practice applying these skills to a problem set. Many students completed this work by the end of class. One thing I think the students came away with from this lesson is the inter-connectedness of mathematics. Also, in looking over the practice problems, the students that completed the work in class demonstrated a successful understanding of the processes and applications of writing the equation of a circle. As I said above, overall the day was successful.

Comment by US March 26, 2013 at 9:59pm

Totally cool!. Alot of nice connections in this lesson.

Christy's post-interview online conversations

Conversation 1

1-31-13

- Posted by Christy on February 1, 2013 at 12:36pm

  First, I was really excited because one of my students told me she liked how I taught!!

  So I am trying new things. I made classmojo for this class too. One students said why are you treating us like little kids? I said I'm not treating you like little kids. That particular student always has an attitude about everything good and bad so I wasn't surprised.

  I also started using popsicle sticks to call on students. One side of the popsicle stick has a green dot meaning they need to be called on. The other side has a pink check meaning they have been called on and answered a question. The popsicles worked pretty well.

  I think I finally realized why the students hate math. They get mad because they don't understand. Now I almost think they talk, text, etc. so they have an excuse for not understanding their teachers. If they have an excuse they don't have to think they are dumb, they can say they aren't trying. So many of these kids just don't know the basics and I think it is really sad.

  So why do I say that? When I was pulling popsicle sticks, I called on a student and at first they gave me attitude and said I don't know how to do that in a not nice tone. Then I said well come up here and I'll help you. After that the students were fine and would come up. They have this thought in their head that I don't want to help them. I plan on changing their minds!

  Okay and on to the content…. Today we worked on more Geometry Review. Nothing that they shouldn't already know. I went over some simple definitions and a few problems involving angles and triangles with a few word problems. I used a PowerPoint with a pink colorful theme. I put some pictures of real world examples in the definition section. Their homework was a worksheet over what we did in class. I also told them for extra credit to go onto the class website and leave a comment on the class webpage anything they want as long as it was appropriate. I want them to get on the class page for themselves and see what all is on it.

Some of my students obviously didn't know what they were doing and some of them were bored with the material. I think that the popsicle's are helping with the students that don't know the material and the student's who are not paying attention.

I am going to work on getting students back on track in any way that I can. I am using a daily worksheet that has the bell ringer, a spot where they put whether they did or did not do their homework and why they did not do their homework, what they are still struggling on and "SMUGI" show me you get it. I am hoping to get my students to start using these to help me help them.

Comment by US on February 3, 2013 at 5:09pm

Wow! , you are really working on a lot of things : classmojo to help with classroom managment, popsicle sticks to invovle every student, EC points to motivate students to go the class websiste, and a comprehensive daily worksheet that includes place for students feedback and self monitoring about homework.

What a fantastic efforts to respond to your student teaching placement. You will certainly reap some positive beneits from your efforts.

Most of all, I think it is insightful of you to conclude that your students really do want to understand mathematics and feel sucessful and that most of the bad behavior is just because is just a cover for own feeling of inadequacy in understanding mathematics. Your determination to help them understand and have some success will not go un- noticed by your students.

The student who said that she liked the way you taught- what do you think it is that she likes?

Looking foward to seeing you sometime this week .

NING Conversation 2- Christy

Feb 7th

- Posted by Christy on February 11, 2013 at 9:30pm

I only had a few students who turned in their writing assignment today, which was supposed to be due a week ago but with the weather we decided to push back the due date. When I read these writing assignments I was in shock. The students really can not write papers. They do not write in paragraph form, they didn't cite sources (and they had to use websites to do the assignment), they used contractions and they said stuff like gonna instead of going to. I cannot believe how poor their writing skills are. I am really not that good at writing but I at least know how to do those simple things. Also I had a student go on a rant in the middle of the paper about how she didn't know why high schoolers had to take so many math classes. It was stupid and a waste of time.

As far as new mathematical material goes we worked on the same things as yesterday. We worked on multiple events and conditional probability. The students really struggled with the conditional probability. They don't understand what conditional probability is or how you find the probability of two conditional events. I plan on going over this in different ways and reviewing a lot!

I also plan on going over common mistakes with the papers. I think some of the papers were pretty good but they still need a lot of work. We will do a peer review in a week to continue editing their work.

I think behavior is getting better every time I see them. Most of the things I try are starting to working. I will continue trying different things with my students.

Comment by US on February 12, 2013 at 1:26pm

Your students weak writing(probably reading skills)contributes makes teaching topics like conditional probability, permuations and combinations challenging because you have to constantly think about how to simplify language so that concepts are acessible to students which is a big task for novice teacher. During the course of reviewing this material for several days, did you find any ways of explaining things that seemed to have worked for students? Which permuation and combination stories really clicked with your students?

Comment by Christy on February 12, 2013 at 5:34pm

Honestly it was kind of different for every student. So different things the more I explain and the more examples I use the more the students catch on.

NING Conversation 3- Christy

Tuesday 2-26-13

- **Posted by Christy on February 26, 2013 at 6:48pm**

I started with an ACT calculator review sheet. I told them to ask their neighhbors if they couldn'tfigure something out. I really wanted them to communicate with their neghbors to work on this. For some them this stuff was new. For some it was old. I really am trying to get them more famliar with using their calculators. They don't know how much the calculator can help them on EOCs and ACTs. I want them to have all the tools they need to be as successful as possible.
Today I taught my Advanced class about Unions, Intersections and Compliments. We started with a PowerPoints with definitions and examples of a Union, Intersection and Compliment. I had the students telling me what they thought the answer was and then I went over it. I made sure to take a fffew seconds to let them proocess the question and most tof the time I got answers. I really enjoy that the students seem to remember from previous classes. They said they had heard of Unions, Intersections and Complliments before although they didn't remember perfectly. They picked up very quickly with the new material.
I then gave them a worksheet that used M & Ms to do probabilities. I asked them for things I think they really had to think about sometimes. The students seemed to do pretty well with this worksheet only a few questions gave them troubles. Also, I added revview from previous classes at the end of the worksheeet. Students seem to forget if I don't review everything daily.
I am struggling to chanellge these kids more. I want them to feel like they are being challenged. If I'm not challenging them then I don't think I am doing my job. They are to smaart for me to spoon feed them. I think I will try to get them to think deeper and give me examples of the definiitions, instead of giving them examplles.

Comment by US on February 27, 2013 at 2:53pm

Thanks for the detailed description :) Yes i think that your worksheet did have problems that they really had to think about. Now, try to recall what particular things on the worksheet students had trouble with and then think about how you might present material differently based on their misunderstandings. Include these details in your reflection about your lesson and in future posts try to include even more details about student's mathematical thinking- doing so will force you reflect more deeply on your teaching. It also will help me understand more about what is going on with your teaching since I can not be there everyday.

Conversation 4

Pi Day

- **Posted by Christy on March 17, 2013 at 4:50pm**

  Today was Pi day. I started by playing Pi music as the students came into the classroom. Some of the students enjoyed the music others did not. Then we did the Amazing Pi Race. Which was basically station set up to mimic “The Amazing Race” on TV. All of the problems had to do with circles so they related to pi in some way.

  I then had them do a review on factoring and multiplying polynomials. All things they should have seen in Algebra 1. They all seemed to remember everything really well. Then we worked on Algebraic Rational Functions, which was basically just introduction to polynomials. We worked on what Rational Algebraic functions are. I tell students I want definitions in their own words. I am trying to push them to think about what I am saying and then make it their own. I also have formulated the notes so that we do a few minutes of lecture and then they do some work on their own, then we go back to lecture then they try a few more. I think this is working pretty well for the most part. There is more time spent on trying to get them refocused when we come back to notes but I think I spend less time telling them I need the talking to stop during my lecture.

  My students test average was a 75 which I was pretty happy about because normally it is much lower. I was very proud of them! 45 minutes. We had a lot of B’s and only a few F’s! I think this was an accomplishment, the test raised pretty much every single person’s grade in the course.

  Their mathematical thinking is well developed but I think they need to be pushed more. They are smart enough and disciplined enough to where they need to be pushed to think of this stuff and not just copy what I say word for word.

  Comment by US on March 17, 2013 at 5:22pm

  Wow!, you did alot of different things in one lesson. What exactly was one of the tasks that students had to do in the Amazing Pi Race. I am curious about how you worded the tasks to mimic the Amazing Race. Did the students work well together at each station? What is Pi music?

  I assume this was your advanced class? How did they do with putting defintions in their own words? What are some definitions that they came up with for Rational Algebraic functions or something else?

Do you think that you are getting better learning results by breaking down the lecture into smaller pieces ?

Congratualtions to you and your students on improved test scores!

Comment by Christy on March 17, 2013 at 5:35pm

I actually got it off of a shared folder at [my student teaching site]. It was calculating volume. Students worked with one/two other student/s. Pi music is just random dongs turned into lyrics involving Pi.

This was my advanced class! Most of them did really well a few copied mine word for word. I then wrote on their notes that I expect them to write the definitions in their own words. Vertical Asymptotes they said were invisible lines that the graph did not cross. I also made them think about why we had asymptotes.

I think I am getting better by breaking the class/lecture into smaller pieces. I think we are getting through more material than we used to. Like you said we did a lot of things in this lesson! I really didn't think we'd get through as much as we did but this format is really working out.

Conversation 5

Monday 8th 2013- Conics

- **Posted by Christy on April 8, 2013 at 4:52pm**

Today we did a practice EOC. The practice EOC will help us figure out what we need to focus the review on. We plan on splitting kids up into groups of what they are struggling on. Then we can give them more help with the things they are struggling in.

After the practice EOC we worked on Circles. The students took notes with a guided note sheet. They started by using their cell phones to come up with 5 facts about circles. (They couldn't use they are round, they have a circumference, etc.) After they came up with their 5 facts they used their facts to come up with a definition of a circle. I had students tell me their definitions. I got some really good definitions. (Much better than the books) After that we talked about the equation, where the center of the circle is given the equation and what the radius is given the standard equation of a circle. After that we talked about graphing circles. I had them graph given the standard form of the equation of a circle. I did the first one with them. Asking them what is our center? Where is the center? What is

the radius? How can we graph this circle given these things? They pretty quickly came up with how to graph the circles.

Next class we will go into translations of these circles. Students will need to be able to identify graphs of circles and understand translation of circle for the End of Course Exam.

I really thought the students enjoyed the lesson. Some of them really used their cell phones as a tool to understand the definition of a circle and get some really great information. I am really glad I tried this with them. I will continue trying to use their cell phones as a tool to gain knowledge in class.

Comment by US on April 8, 2013 at 8:32pm

Its nice the way you involved the students in using technology to come up with a definition of a circle. What are some of the definitions that the students' came up with? In the future, you may want to think about how you can use the students' owns definition to bridge/ link them the formal definition. Its great that you students seemed to have grasped how to graph a circle given the equations. What difficulties do you think they will have with translations of circles for next class?

Conversation 6

Friday April 19th

- Posted by Christy on April 22, 2013 at 3:53pm

Today I again taught radicals. We started with a bell ringer. The bell ringer was over misconceptions from last class. Last class we went over Completing the Square. I had students do an Exit Slip on a Sticky Note they then put their sticky note in either a green spot, black spot or green spot. Green meant they thought they definitely got it right, the black meant they thought they got it right but they might've gotten right, the red meant I definitely did not get it right. I had most of my students in the green and just a few in the red. I then analyzed their answers. I found common mistakes and typed them up as a bell ringer. They had to fix the common mistake. I allowed the students to work in groups for this. Most of them came up with the correct mistakes. We went over the mistakes a class. I think this really helped them.

After this we worked on radicals. The students remembered more about radicals than my classes yesterday. We did the same PowerPoint as the one yesterday. I just went over the basics of Radicals for the most part. We did some examples with square roots and cube roots and the difference between the two. I again showed the video on radicals.

After the video and review of radicals we worked on the Unit 4 Quadratics worksheet. The students have trouble remembering some of the simple mathematics. Again, a lot of them do not try to do the homework, which results in low retention rate. I wish they valued their grades more and knowledge more.

I think their mathematical knowledge is better than my other classes although I think they should be much higher. I think these kids could do much better than they are doing. I think they struggle with remembering simple facts. I try to review as much as possible in this class as well to help retention.

I think I will continue doing bell ringers like the one I did today. I really like that and felt it really helped my students. I will try to continue reviewing to sharpen their basic mathematic skills.

Comment by US yesterday

I liked how you gave the students an opportunity to assess their own understanding by choosing a green , black or red spot for their exit slip note.

I also like how you gave students an opportunity to " find the error" This is nice way to allow students to do some critical thinking. **Did you find that the students were more involved with this activity than with other things that you tried to do? If so or not so, why or why not in your opinion?** I suspect that the fact that you used " real errors " that students had made on the exit slips might have made this activity more motivational for the students.

Appendix E: Data Analysis Tables for Research Question 1

Table E 1: ***Content of online mentoring in relation to elevating conceptual understanding and surfacing 'big' mathematical ideas***

Date	Mentoring conversation	ST Experiences	Mentoring Responses
	Topic- Barriers to effectively teaching underlying concepts		
February 4, 2013 at 10:49pm	Jake. After my conference with [my US] last week, I was really amped up and focused on trying to lead these students on a path of understanding rather than memorization. So, throughout the shortened class period. I was working to try to get them to understand what was really going on when they are finding both real and imaginary roots. Why might only one root show up on a graph when there are 8 other imaginary ones? Where do these imaginary roots come from? etc. These are questions I was asking and I thought we were having good conversation about, until the inevitable happened. The classic, only 5 minutes left. I had gotten nowhere near what I needed to get through to allow them to do their homework. Because of my quest towards understanding, they were now lost and short on time. I doubt any of them really understood what I was talking about. I felt like the whole class was a giant step back in the progression I had made thus far. It was A1, to be fair, they are lowest performing class on average, out of the	Stimulated by discussions with his US during a post-lesson conference, Jake decided to focus on teaching for" understanding". In addition to teaching students how to find roots of higher order equations, he wanted them to understand the concept of real and imaginary roots. In Jake's quest to teach for understanding, he found that his students got lost and that the he did not have enough time to teach them the skills needed to do the homework. Jake decided to abandon his quest to teach for understanding	

three, and it was a shortened class period, so I had a lot working against me, but I was furious. More than anything, I was frustrated that I took the time to really "teach" rather than show, and it came back to bite me in the butt. I couldn't help but think of how little incentive there is now for students to actually understand what they are doing, because that is not what they are tested on. They are tested on what they can memorize and do, not what or how they understand.

But, as all good teachers do, I had to mid-game adjust for third block, A3. Knowing now that my efforts had a very high probability of going to waste, I used my instruction time to show them how to use the calculator function. They knew how to do it 100 times better, but I am not convinced they really know what they are doing... but what else can I say besides they will do well on a test, be it standardized or what have you.

Right now, there are few things more frustrating than the system, and teaching students to regurgitate calculator functions has been grinding my gears. I am still reeling from this morning, and I know a large portion of my errors were due to the fact that I didn't know where to anticipate the misunderstanding, but I can't get over this idea that my efforts were worthless in the first place. From the start of my preparation, I was fighting a losing battle. Oh well, you live and you learn, and today I happened to learn in the span of an hour.

in subsequent classes during the day and reverted to just teaching students how use calculator find roots of equations. Jake conceded that although, he only showed his students in subsequent classes how to regurgitate calculator functions, they would probably do well on a standardized test. Jake was frustrated that the system(district curriculum guides , department assessments…) provided no time or incentive to teach for understanding.

February 5, 2013 at 12:03am	US: Glad you got this off your chest. So much to talk about here! First all I am really impressed that you took on the challenge/risk to teach for understanding. There is a lot to glean from your experience today. First of all, teaching for understanding takes time, and sometimes involves leading students through some confusion on the way to clarity and yes, the assessments given to students may not test for particular understandings that you take the time teach. So there are real hurdles here but perhaps there are ways to deal with them. Time is real hurdle, so we have think about what depth of understanding we can achieve within a limited time frame. You have choose your "teach- for-understanding" battles wisely. It is impossible to teacher everything for complete understanding but we can certainly do some significant things with conceptual understanding and sometimes we have to just teach them how to do it for the sake of time. Also remember you are starting from scratch. If you had been teaching these students since the beginning of the year with the intent on teaching for understanding, things may not take as much time because you students will be used to grappling with concepts. Also, after some years of experience, you will better be able to anticipate students' misconceptions and you will have a better sense of how long things will take to teach for understanding. Now about assessments, you are correct that assessment drives instruction? Do the math teachers at [your school]-use common assessments are do	US highlighted the lessons to be learned from Jake's frustrating experiences about teaching for understanding. US concurred that there are real hurdles to be overcome when teaching for understanding and she acknowledged that some assessments may not measure conceptual understanding. Yet , she but insisted that although it is impossible to teach everything for complete understanding, teachers can teach a significant amount of material for conceptual understanding. She encouraged Jake to envision his potential for teaching for understanding in the future, when he will have more experience/knowledge of students misconceptions, more autonomy to design assessments and more than just a few weeks to cultivate students 'conceptual understanding .

	teachers create their own assessments? Do the teachers collaborate to create common assessments? What kind of thinking about learning mathematics is underlying the design of the assessments? It is perhaps too early in your career to change or take on the system but the nice thing about teaching is that you have some autonomy in your own classroom. When you have your own class, you can create assessments that include at least a few questions that assess student understanding? Your classroom environment can reflect your teaching philosophy and still fall within the curriculum guidelines. You might feel like you were fighting a losing battle today, but there are battles to be won in the future.	
February 5, 2013 at 10:23am	Sam: Jake I also appreciate your reflection on this experience. I had a similar experience last week when I taught an intro to Trig lesson. I felt like the students needed to really understand the concepts in the lesson and I emphasized the concepts. Like you, I got to the end of the lesson with about ten minutes left in class and the students did not have nearly enough information to complete the homework assignment. In fact, I had an activity prepared and we could not even get to it successfully. It was unbelievably frustrating and I also felt like I was experiencing the first day of teaching all over again! It literally took me 20-30 minutes to calm down enough inside to think about what had just happened. After talking with my teacher I	Sam empathizes with Jake's frustrations and recounts a similar experience of running out to time to get to curriculum content because he spent time trying to help student "really understand the concepts"

	realized that I do not yet have enough experience in the classroom to truly understand where common misconceptions or misunderstanding will occur in the curriculum. I am encouraged to think there will come a time when I can anticipate struggles instead of reacting to them. I can sympathize with your experience and I encourage you to keep working on developing the strategy of teaching for understanding.	
February 5, 2013 at 11:08pm	Jake: (in response to US) The General Alg II teachers use common assessments that we create during PLC's. From my observations, EOC and college and career readiness standards determine both the content and the form of the test. Since these are things students, teachers, and schools are graded on, there is no reason not to tailor your classroom to such standards, despite their application to the real world. One of the biggest struggles I had was obviously guessing where the mistakes were going to happen, and add to that I had 30 less minutes in A1 then in both A3 and B2. I understand I was fighting an uphill battle, but the whole situation just didn't sit well with me. I appreciate the advice and plan on continuing to look for places to insert deeper understanding into the picture	Jake resolved to continue look for places insert deeper understanding but maintains that material presented on common assessments provide no incentive to teach for in-depth understanding or application.
February 5, 2013 at 11:08pm	Jake:(in response to Sam) Its good to know someone else feels the same way. It goes against every one of my natural tendencies, but I never want to think I have things figured out, especially when I don't have a job yet. So it is	Jake appreciated having a colleague that shared his struggles

	helpful to know my struggles are not just "my" struggles, they are teacher wide struggles. Still though, I want to continue to be open with my flaws in the classroom, what I am struggling with and being open to new strategies either from supervisors or peers. Per usual, your input was helpful.		

Summary : In the conversation above, Jake and Sam recount similar experiences of trying to teach a lesson with an emphasis on helping students understand the underlying concepts. Both were discouraged by the outcome- taking the time to teach for understanding took more class time than anticipated and resulted in not covering or getting behind in the required curriculum. Jake was frustrated that curriculum/standardized exams seem to provide no incentive to really teach for understanding. US conceded that time and curriculum are real obstacles to teaching for understanding but urged ST to learn from their experience about how to address these obstacles and to maintain a vision for teaching for understanding as they progress in teaching career

Date	Mentoring conversation	ST Experiences	Mentoring Responses
	Topic –Unpacking the concepts underlying procedures		
February 22, 2013 at 12:26pm	US: Looking forward to hearing about how your algebra 2 lesson on simplification, addition and subtracton of radicals went today 2/22. This is a tricky topic. I want to hear the details about how you presented the material and how your students responded and what you learned about what you might do differently next time. How to teach radicals is an interesting topic for discussion.		
February 23, 2013 at 9:18am	Jake: Like I posted earlier, I was nervous about how simplifying radicals was going to go over. Not that it is super difficult and hard to understand, but up until yesterday, what I had taught seemed to be calculator based and very simple, requiring very little thought. For the	Jake taught his students a procedure for simplifying radicals that he observed in another high school. The procedure involves make prime factors trees	

	lesson, I introduced simplification, addition and subtraction of radicals. The route that I took in explaining the process I gathered from my time observing at … the spring of my senior year of college. There, they taught students to make trees and circle pairs of factors. For each pair, you write the number represented outside of the radical. Multiple numbers outside are multiplied together while multiple prime numbers left inside are multiplied together and kept under the radical. I realize this may simplify the "simplifying" process to a point that mathematicians might cringe, but from what I have seen, it is the most effective way to keep students working on problems. The other way I have seen it taught is finding the largest perfect square factor and simplifying from there. Obviously the answer will be the same, but for a class of students with limited multiplication knowledge (some not all), this process seemed like a reach. I did specifically tell them that if they felt they had a better way to go about simplifying, be my guest. The homework they took home over the weekend will tell the story as to whether they understood it or not. I was walking around checking their answers, and for the most part they looked good. I was surprised to see one student who hasn't particularly done well thus far understanding the process. [Fingers crossed]	and identifying pairs of factors and writing number outside the radical to represent each pair of factors. Jake acknowledged that the procedure might be frowned upon by mathematicians but he felt it would be more effective than the commonly taught process (rewriting radical as product of two radicals) for his students who have poor multiplication skills and low motivation.
February 23, 2013 at 12:55pm	US: One of my students showed me this procedure for simplifying radicals that she learned from her high school teacher… Yes, this	US confirmed that procedure Jake chose to teach can be easily reduced to set of steps to be

procedure does simplify the process. Of course, as you have suggested, if students just memorize the process without understanding why, teaching the method does once again reduce mathematics to a bunch of procedures to memorize in order to pass a test. With that being I said, I do think that the narration that teacher uses when teaching procedure can help to make it more than just another process to memorize. The prime factorization of number is such a powerful tool because it tells us so much about a number by breaking it down to its component parts - from prime factorization of number we know all of the factors of a number. We can use prime factorization to simplify fractions to find GCF, LCM of two numbers and more. I think that the big problem with the way that students learn prime factorization, beginning in elementary school. Usually, students are just taught how to make the trees but do not understand the meaning of the numbers at end of each branch. So, I think the process of using prime factorization to simplify radicals can be very powerful if we point out what all those numbers at end of the tree roots mean. Do we as teachers point out what it means when we see two of the same number or doubles or do we just tell students to just circle pairs and write number outside the radical? Do they understand that the doubles indicate perfect square? Do the students know that all the numbers at end of the tree can be multiplied together to get the original number. My student, who showed me this method, was able to use this method effectively

memorized, but she pointed out that the same procedure could also be taught with emphasis on understanding concepts underlying procedure(which includes thoroughly understanding what prime factorization reveals about the composite factors of a number).

To illustrate the downfall of student's just learning procedures without understanding, the US discussed an example of one of her own students who was able to successfully use the procedure to simplify square roots but, who had just memorized the procedure of looking for pairs of same factor and did not understand underlying concepts. Consequently, the student was not able to apply procedure to simplifying radicals with an index other than 2.

	to simplify radicals with an index of 2 (Square roots) but she did not know what to do when the index higher than 2. For example for cube roots, she actually could use the same method- just look for triples (three of the same numbers at the end of the branches) but she did not know what the numbers in the tree meant so she did not know that you she could look for triples to find perfect cubes. Topic-Unpacking concepts underlying procedures		
February 25, 2013 at 10:34am	US: Tell me about some of the specific student misconceptions about the volume 3-D figures that you discussed with your CT or that you anticipated or that you encountered during your teaching? How do you facilitate students understanding in light of these misconceptions? There is one misconception that I have encountered often when teaching this volume. I wonder if it also came up in your discussions with [your CT] or in your teaching. Looking forward to your response :)		US asked to Sam to describe some of the student misconceptions he encountered, or discussed with his CT, in relation to teaching the volume of 3-D figures.
February 25, 2013 at 2:49pm	Sam: To get straight to the misconceptions we discussed. My CT and I discussed how difficult it is for students to separate the general volume equation of V=B*H from the equation for the area of a triangle A=1/2bh because they become confused as to why a triangular prism has two b's and two h's. Additionally, the students commonly struggle with the idea that the "B" represents the entire base area. Many of them want to take a side length of the base and use it	Sam described a common misconception-students confusing B–meaning area of the B with b meaning length of base.	

	for the "B" value instead of calculating the base area. Finally, some students struggle even identifying the base unless the figure is drawn with the base oriented on the bottom. To deal with these issues, I taught the students how to begin each problem with the general volume equation V=B*H, then identify the base and replace the "B" with the area equation of the base figure. Once this has been completed they can plug in the actual numerical or variable values to solve the equation. By organizing the problems in this way, it allows the students to clearly see the relationship between the "B" and the base area equation of the polygon figure that makes the base. Also, making sure that they have a 3-D figure in their hands when we are instructing helps to solidify the identification process. Overall, there were a few questions about the equations but it seemed to work pretty well.	Sam described the teaching strategy he used to try to address students' tendency to forget that 1) B represents the area of the base and 2) the procedure for determining B varies depending on the shape of the base.
February 25, 2013 at 10:17pm	US: Yep, misunderstanding the meaning of big B and confusing big B with little b in volume formulas are common misconceptions Cool idea to start with general formula and then replace it with area equation for the base … Actually, the formula for the volume of cylinder V= pi* r^2* h is exactly area formula for a circle which is the base of a cylinder times the height. In middle and elementary school, students should learn why the volume formulas for prisms and cylinders work for finding the number of cubic units inside the figure, When students	US liked Sam's teaching strategy and extends the conversation to discuss how envisioning the volume of a prism as certain number (determined by the height) of layers of a certain (determined by the area of the base) number of cubes, should help students make sense of the formula

	understand that the area of the base simply tells us how many cubes in each layer of the figure and that the height is the total number of layers then the volume formula just makes sense. I am just not sure how much conceptual understanding high school students receive or retain from middle school.		

Summary: In the conversations above, Jake and Sam's comments about their plans for teaching were prompted by the US' request for more detailed description of their instructional strategies for particular topics In both conversations above, Jake and Sam discussed their decisions to teach a procedure would make it "easier" for students to complete problems correctly. Jake chooses to teach a certain procedure for simplifying radicals that involves making factor trees and circling pairs of factor. Jake admits that procedure just involves memorization without any conceptual understanding but felt that it would be easier for his students who have difficulty with multiplication. The US responds to both Jake with a lengthy commentary about underlying conceptual ideas behind the procedure that Jake chose to teach his students. US comments implied that such concepts behind the procedure could be highlighted for students but Jake does not respond in any way that suggests that he might try to highlight these concepts.

A similar scenario occurred in other online conversation. Sam noted that his students had tendency to confuse B with little b when using the volume formula. To remediate, his students' error, Sam decided to instruct his students to follow the following procedure: Write general formula for volume first and then, replace B with formula for the area of the base of the figure. Similarly, the US responds to Sam with a about comment of the underlying concepts justifying the B (area of the base) in formula for finding volume of 3- D figures. Similarly to Jake, Sam did not respond to US comments and thus there was no indication in online conversations that Sam had any intentions to address underlying reasoning for the B in the volume formula.

Date	Mentoring conversation	ST Experiences	Mentoring Responses
	Topic- Discussing instructional moves aimed at elevating the concepts		
January 16, 2013 at 5:51pm	Kathy: However, when calculating percent of change many of the students were confused by the formula they were told to use (big-little/original=%/100). If the problem stated that the original price was $25, but there was a discount of $10, the students would set it up as (25-10)/25=x/100. The were confused when I	Kathy observed that students' confusion when solving percent change problems stemmed from the formula they were given,(big-little/original=%/100).	

	explained why this wasn't correct because they though they were following the formula correctly. I think it would have been more clear if they were told to use increase or decrease/original price=%/100. I didn't feel like it was my place to suggest using a different formula, but it made it difficult to explain to kids when the terms "big" and "little" were unclear.	She observed that “big-little” was unclear and misleading and asserted that the formula, “increase or decrease/original price=%/100,” would be more clear.	
January 20, 2013 at 2:43pm	US: First let me say in general, that I am impressed by how often your blog posts address your thinking about how to best teach math specific concepts. Our primary purpose as mathematics teachers is to effectively teach mathematics concepts. Now specifically in response to your post, above, you bring up an important issue about what words or vocabulary we should use to most accurately represent concepts to students while still being clear and accessible to students. Sometimes, as teachers we are tempted to just give the students formula that take away most of thinking so they be successfully solving problems but students never internalize what’s really going on the problems. The problems your students were having using the formula also reflect a bigger issue in teaching mathematics- plugging numbers into formula without understanding the whole situation or big idea. I very much agree with you that "increase or decrease/ original price = % /100" is a formula that would serve students for broader range of percent change problems (given original and new price **or** given original price and discount or mark- up amount) and using the word increase		US praised Kathy attention to the details of teaching specific concepts. She agreed with Kathy’s modifications and elaborated that using “increase or decrease” rather than” big – little” would force students to read and interpret information given in the problem rather than just plug numbers into a formula. US situated Kathy’s concern about the percent of change formula within the wider frame of concern about teaching students to use formulas without thinking.

	or decrease forces students to think about the increase or decrease and how to find it- either finding it in the information given or by calculating it from the information given. Even though it may not have been your place to suggest a new formula in your current teaching situation, all of your thinking about how to teach math concepts triggered by your student teaching experiences now will certainly benefit your preparation for teaching in the future. Keep it up!	
January 20, 2013 at 6:11pm	Kathy: I definitely see formulas becoming an issue. Students use them mindlessly and often do not understand what is going on what so ever. I feel like its important to explain to students where the formulas come from even if they will not be expected to recall this later on a test etc. I actually saw a good example of this last week when she was explaining how to get the point slope formula from the slope formula. Even though most students will never recall how to do it, I think that they appreciated knowing that its just a different way to write the slope formula. When coming up with formulas and explanations, we also have to choose our words carefully because they might not have the same meaning to the students as they intended. I'm sure that I will fall guilty to this many times, but being able to restate in a way that is less confusing to the students is important.	Kathy agreed that students use formulas "mindlessly and often do not understand what is going on". Kathy stated the she felt that it is important for students to see" where equations come from." As an illustration, she discussed how her CT explained how the point slope formula for the equation of line is derived from the slope formula.

January 20, 2013 at 8:52pm	US: Yes! Showing how the point-slope formula can be derived from the slope formula is important, even if students cannot recall or replicate the process because doing communicates so an important big idea in mathematics - equivalent forms of the same equation. People who know real mathematics understand that all equations can be manipulated into different forms.		US liked Kathy's comments about showing how the point- slope formula can be derived from the slope formula to another important mathematical concept for students-equivalent forms of an equation.

Date	Mentoring conversation	ST Experiences	Mentoring Responses
	Topic- Discussing instructional moves aimed at elevating the concepts		
February 25, 2013 at 8:44pm	Kathy: After the pre-assessment, I put up 4 multiplication and 4 division problems with monomials that simplified with the answer written beside it. I asked the students to quietly look at the problems and try to come up with a rule on their own for how I got the answers. To my surprise, no one blurted out. However, they didn't seem to want to think about it as long as I had in mind. I could tell they were growing antsy, so I asked them what they came up with for the multiplication problems. The student who had the most difficulty with solving systems was the first to raise her hand …. She correctly stated that you add the exponents and multiply the coefficients… Then, we worked some practice problems. There were 16 multiplication and 16 division problems. Almost every single student finished in about 10-15 minutes. I was very impressed! Although, they still made some	Kathy was pleased that her students were able to derive `the rules for simplifying exponential expressions. She noted that it was hard to help students identify when to use which rule. She planned to show them how to expand the problems as an alternative to memorizing the rules	

	mistakes with exponents of 1, they seemed to have it down pat very quickly…. know that the hard part with this is helping them tell the difference between when to use which rules. I hope to keep highlighting those differences. I also want to show them more of how to expand the problem into multiplication if they forget the rules.	
February 26, 2013 at 6:12am	Now about the mathematics content- simplifying exponential expressions with rules, you make a good point when you say " I also want to show them more of how to expand the problem into multiplication if they forget the rules." because as you know the most common error student's make is mixing up or forgetting the rules. Because I have found that my remedial college math students cling to trying to using the rules, often incorrectly, and refuse to check answers by expanding and multiplying, I changed my teaching strategy so that now I teach the topic of simplifying exponents by expanding first and actually give quiz on simplifying by expanding before I teach the rules. I want students to find that they can be sucessful with simplifying by simply using their knowledge about meaning of base and exponent before I introduce the rules so that if they mix up the rules they will know and feel confident enough to fall back on " common sense"- expanding into multiplication	US picked up on Kathy's thought that showing students more about how to expand problems just in case students forger the rules. US shared her strategy of teaching students how to expand before teaching the rules.

Summary: In each of the conversations above, the US and Kathy engage in dialogue about how to enhance students conceptual understanding of two specific topics; simplifying exponential expressions and calculating percent increase or decrease. Kathy suggests a way to modify the presentation of formula so that it requires students to think about concept and not just plug in numbers. The US responded by applauding and affirming the Kathy's insight and attentiveness to elevating conceptual ideas. Kathy responded to the US and extended the conversation to a discussion of importance of helping students see where equations come from. In the second conversation, Kathy plans to show students how to expand exponential expression in effort to enhance their understanding of concepts underlying the product rule, power rule for simplifying exponential expressions. The US shares her experiences and strategies for teaching students to expand exponential expressions as an alternative to memorizing the rules for simplifying exponential expressions. In summary, in the online conversations above, Kathy initiated a concern for elevating underlying concepts and consequently participated in a dialogue with the US about concrete ways to enact instructional strategies that might help to highlight conceptual understanding

---

Table E 2: ***Content of online mentoring conversations in relation to eliciting students' mathematical thinking***

Date	Online mentoring conversations	ST experiences	Mentoring responses
	Topic–Surfacing students thinking /asking students to present solutions		
February 27, 2013 at 2:53pm	Kathy: Today in advanced, we continued working on adding and subtracting polynomials. We were originally scheduled to move on to multiplying, but since the other teacher we are collaborating with didn't get that far, we slowed down a little. This turned out to be a really good thing. They really did need more practice since we didn't get to this too much yesterday. I tried a new activity and really loved it. Instead of doing another boring worksheet 1 though whatever number, I cut up the questions and put them in a cup. I put the worksheet on the board with the document camera. I asked for volunteers to pick a problem from the cup and come work it on the board in front of the class. Some were eager to volunteer and others were afraid they wouldn't know how to do it. Regardless, I had no trouble getting volunteers to come up. They were really excited about this activity and I was very happy with the response. It is definitely something that I want to continue to do in the	Kathy provided an opportunity for students to present their solutions to problems on the document camera. She was pleased that many students volunteered to do so. Even though the it took more time, Kathy valued the opportunity to "see how students were thinking "	

	future and maybe try with the general classes. Even though it took longer than just working through the problems, it was more fun and it let me see how students were thinking about things and the little mistakes they were making. Even when students made mistakes, we helped them work through it and we made sure to tell every student good job and thank you for participating. Every student still had to write down all of the answers to all of the problems and many of them worked ahead.		
February 27, 2013 at 3:03pm	US: I love what you did with the worksheet and having students come up and work problemsYes even when students make mistakes, everyone can learn as long as the teacher guides the conversation in postive encouraging manner. Beleive or not, I have had my college student come up and do problems and they love it, because we make a lot of jokes and learn from mistakes and get to talk about how they think about a problem Topic–Surfacing students thinking- asking students to present solutions		US affirmed Kathy's decision to have students work problems in front of the class and shared her own experiences with asking students to present solutions. She underscored that surfacing and discussing students mistakes in a positive affirming classroom environment can be great way to facilitate learning.
January 25, 2013 at 4:25pm	Sam: Another day of teaching and another first time experience. Today was my first review session. …in the final	Sam provided an opportunity for individual students to present problems to the entire class on the	

20 minutes of class I gave the students an opportunity to ask quesitons corporately. It was during this time I introduced a wrinkle into the flow of the class. I offered individual students, on a volunteer basis, an extra-credit opportunity for presenting problems to the entire class on the board. It is my experience that when you explain a concept to another person it helps to cement that concept into your thoughts and working knowledge. In this way I was hoping to provide yet another method for helping the students master the material.

…. I only had one student take advantage of the extra credit opportunity during the A1 class but it was a significant occurrence. This student, I will call him Baljeet, has not necessarily warmed up to me since I took over the class. I can tell he is a bit skeptical and does not trust easily, however he volunteered to present on the board. Baljeet chose to present a particularly challenging problem. His setup was absolute perfection but the algebraic processes tripped him up and he did not arrive at the correct solution. After Baljeet went back to his seat I praised his problem setup and interpretation of the concepts we have been learning. I then explained where the algebra should have taken the

whiteboard. Sam described positive outcomes of this activity for two particular students. Having the students present problems, gave Scott an opportunity to affirm students' thinking, to address misconceptions and to connect with students personally.

	problem. However, as they were leaving class Baljeet actively engaged me in a conversation about the problem and how he could see where he went wrong. It was the first real conversation we have had since my arrival. It was a good thing. Following this I had an even better experience with the review time with A3 geometry. In this class I had three students volunteer to present problems on the board. One of these students, I will call Buford, is not the kind of kid you would expect to volunteer for board work. Buford expresses that he does not understand what we are learning nearly every day. However, today when he came to the board he presented his problem flawlessly. I could see his confidence growing during this exercise and I am excited to see how far Buford can go with his math knowledge.	
January 25, 2013 at 10:18pm	US: Bravo for the" wrinkle". It is great that you had some students who were willing to explain their solutions. Teaching is full of surprises? Who would have predicted that Baljeet and Buford (I love the pseudonyms) would come forward to present? It will interesting to see what happens with these particular students in future classes. Based on this initial experience, do you think that perhaps other students may volunteer in the future?	US praised Sam for providing an opportunity for students to expose their thinking by presenting problems to class. She questioned Sam about how he facilitated the students presentations and how the rest of class was engaged during the presentations

	Also do think that the way you handled Baljeet's presentation will make students feel comfortable with presenting problems even if their answers is not completely correct? How did the other students respond /listen to the presentations? What did you do while the students were presenting- just listen? Interject? Rephrase? Ask questions? Sounds like a rewarding class. I would have loved to have been a fly on the wall	
January 31, 2013 at 11:04pm	Sam: I do hope that my response to these students will encourage other students to engage in cooperative learning opportunities like board presentations. I have a deep desire to see all my students master the concepts in my classroom and feel comfortable working with other students to achieve successful results. When Baljeet was presenting his work I did not interject, but allowed him to complete his thoughts and then I added my analysis. This seemed to work well because he was able to fully explain how he came to his solution, which allowed me to address some of his misconceptions in his process or conceptual understanding.	Sam described how he facilitated the individual student presentations.
April 8, 2013 at 5:01pm	Kathy: The advanced class also reviewed, but there was an additional	

requirement. Their review sheet consisted of problems that were commonly missed from the radicals test, as well as the polynomials test, and old material from their first trimester in the class. They were allowed to work on this alone for about 30 minutes. Each student was asked to pick several problems out that they would feel comfortable presenting to the class. After the 30 minutes was up, I randomly drew students' names from a cup and asked them to pick the problem they wanted to present as long as it was not already selected. They were asked to explain the solution to the problem. Several students did really well with the explanations, while others wanted to explain little. For those students, I tried to ask them questions to make them explain such as "Why did you do that?" or "how did you know you could do that?". Getting students talking about math and explaining their thinking is really what I am most excited about as a teacher. I just love hearing them talking things out! In addition to that, it was interesting to see which problems they picked based on what they thought was "easiest." Different students have different strengths, and I think this allowed that to be incorporated into the activity

April 8, 2013 at 9:15pm	Its fantastic that you are getting your students to explain problems even those that who want to' explain little. way to be a teacher that helps /insists that student find their mathematical voices	

Summary–Surfacing students thinking- asking students to present solutions

In the conversations above, two student teachers discuss their experiences with allowing individual students to present solutions to the class. Both student teachers expressed their delight with having the opportunity to observe how individual students were thinking about problems and to address students' misconceptions where necessary. The mentor affirmed and applauded both ST's decision to take the time to allow students to present problem and shared in their feeling of excitement about the positive outcomes. In addition, the US' comments and questions directed the student teachers to consider a teacher's role in effectively facilitating individual students' presentations.

Topic–Prompting ST to enact teaching strategies that elicit students thinking

February 20, 2013 at 4:55pm	Jake: I was thinking today about how it is about time to take a risk. I feel like I have reached the point of comfort-ability, at least in the Algebra II classes, and they seem to be needing something a little different. The problem is my creative juices are not leading me to anything interesting. I know the unit coming up is covering radicals, but the theme with so much in Algebra II is wrote. I don't know how to mix up presentation techniques to attract to differing types of listeners. I try to be fun and interactive, but math alone has the ability to turn people off. More than anything, what I have noticed is that my desire isn't necessarily for students to learn math, it is for them to have fun doing math; and whatever we	Jake expressed his comfort with teaching his Algebra 2 classes but he felt like, he should begin to do something to make is lesson more interesting for his students but he was at a lost about how to do so.

	have been doing seems completely opposite of this. I don't have bad students, problem students or students that are resilient. They are obedient, good kids who don't complain much at all, so for their sake I feel it upon myself to make things more interesting; I just don't know how to do it. Add to this their age and anything I come up with seems too childish or gimmicky. I have been reading other posts trying to find ideas, but I am still at a loss.	
February 21, 2013 at 1:33pm	US: Its great that your have got a comfortable postivie atmosphere going in your Algebra 2 classes.Yes it is hard to make algebra 2 content interesting or fun to do. Perhaps you could make things a little more interesting (intellectually engaging) by doing some things that I have read from other student teachers: For example, 1) do a find the error activity. 2) Show three examples of how to do something without explaining and see if students can discover what you did 3) a group quiz- pair a stronger student to tutor weaker student for 15 minutes then quiz the weaker student reward both students if weaker student improves. 4) show examples and counter examples for students to derive definitions or proceedures 5) perhaps even a jigsaw activity. These are just rough suggestions and need to be	US provided some specific suggestions about what Jake could do to make his presentation of material more interesting to students by engaging his students in doing the thinking. Her suggestions were aligned with standards-based teaching practices- eliciting and attending to students' mathematical thinking, promoting student collaboration and mathematical discourse, and facilitating active discovery and mathematical investigations

	tweaked for your particular class…	
February 21, 2013 at 10:12pm	Jake: I really like the "find the error" because it gives me the ability to highlight common mistakes I am seeing on a daily basis. The more I can show them what they are doing wrong the better; but when correction comes to figuring it out on their own, we have problems.	Jake liked the “find the error” suggestion but doubted that his students would be able to figure out their errors on their own.
	Topic–Implementing specific strategies to elicit students thinking throughout a lesson	
February 28, 2013 at 10:09pm	Jake: Today is a day I will never forget. .., I took some risks in the way I presented adding and subtracting rational exponents today. After having my observation with [my US] yesterday, I got a really good idea of where I should direct my emphasis currently to become a better teacher. I need to get the students more involved, and as I thought about it, I think my inability to do this so far has been the reason why I feel such a weight on my shoulder at times. It's as if I am shouldering the load of learning rather than passing it to the students for them to handle. So in response to our discussion, I put together a note sheet that to show on the document camera as we went	Jake implemented new teaching strategies. Instead of explaining how to do problems, he showed examples and asked students to derive the pattern/find the rule. He “forced” the students to “walk through the concepts rather than giving them the steps.” Jake was thrilled with the positive student engagement that resulted from his new approaches. Moreover, Jack felt more like a facilitator of student learning.

through the lesson. I didn't do groups or anything like that, but I did use some ideas from some other blogs, namely not saying anything, showing them examples and asking them if they could spot the pattern. Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked. ... The variety of students who I called was much greater than it has ever been. In A1, it is usually hard to keep their attention, seeing they are still half asleep, but today, there was smiling, talking and much interaction. I, especially, got really into it, which is what I had been waiting to do the whole year. I don't know if it was being able to walk around or what, but man I was getting excited because of how engaged the class seemed. I forced students to walk the class through the concepts, rather than giving them the steps myself, something US pointed out as a tendency of mine. It was the teaching day I had been waiting for…

I still don't know if I am the creative type that will formulate small group activities and stations that allow kids to master the content and stay engaged for the whole hour on a lesson by lesson basis, but as of right now I am ok with that, because that isn't who I am. If, though, I can continue with what happened today, and demand student involvement in

	other areas while being engaged and excited, I can feel the same result occurring, just with my own zest.		
March 1, 2013 at 6:13am	**US: Yeah!** I am so impressed that you were able to turn things around in your class so quickly by doing something a little different to engage your students and that you found it rewarding. Keep it up and don't limit or doubt your ability to try **all kinds** of different things somewhere along the line. Don't be afraid to fail, we are always learning to teach. As [Sam]noted, keep aiming for helping student's to find their voice- to find math ematics inside of them.		US applauded Jake for implementing some different teaching strategies with positive results. She encouraged Jake to continue to try new strategies and to expand on his efforts to engage students in thinking as a part of the process of learning to teach. Her statement “keep aiming for helping student's to find their voice- to find mathematics inside of them” served to reiterate overarching standards-based goals for teaching mathematics (e.g. eliciting students thinking and facilitating communicating about mathematics). .
	Topic–Implementing specific strategies to elicit students thinking throughout a lesson		
March 7, 2013 at 10:51pm	Jake: In Algebra II, we learned about multiplication and division of higher ordered radicals, multiplying by conjugates, and multiplying and dividing fractional exponents… I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I	Jake engaged students thinking with “if then statements” derive processes for simplifying expressions with rational exponents.	

	had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner. I really enjoy this style better than what I was doing because it is more interactive and it forces them to think on their own		
March 7, 2013 at 10:51pm	US Nice! I am going to use this idea in my teaching. I like it because, reasoning with " If then" statements is "big idea" in mathematics.		US affirmed Jake's "if then" activity.
March 20, 2013 at 11:47pm	Jake: In Geometry, theorems are obviously what most of the teaching centers around, so I was tired of just giving students the theorem and having them memorize (what my CT typically does by PowerPoint), so today I switched things up a little bit. Much like I have been trying with my Algebra 2 classes, I tried to get them to discover the theorem on their own, still in a discussion type setting. In this case, though, I gave them a diagram of what the theorem stated (in this specific case, it had to do with central angles, arc measures and chord lengths). From the diagram, I asked the students to infer as to what the theorem was going to establish. B1 worked like a charm, so much so that a student who is typically	Jake engaged thinking in geometry -give diagram come up with the theorem.	

	lost and frustrated with a crap ton of questions along the way, was excited because he/she "understood something on their own." (he/she was the one that was able to state the theorem to the class in her own words		
March 21, 2013 at 1:06pm	US it's great that you were able to "switch things up" in Geometry , like you have done in Algebra 2, with such positive results - engaging students in thinking and figuring out things as well as connecting with a student (he or she) who is usually confused. I think you are also to be commended taking the leap to present a few things differently (than your CT might have done) with the aim of engaging students more in the lesson. Perhaps your leaps don't always land they way you want but a least you are taking steps toward involving students more in thinking and you are learning about what works and how to make things work better.		US commended Jack for once again, taking a leap to present new material in a way that engaged students in thinking and reasoning. US congratulated Jake for his success in doing so in his advanced geometry classes
April 8, 2013 at 11:16pm	Jake: Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. In the past, what I have done when introducing new theorems is given them the picture and had them give the words of the theorem. Today I switched it up. The definition of the theorem would come on	Jake implemented another strategy to elicit students' thinking when introducing new theorems. He shows students a written statement of theorem and asks students to generate picture or equation that represents the theorem. Furthermore, he	

April 9, 2013 at 6:22am	the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem. Once the two minutes was up and I everyone had made a solid attempt, they turned to their partner and took another two minutes to converse about the right answer and record a final answer on the board (both picture and equation). Once the second two minutes was up, each group would hold up their boards, we would look around at all the submissions, go over the right ones and talk about what happened with the wrong ones. I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed to understand the material. Instead, I was able to focus more on classroom management, controlling and incentivizing positive dialogue. I like the way it went because it forced them to really understand the words of the theorem in order to draw a picture or formulate an equation. It had a nice group aspect to it as well. Definitely going to keep this in the back pocket for years to come. US: I love it , I love it.. I love it. What' I love about what you did in geometry	integrates a think-pair share element where students first, have two minutes to think on their own and then. two minutes to converse with their partner and compile one final answer on a whiteboard. The group responses are the catalysts for a class discussion about the meaning of the theorems.	US was thrilled with Jake's willingness and success in developing and adapting strategies to invoke students thinking when presenting material. She highlighted how the activities that Jake developed provided an opportunity for his students to work on important aspect of mathematical thinking translating pictures to words

today is that you progressed a little further in engaging the students in doing the mathematics- but just tweaking something you have already done . You reversed your picture the words strategy and to words to picture strategy- both of which are important aspects of mathematical thinking

Summary : Implementing strategies to elicit students' thinking is the overarching topic of the conversations above. In the first conversation, the US provides the ST with several specific suggestions about strategies that could be used to elicit students thinking and communication about mathematics. In the next conversations, a ST describes his experiences implementing similar strategies throughout two different lessons. The ST finds that implementing strategies that elicit students thinking, made him feel more like a facilitator throughout the duration of the class: "Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked" & "I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed to understand the material." Furthermore, the US encouraged Jake's efforts by articulating in various ways the overarching goal of strategies- to elicit students thinking. You reversed your picture the words strategy and to words to picture strategy- both of which are important aspects of mathematical thinking & , keep aiming for helping student's to find their voice- to find mathematics inside of them.

Table E 3: ***Content of online mentoring in relation to connecting mathematics to real-life contexts***

Date	Mentoring conversations excerpts	ST experiences	Mentoring responses
January 12, 2013 at 12:06am	Jake: Over the course of my early lesson presentation, I want a significant portion of my focus to try to be real world application. To be honest, I am not sure how much time in each block I will be able to devote to such, but it has been something over the last semester I have felt quite passionate about when running a classroom. With Trig and the Pythagorean Theorem coming up in Geometry, it shouldn't be all too hard. The most difficult part will be finding the time. The curriculum is so crunched, lateral thinking seems to be an afterthought, but if at all able, I would like to bring some of that real world problem solving, even if only a pinch.	Jake wanted to focus on infusing real- world applications into his teaching. He acknowledges that time and curriculum constraints might limit his ability to do so.	
January 12, 2013 at 8:49pm	Bob: … I wish you will share your real world connection through the blog so that we can share your idea. Sam: …What kind of real world applications are you looking to bring into your classroom? I wonder if we could work together to develop some of these concepts for geometry class? Also, I feel how tightly packed the curriculum is and wanted to know how you plan to inject some of your own thoughts and ideas into	Bob*, [another student teacher in the MIC program,] asked the ST to share his ideas about how to integrate real- world applications. Sam*, a MIC student who was student teaching at the same school as Jake, expressed interest in collaborating with ST to develop real-world applications for their geometry classes.	

January 12, 2013 at 9:54pm	what is already laid out? Don't feel like you have to answer all these questions here, we can definitely talk about these at school as well. US: … time constraints and curriculum constraints often hinder the possibilities of doing "lengthy big" real world projects but I think you are right on target to be determined to do something" if only a pinch"(like introducing a topic in a real- world context, doing a few meaningful real- world application problems, using or collecting real-world data or measurements to solve problems...) You will no doubt learn a great deal from trying about what it may take to effectively integrate real -world applications in the future. I will just leave you with on question to think about, " What is the real-world for your students?' What in the real-world do they care about ? Looking forward to reading about how things go next week .		US affirmed that time and curriculum constraints may not support the infusion of extended real- world lessons but encouraged ST to try to develop ways to integrate real- world applications. US also probed ST to reflect on what real- world topics will connect with his students.
January 13, 2013 at 2:28pm	Jake (in response to Sam): The real world applications for the semester I haven't really looked into, but I know the purpose. I want students to continue to ask "why." Whether it is by using examples of things that are relevant to them (music, youtube,	Jake had not yet explored/developed any specific ideas/ lesson plans for integrated real- world applications but had an overall goal of developing real- life applications to simulate students' curiosity.	

January 13, 2013 at 6:21pm	etc,) or even asking them where they would like to see things applied, the moral of idea is to relate the content to their interests. For example, they are doing proportions right now in Geometry which has real world written all over it (Mathalicious). If only I could do something before they get out of that. I have no idea how to inject this stuff into tightly packed curriculum maps. It seems like you have to just do it whenever you are teaching the lesson as an example and hopefully it makes the theorem/concept easier to remember. Jake (in response to US) My aim isn't necessarily to find questions that apply to the world they currently live in, rather spark their interest into the world they are about to be apart of. I aim for students to be thinking about things way higher and more advanced than they are at. Things they want to do with their lives and how simple math principles apply to their aspirations. Maybe how it relates to music, athletics, architecture, or technology design. The youth should be asking questions they have no business solving in the short term, but desire to solve in the long term.	Jake's motive for incorporating real-life applications was not necessarily to connect to his students' world but to extend students interests beyond their current experiences.

February 26, 2013 at 11:58pm	Jake: My lesson in Algebra II today was on the multiplication and division of radicals. The lesson took about 45 minutes, which for me is a short lesson. I like to give them time to work on their homework: 1. because I now I am able to help them on any problems they might have and 2. I know if it goes home without them understanding, they won't work on it. So the lesson ended at the time it was supposed to, problem was it felt like pulling teeth to get there. I don't fault the students for not being interested, I mean multiplying and dividing radicals isn't the most intriguing of subject matter. From there, I was mentally preparing for A3, because if I wanted to be more successful, I knew I had to change something. This time, I started class with an example of where we would use radical simplification in the real world. I showed a video of a skydiver, then talked about how the formula for final velocity uses radical simplification. From there I went into my lesson, but still the interest was not there. I have always been told that you can't please everyone, and today I found this to be quite true. My woes have nothing to do with the	Jake introduced a lesson on multiplication/division/simplification of radicals by showing a video of a recent skydiving event. He presented a velocity formula which included radicals and related using the formula to the skydiving event. Jake was disappointed that his real-world application did not motivate any more interest among students for learning about radicals and noted that after the real- world introduction, teaching the rest of the lesson was like “pulling teeth.” ST lamented that perhaps there is no way to make learning radical multiplication interesting to students.

February 27, 2013 at 2:28pm	students, and as I continue to teach, I don't want to be a teacher that constantly complains about their students, but how interesting can you really make radical multiplication? This has been the hardest part to digest for me. And it is not even that they weren't understanding. It seemed like they understood mildly what was going on, but they looked miserable, and I am not in this occupation to pull student's teeth. US…. Begin to try to do different little things(e.g. show worked examples and ask student to find the rule, think-pair share, use two different strategies to solve a problem, have students present their strategies, show and error and have students 'work in pairs to determine the error, call on students who never talk, insist that stronger student teach weaker students, let students struggle with a problem, ask why, encourage students to ask why, include students who seem to have no voice in the class....) Little things can make learning the mathematics more interesting. The math itself might be dull and irrelevant but learning it can be more interesting. …I have read some interesting things that your	US did not comment on efficacy of real- world application in the lesson but rather focused on pushing Zack to adopt more engaging approaches for presenting the curriculum. The approaches that US suggest focus on aspects of standards-based instruction- eliciting students' mathematical thinking, student collaboration, reasoning, cultivating student discourse

	colleagues have tried to do in their classes to make learning more interesting .Following are some excerpts from two MIC student's blog post's this semester: . I know that you do not have time to read everyone's posts and neither so I am sure that I have missed a lot of good stuff but I hope the excerpts below help to give you an idea about how doing different little things can play out in the classroom.	
March 5, 2013 at 7:30pm	Jake: Today I finally prepared a lesson I was really excited about. It was in advanced geometry and we were "reviewing" linear equations...or at least I thought we were reviewing. What really excited me about the lesson was my real world application activity. I spent a lot of time putting together a sequence of videos, questions and tables to show how we might use linear functions to predict future occurences, in my case the olympic 100 meter race. I had a video of the world record race in 1912, 1936, and 1991 and based on those times, the students in groups were going to predict the current world record time. Their results they were going to record on the board. After each group had written a response on the board, we would watch the	Jake prepared a real- world lesson where students had to use linear functions to make prediction about real events. ST was excited about the opportunity to finally involve his students in a real- world problem solving lesson but never got around to doing the real world activity part of the lesson. The progression of the lesson was derailed when he had to spend more time, than he anticipated, on reviewing the pre-requisite skills necessary for completing the real world application activity. Jake was disheartened and "blindsided" by the outcome of the lesson.

video and celebrate the winner (the closest to the right answer) by having them explain how they did it. Like I said in the last post, this is the stuff I am most passionate about, and finally I was going to be able to do it. It made it easier that the lesson was in general an algebra one review, but much to my , the lesson was not review. I had planned the speed of the lesson, pace and questioning strategies all to the specifics of advanced geometry students reviewing simple algebra concepts, but I quickly found out this was not the case. I was knee deep in the lesson when I found myself spending time on things I did not plan spending so much time on. The students felt lost because of my pace, but I felt lost because of their current algebra knowledge. Because of this curveball, I wasn't able to do my activity and had to spend all of class going over example problems. After firstblock I was really disheartened because I ruined my chance to do a real world problem. If I had only known to go slower I think everything would have gone better but I had no idea this wasnt a review session. I felt blindsided. Not the best way to start the morning. I still have plans to throw in some real world stuff in the

March 6, 2013 at 7:09am	next lesson, but I question the time constraints allowing me to do so. Sometimes you swing and miss, I understand this, but I thought it had a kot of potential, so maybe that is why I am frustrated. Oh well, I guess it is on the next one. US: I applaud you for planning such a fantastic lesson plan for Advanced Geometry that would include an opportunity for students to look at real data, think, make predictions collaborate and then calculate. Sorry that it did not work out the way you had planned but welcome to the truth about real- life application lessons - that fact is that the" cool" real- life application can get bogged down and buried by the student's lack of facility with doing the necessary mathematical manipulations. Your experience with this lesson is not uncommon- but there is no need to throw out your lesson or others like it. This lesson will rise again, you just need adjust it a little and I am sure that you have already thought about some things to		US applauded Jake for planning a comprehensive real- world application lesson. US informed ST that his experience of students' lack of necessary pre-requisite skills for completing a real – world activity was not uncommon. US encouraged Jake to learn from this experience and to not give up on doing real- world application lessons
March 7, 2013 at 10:55pm	do- ways to review the mathematical skills needed at the beginning of the lesson or perhaps at the end of the lesson before or perhaps through a homework assignment... So don't	Jake concurred with US, planned to learn from his experience and to, perhaps, try the lesson again in the future.	

March 7, 2013 at 10:51pm	give up on your application lessons, assume that students that will need to review the prerequisite mathematical skills needed for the lesson. Jake : You are right about knowing now a slower pace/review is needed. I by no means plan to scrap that real world activity because I enjoyed making it too much. It seems like a good thing to have in my back pocket for who knows when. Jake: In Geometry, I had to do a little bit of damage control from last block seeing as my expectations were different from reality when it came to the student's knowledge of linear equations. … lesson was on solving systems and completing the square to find the equation of circles (two unrelated topics). Had I more time, I would have loved to dive into the real world application of solving systems, because there are oh so many, but unfortunately I am finding more and more that there is little room for my passion in this jam packed curriculum. However, one student in the back of the room did ask (almost as if provoked from Heaven) "when will we ever use this	Jake taught a lesson on solving systems of equations. He would have loved to have infused some real- world applications in the lesson but, in light of his previous attempts to conduct real- world application lesson, he did not plan to do so for fear of not completing required curriculum topics for the lesson. Jake was thrilled when a student's question created an opportunity for

	in life?" I jumped at the opportunity to explain Supply and Demand curves and how the intersection represents the Market Clearing Price of any good or service (classic Economics). This is what I wanted to infuse from the start, but knowing how the last block went, I knew I wouldn't have time. I do think that question was Heaven sent because I needed a little taste of students really wanting to apply the material. .	him to discuss a real- world example of solving systems of equation- finding the market clearing price at the intersection of supply and demand curves.
March 19, 2013 at 8:19pm	US: …Hope that you have not given up on “real life applications in geometry because of your initial experience. Perhaps you can try something" real" again keeping in mind what you learned from your first attempt- something that will take less time, anticipating mathematical skills needed and planning to review them beforehand...	
March 19, 2013 at 11:12pm	Jake: What I might start doing, since my review warm ups just seem to turn people off (i.e. factoring), is do a real world problem warm up. Give them a scenario, maybe with a video	Jake generated some ideas about how he might involve his students in some real-world application experiences without taking much time from the required curriculum.

March 20, 2013 at 3:06pm	or a picture, and ask for a written solution of how you might go about solving the problem and an anticipated answer. Make it out of 10 points and add it to the homework grade. If they did it, because of the subjectivity, it would be easy participation points, plus it gets them thinking outside the box. It doesn't have much content relation, though, which is the obvious drawback, but I think it would be fun, and if we are training kids for the real world, I couldn't see a better application. US: Sounds like a good idea about a real world warm-up.	
March 23, 2013 at 12:18am	. Jake: Today was an absolute whirlwind... but before we get to that, I must write about what happened yesterday. As I wrote about a couple days, yesterday I was planning a real world activity from Dan Meyers blog (DY/Dan) that modeled exponential relationships. I had videos to show, questions to ask, problems to solve.. the whole 9, but just like what happened to me last time, it wasn't meant to be. During the lesson, the projector bulb decided to shoot with 20 minutes left in class which was	Jake spent a great deal of time planning a real- world activity for his advanced pre-calculus class but was not able to present the activity because he projector screen blew out just prior to beginning the activity. Jake was doubtful that real-life activity would have been engaging or effective for pre-calculus students. Jake admits that he would have felt very frustrated if the real-world activity, that he had worked so hard to plan, once again, did not work out well. So perhaps, it was “a good

	when I was going to begin the activity. With no spare way to project the computer screen to the class, yet again I had to ditch my efforts. It wouldn't be so frustrating if I hadn't prepared for so long for it. Come to find out, though, it may have not worked that well anyways. I get the feeling from this advanced PreCal class that the students feel very smart, so smart that the dumb activity I prepared wouldn't have been worth their time, and I will give them this, if I had gone through with the activity and fallen flat on my face, I would have been ten times more frustrated than I am now, so maybe it was a good thing. US: Sorry that you had ditch your real world activity in Pre- Calc. Hope that you will have opportunity to try once again before the end of student teaching and of course, you will have several opportunities to try again when you begin a teaching position.	thing" that the projector bulb blew out.	
March 23, 2013 at 9:41am			US expressed her regret that Jake could not present his real world activity and encouraged ST to try again. She reminded Jake that he would have several times to try again during his future teaching career.

The conversations above recount Jake's expectations for and experiences with integrating real- life applications in his lessons. At the outset of student teaching, Jake had great expectations about how real- life applications could enhance and motivate students learning of mathematics. Consequently, he hoped to focus on infusing real- world applications in his teaching yet he acknowledged that time and curriculum constraints might limit his ability to do so. The US encouraged Jake's aspirations probed Jake to articulate his ideas about real- life topics that might connect with his students. In the online conversations above, Jake described several occasions where he carefully planned ways to incorporate real- life connections in his lessons. Jake's first attempt involved- connecting current sky-diving event with velocity equation involving radicals. Jake was disappointed that real-world connection did not seem to motivate his students'

enthusiasm for learning about radicals. In response to Jake's finding that introducing a real world connection did not magically motivate his students to learn new mathematics topics US suggested that Jake focus on implement strategies engage students' thinking when presenting of math topics required in the curriculum. On another occasion, Jake planned an well- conceived real- world lesson but never got a chance to get to real-world activity part of the lesson because it took longer than he had anticipated to review pre-requisite skills need to complete the real-world activity. Jake felt disheartened by his failed attempt to involve students in real- world activity He lamented the loss of class time and was hesitant about planning another real- world lesson for future geometry classes. In response, the US consoled Jake and encouraged him use lessons learned from his experiences to inform his design of future real- world lessons. Jake generated some other ideas for ways to incorporate real- life connections for his students but never had a chance to try them out during student teaching. Jake's most rewarding experience integrating a real- life connection was un-planned. In response to a student's question about real-life uses of systems of equations, Jake jumped on the opportunity to explain the intersection of supply and demand curves at the market clearing price.

---

*Pseudonym for student teacher

US= University Supervisor/Researcher

[a] Online mentoring conversations excerpts in the table are portions of actual blog posts and responses between student teachers and university supervisors. Sections are highlighted to point out the basis for the comments in the interpretation column.

Table E 4: ***Online mentoring conversations related to facilitating active discovery and mathematical investigations,***

Date	Online Mentoring Conversations **Topic:** Facilitating an " independent" discovery activity	ST experiences	Mentoring responses
January 24, 2013 at 7:43pm	Kathy**:** I had the students work on an independent discovery activity. It walks students through graphing different lines and seeing how they look when graphed and asking students what they notice about the slopes. Students were supposed to reach the conclusion that parallel lines have the same slopes and that perpendicular lines have opposite reciprocal slopes. The students who took the time to read it and follow along reached the appropriate conclusions or something close to it, but there were yet again some students who didn't bother to read it or even try. So when it came to the discussion time for the students to talk about what they found out, there wasn't much discussion at all. I had to give the answer so that I was sure the others who didn't participate knew what it was. I have a similar discovery activity planned for graphing absolute value functions next week. I am not so sure if I want the students to do it independently or not now because most of them didn't do it. I might just lead from the front of the class and have the students follow along instead.	Kathy had her students work on an independent discovery activity. Kathy was disappointed in some students' lack of engagement in the discovery activity. Kathy proposed that perhaps she will not try to have students work independently on the next discovery activity.	
January 24, 2013 at 11:00pm	**US:** Bravo, for trying a discovery activity! Discovery is **inductive reasoning**- making a conclusion or conjecture based on observations of patterns. Inductive reasoning is an important aspect of doing		US applauded Kathy's efforts to facilitate a discovery activity.

	mathematics and you mentioned in you were interesting in students learning about reasoning. It's great that the activity worked for those who were willing to read and do it. Now challenge yourself to think about how to get more students involved in a discovery activity: 1) Perhaps more students might be motivated if they are working in groups and given reward for making a discovery (e.g., the first group to make the discovery gets 10 points or pieces of candy, next group gets 8 points/candy, third group gets, 6 points.. and include in the instructions that you should be able to ask anyone in the group to explain the discovery to make sure that everyone in the group is involved . 2) Perhaps you also want trying lead the activity from the front of the class but insist on everyone write down their observations on small slip of paper that you collect and give a reward to everyone writes down a reasonable conclusion , or maybe you could read some of the conclusions out loud and make big deal about the best conclusions. 3) Perhaps the students might be motivated by the way you introduce the activity- perhaps build in some competitive aspect in the discovery activity since the student seem to "feed off of the competitiveness"… These are just ideas and are not set in stone or perfect but perhaps they can help you come with ideas based on what you now about your students.		US highlighted that the instructional value of doing discovery activities is to cultivate inductive reasoning skills. US suggested some strategies for motivating students to work on completing a discovery activity and encouraged the ST to think of additional strategies based on ST's knowledge of her students.
January 25, 2013 at 8:21am	**Kathy:** Those suggestions sound really good, especially since they seemed to like the competition in the teams with the clicker questions! I will try that when I do the next discovery activity with graphing absolute value functions. I think I could	Kathy liked the US' suggestions and articulated ways she could modify her introduction to discovery activities in	

	definitely have sold the activity better. Maybe I'll say something like "So we are going to start something new today and it is kind of tricky, but I know you guys can all figure it out. I'm going to put you in groups so you can work together to figure it out. The first group to figure it out gets candy! Let's Go!" I might also require the group to have someone summarize what they found to the class.	order to motivate students' participation.	
January 25, 2013 at 8:48am	US: Yes! Yes! I like how your ideas about how to introduce a discovery activity. Keep tweaking your pitch (and keep thinking about the details of how you will organize groups rewards, participation). Often in teaching you can motivate students by the way you "sell "an idea with your enthusiasm. Not only are we entertainers, psychologists, counselors, comedians and actors we are also salespersons. Teaching is such an interesting multifaceted profession. It will be interesting to hear about what happens next time you try to do a discovery. No matter what, you will learn something about teaching that will help you in the future.		US complimented Kathy's initial efforts to modify her approach to introducing discovery activities and encouraged ST to continue to think about ways to prompt more student engagement in discovery activities.
	Topic: Facilitating a teacher-directed discovery activity		
February 5, 2013 at 5:33pm	Kathy: I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. Basically, they would graph various transformations of the parent absolute value function and try to generalize what happens when you add or subtract a number inside or outside of the absolute value bars. I told them to make sure that they help their group members	Kathy implemented specific strategies in hopes of prompting more productive student engagement in a discovery lesson. Student engagement did not meet Kathy's	

	and work together because the first two groups with correct conclusions would get candy. I also told them that I would call on one spokesperson from each group at random to explain their findings to the class which would mean that they would all need to know what was going on. Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction and some students were having extreme difficulty progressing through the steps. I kept having to clarify how to do things on the board even though the steps were very explicit- they just weren't reading the steps. I do think that there was more participation and effort than there was for the last discovery activity, but it did not meet the expectations that I had in mind. … Since there wasn't much progress, I chose to stop them where they were and direct their attention to me at the board. ` …. In the future, I am unsure about doing discovery activities. I though for sure that it would go much better this time in groups, but it did not. There is just such a divide between the students who really get it consistently and those who don't-on every new topic.	expectations but she observed more student participation and effort than first attempt to do discovery activity Groups had difficulty making progress working independently, so Kathy decided to direct the discovery activity from of the front class. Kathy expressed doubts about doing discovery activities in the future.	
February 5, 2013 at 9:32pm	US:… congratulations for making some major adjustments to your approach to group discovery activates that probably helped to generate "more participation and effort than there was for the last discovery activity"…So, you are making progress. Remember you are learning to teach and there is a lot to learn from this experience of trying a discovering activity. The major thing that I hear and		US congratulated Kathy for making progress in facilitating discovery activities. US praised Kathy for making major adjustments during the lesson yet still managing to

	have experienced myself is that unfortunately, many student are not use to and not proficient at reading step by step directions especially in relation to mathematics and thus they get really bogged down or lazy when asked to do so. And I am sure that your directions were very explicit. So what do you do- I think that you made a very appropriate adjustment in graphing the functions in the board and asking them to make conclusions. You still got the students to make discoveries (make observations and draw conclusions) without getting slowed down by having to teach them how to read. Perhaps, you could still incorporate a group component by asking group members to discuss their predictions and write them down as a group.- perhaps you could give every group a white board(Are schools still using mini- white boards or perhaps students have an app that lets them write on their IPADS) Also, I think that having the students use the graphing calculator and make predictions and then work individually on worksheets were effective and necessary follow-up activities to reinforce and cement discoveries….I can understand your hesitation about doing discovery activities but I believe that you will learn how to design and tweak discovery activities to make them work for your students. You have already learned a lot from just two attempts at discovery activities!		provide opportunities for students to make discoveries- use inductive thinking. US suggested strategies to prompt more productive group work during the lesson. US highlighted Kathy's inclusion of effective follow-up activities that helped to reinforce the concepts introduced by the discovery activities US affirmed Kathy's potential to learn and develop more strategies to effectively facilitate discovery activities in the future.
February 6, 2013 at 6:39am	Kathy: Thanks for the encouragement… I think that after I read these and thinking it over last night, it wasn't as unsuccessful of a day as I had thought. I do like the suggestion to have them discuss and make predictions as a groups. I think they'd	Kathy felt encouraged by feedback from her US and particularly embraced one of her US' suggestions for improving group	

	definitely be more likely to try when they are just faced with one question at a time. We do still use the mini white boards, but they have a whiteboard app as well which is much easier to pull put at a moments notice. They seem to like both versions, but the mini whiteboards seems to still be more exciting for what ever reason, perhaps because they don't get used as often now. Even though they may not be as independent as what I had in mind, I do still like discovery, and hopefully I can at least engage them in this make predictions, see what happens, and make generalizations type activity.	interaction. Kathy acknowledged that her students may not have been able to work independently on discovery activities but she hoped to still engage her students in the type of thinking/reasoning involved in doing discovery activities.
	Topic- Facilitating a concrete demonstration discovery activity	
March 3, 2013 at 10:15pm	Sam: …The geometry lesson was on the volume of a pyramid and cone. This information builds from our last class session where we talked about volume of prisms and cylinders. The lesson was broken into different components (warmup, hw review, volume review with examples, concrete demonstration, new material with examples, exit slip) and therefore kept the students moving and engaged. I was able to do a really cool demonstration for them that helped us derive the equations for pyramid and cone volume. I took a cone and cylinder of the same base and height and asked them to guess the relationship between the volume of the two figures. Most students guessed that the cone was about half the volume of the cylinder. A few guessed that it was one third the volume. I filled the cone with water and then transferred the	Sam did a demonstration with concrete materials to help his students to discover the relationship between pyramid/cone and prism/cylinder with same base and height by. Sam was pleased with how well the students engaged in the activity and how clearly they understood the relationship between volumes Sam proposed modifying the activity to allow

	water to the cylinder. I did this three times and after each transfer the students were allowed to amend their guesses. Obviously by the third time we discovered that the cone was one third the volume of the cylinder. I performed the same investigation with a square prism and pyramid of the same base and height. Again the students were able to see that the pyramid was also one third the volume of the prism. It was awesome to see the students engage in this activity. They seemed to clearly understand this new relationship and information. I think to extend this investigation I could try to obtain a set of figures for every two students and supply them with something like uncooked rice so that every student could have the opportunity to physically demonstrate this volume relationship independently. This is definitely something I will add to my toolbox and use in the future whenever I teach geometry.	students to work in pairs to manipulate concrete objects themselves in order to discover the relationship between the volumes.	
March 4, 2013 at 9:59pm	US: It's great that your discovery activity for finding the relationship between the volume of cone and cylinder and pyramid and prism with same height and base worked out so well. (The first time I tried the same activity with a class, the water spilt all over and the 1/3 relationship was not very clearly seen because three fillings of the pyramid did not quite fill the prism. It actually worked better when I demonstrated with rice.) It is worth thinking about what made things work out so well and what you could do better so that you can effectively facilitate similar activities in the future. I was not there to observe but I think that asking students to guess the relationship first key element in setting up the		US prompted Sam to reflect on which and how instructional moves helped to facilitate the effective discovery activity. US highlights two instructional moves-asking students to guess the relationship first, and allowing students to amend their guesses-helped to engage students in thinking and motivated students to attend the activity.

	activity. Also allowing students amend their guesses after observation engaged students in thinking and re-thinking. Did students call out their predictions or write down their predictions? I am not sure what follow up questions you asked but I would suggest that you think about what might be effective questions to ask to cement students understanding and debrief the activity. For example, if a cylinder has volume of 24 square inches , what must be the volume of the cone with same height and base?...If pyramid you used in your demonstration has volume of 10 square units, what is the volume of the prism with same base and height... If X represents the volume of the cone and Y represent volume of cylinder with same base and height, write an equation that represents the relationship that we just discovered...)You certainly might want to try one day having students work in pairs to find the relationship independently but you will need to consider how you will set up and introduce the activity and debrief the activity as well as how to handle all the materials.		US suggested other instructional moves that could perhaps enhance the discovery activity–asking follow-up questions to asses and reinforce learning and asking to students to write down their predictions US supported Sam's proposition to allow students to work in pairs to discover the relationship but advised him to carefully consider, how to introduce, debrief and organize the discovery activity when students are responsible for manipulating concrete materials.
March 4, 2013 at 11:21pm	Sam: Thank you for your comments and insights. The suggestions you make are fantastic. I did not have the students record their predictions. This could have provided written evidence for each student as to how accurate they were at each opportunity. Furthermore, the square prism I used in conjunction with the pyramid did have measurement markings on it up to 1000mL. This allowed us to quickly identify that the pyramid filled up approximately 1/3 of the figure when we observed the water coming up to about	Sam appreciated the US' suggestions and elaborated on the potential impact of implementing the suggestions on the efficacy of the lesson. Sam expressed his understanding of the need	

	330mL after one transfer. However, it would be even more effective to have the students extend that experience as you suggested by working toward a generalization of the volume formulas for each figure. This is definitely something I will work to add into this particular lesson or concept in the future. In regard to the logistical challenges of using physical manipulatives, I find that timing and lesson efficiency are the two main concerns when considering hands-on activities. These types of activities can be so rich and effective at cementing understanding in the minds of students while at the same time there can be disasterous results from an activity that does not go as expected. I know it would take a lot of practice and a classroom full of trusted students for me to allow them to work with water and three dimensional figures. However, using something like rice is not at all out of the realm of possibility for this kind of activity. Thank you again for sharing your ideas. I am grateful to have the feedback.	to be careful about planning and facilitating activities where students' are expected to manipulate concrete materials in order to derive concepts

The online conversations above address various issues involved in designing and facilitating effective discovery activities in the mathematics classroom. One important consideration when designing a discovery activity is whether students should be asked to work independently in small groups to manipulate materials and to read and follow directions. Kathy found that students' inability to work independently clearly impeded the progress of her discovery lesson. Both Kathy and Sam experienced positive outcomes when leading a discovery activity for the entire class-i.e. manipulating objects, asking guiding questions, giving step-by-step directions. Another important consideration when facilitating discovery is debriefing activity to making sure students really absorbed what they were supposed to discover. In the conversations above, the US highlights this consideration for both Kathy and Sam. In Kathy's case, the US noted how Kathy's inclusion of follow-up worksheet served to help reinforce students learning. In Sam's case, the US asked Sam to think about, as well as provided examples of, some follow-up questions he could have asked to assess and cement students' understanding of the discovery .Yet another consideration that surfaced in the online mentoring conversations were instructional strategies that help to motivate students' participation in a discovery activity-asking students to make and amend predictions about outcomes, introducing the

discovery activity in an engaging manner, incorporating group competition, and giving rewards for completing the activity.

Table E 5: *Content of online mentoring in relation to promoting student collaboration and mathematical discourse*

Date/Time	Mentoring conversation	ST experiences	Mentoring responses
	Topic- Encouraging a vision of promoting mathematical discourse for all students		
January 11, 2013 at 9:07pm	Kathy*: In second block, I went to visit an advanced geometry class. The teacher is known for being very loud and "crazy." I was very glad that I went to watch the class... Overall, I really enjoyed watching her class. She asked the students lots of questions and let them do most of the thinking and calculating. The students also asked a lot of questions to her, which she didn't always immediately give an answer to. Part of the reason the class was this way was because it is an advanced class, but I still think it can be done with lower level classes as well. I really want to try to involve the students when I am teaching.	Kathy observed an advanced class involved in productive mathematical discourse. Kathy wanted to similarly involve students in mathematical discourse in her own teaching and she believed that the mathematical discourse that she observed in this advance class could also happen in lower level classes.	
January 11, 2013 at 10:00pm	US: ... I impressed that you think that lower level students can also be engaged in classes where there is constructive mathematical discourse and communication like you observed in the advanced class. Try to hold on to that vision of classroom interaction for all students. It will be tempting when confronted with behavior issues and weak academic skills to abandon any attempts to engage students in ways other than lecture and worksheets.		US encouraged Kathy's desire to engage all levels of students in mathematical discourse.
January 13, 2013 at 9:59pm	Kathy: I am surely going to try my best!		

252

	Theme- Encouraging a vision of mathematical discourse for all students		
January 11, 2013 at 9:01pm	Roger: One of the ways that I was able to reach a couple of students in the Algebra I class was to keep them from looking at the graphs that were possible answers, and instead, try and sketch the graph on their own. One of the important questions the students had to consider was what was the information describing of this. An example of this was when the students were given a certain situation and had to describe two different graphs, distance vs. time and speed vs. time. This was one of those times that I noticed the personality of the class actually lead to positive aspects of the students learning, because they took the opportunity to talk with their friends and critique each other while reaching a solution. Also their willingness to ask questions helped guide me toward concepts the students needed to gain a better understanding. One of the things this showed me today were the benefits of classroom discussions. Students were engaged and talking. However, this was contrasted with the reserved nature that much of the advanced classes showed. However, I also realized that the content being covered also influences how effective this approach can be. Some material more easily lends itself to this style, while content like the trig identities require more creativity to utilize this approach.	Roger observed the positive benefits of classroom discussion in algebra 1 classroom. Roger noted that he had not observed such classroom discussions in advanced classes and acknowledged that some material lends itself more easily to classroom discussion.	
January 11, 2013	US: It's great that you witnessed first-hand the efficacy of students communicating about		US applauded Roger's

at 10:22pm	mathematics in a classroom but you also noted that you have not witnessed similar discussions in advanced classes at [your high school]. You might want to think about what teachers can do to cultivate/ motivate/demand mathematical discussions so that it is not just left up to students having the " personality" to talk and critique each other. I have also noted that sometimes because advanced students are so cooperative and there is so much material to " cover" that we neglect to create opportunities for them to communicate/debate their thinking with each other.- On the other hand its interesting to note that Kathy (See conversation above) observed an advanced class today where the students were very engaged discussion- answering and asking questions		observation about the efficacy of students' mathematical discourse and urged Robert to consider what teachers can do to cultivate classroom discourse.
January 11, 2013 at 11:18pm	Roger*: It is a really interesting dynamic to witness because of the time that I have spent in other classrooms. I may be underselling the classroom interactions because I have experienced such hectic environments that watching students actually focus and take note of what a teacher is saying appears to be silence by contrast. I think the advanced classes have to potential to have very productive conversations about mathematical concepts because of their exhibited understanding of math in both general and technical terms. But I also think you hit the nail on the head when you talked about those opportunities being restricted because of the	Roger acknowledged that the volume of material to be covered in math courses could limit the opportunity for classroom discourse.	

	sheer volume of material to cover.		
January 13, 2013 at 2:43pm	US: Do you think that as mathematics teachers we are obligated to provide or push opportunities for students to communicate productively about mathematics concepts or is Ok to just make sure we cover the material? Is learning to communicate about mathematics apart of learning mathematics?		US questioned Roger about his perspective on providing opportunities for mathematical discourse in light of fact that there is a large amount of material to be covered in the curriculum.
January 13, 2013 at 6:52pm	Roger: I absolutely believe it is essential that students learn to communicate in mathematical thought. For one reason communicating reveals a level of understanding on the part of the students. The second reason maybe based on a level of bias, but I think that level of mathematics that we teach in high school is the level that students need to become effective citizens. So in this way I think communicating is important for the students future success. The mission for us as teachers then becomes finding ways for students to participate in mathematics as a conversation	Roger declared his belief that engaging students in mathematical conversations is an essential aspect of teaching and learning mathematics.	
January 13, 2013 at 10:28pm	US: Yeah! So think about how you can create opportunities for mathematical conversations, even if they are brief, and begin experimenting with little (and maybe big) ways to create mathematical discourse when you start to take over classes. Everything you try may not work but you will no doubt learn a lot from trying and that's what student teaching is about- learning to		US challenged Roger to act on his beliefs and thus think about and experiment with ways to create opportunities for mathematical

	teach by trying stuff. Looking forward to hearing about what you try and what you learn :)		discussions in his classroom.

Summary- Encouraging a vision of promoting mathematical discourse for all students
In the conversations above, the student teachers' classroom observations provided glimpses into the positive benefits of mathematical discourse among students and teachers. Both Kathy and Roger, prompted by their observations, expressed their desires to cultivate mathematical discussions in their own teaching. The US encouraged them to maintain and pursue their goals to promote classroom discourse. The conversations above also touched upon the idea that facilitating classroom discussion might entail different strategies depending on the topic and the level of the students.

Date/Time	Mentoring conversation	ST experiences	Mentoring responses
	Topic–Highlighting strategies that stimulate mathematical discourse		
January 15, 2013 at 5:36pm	Kathy: In the other 3 classes, percentages and solving equations were the topic again. This time around percentages played a larger role in the class rather than solving equations. Students were given different scenarios and asked to determine which was the better situation. Of course, students were tempted to say that having a higher number of successes (quarterback pass completions, correct answers on a test, etc.,) regardless of how many attempts were made, was better (Ex. 42/50 would be better than 22/25). After they calculated the percentages and compared, they realized that this wasn't always true. In 4th block in particular, this generated a good discussion about how much data would be needed to rely solely on this percentages etc. This gave me a glimpse of what it could be like to have the lower level students engaged in discussion. I think that having them	Kathy observed that dissonance between students' predictions and calculated outcomes generated a "good discussion" in lower level class and hoped to use a similar "first- predict-then-compare-to-results" strategy to stimulate discussion in her teaching.	

	make predictions and comparing that to results would be helpful in the future.		
January 15, 2013 at 9:08pm	US: You make a keen observation about how ' asking students to make a predictions and then comparing the predictions to the results" is nice strategy for engaging the students and perhaps stimulating a conversation. Starting with students' input generally helps to bring students into a lesson.		US affirmed Kathy's observations about the efficacy of the "first-predict-then-compare-to-results" strategy for generating discussion and generalized that eliciting students' input is a way to bring students into a lesson.
	Topic–Highlighting strategies the facilitate mathematical discourse		
January 15, 2013 at 10:11pm	Sam: Today was a little more broken up as I took an opportunity to observe in two other classes during second and third block. The first class and teacher I observed was Ms. Baker's++ general Algebra I class. Additionally this class is a special education collab class, so I also observed one of the special education teachers during this time. This class was working on solving systems of linear equations in two variables using cancellation. …. Ms. Baker uses a reward system for positive engagement during class. If a student shows strong engagement with the concepts then that student is rewarded with candy from the front of the room. Additionally, Ms. Baker praises	Sam observed an algebra 1 class where the teacher successfully cultivated classroom discourse by praising, complimenting and rewarding students for participating in dialogue.	

	the students at every opportunity. She is very complimentary when a student participates and provides dialogue or feedback. This seems to encourage activity from most of the students. There were still some students that refused to engage with the lesson, but only one or two. I was impressed with the amount of mathematical conversation occurred between the teacher and the students.		
January 16, 2013 at 3:39am	US: In your description of Ms. Baker' class, you indicated that she rewarded (with candy, with praise...)" for positive engagement" with the concepts. I assume that positive engagement here means a lot more than just giving the right answer. You noted that her rewarding of students for giving dialogue and feedback seemed to encourage the students' participation in the lessons. Nice catch on what a teacher can do to promote positive classroom discourse in classroom…..		• US applauded Scott for attending to the how the teacher's responses encouraged productive classroom discourse. In an effort to tease out the specifics of classroom dialogue, the US asked for clarification about type of student feedback that the teacher rewarded.
January 16, 2013 at 10:16pm	Sam: In my description of Ms. Baker classroom I did mean to say she was rewarding for more than just correct answers. She would reward students as they demonstrated complete understanding of the concepts she was instructing. I picked up on this because she did	Sam clarified that the teacher strategically reserved rewards for students who provided more than just right answers that is- students who "demonstrated complete	

	not reward every time a student simply provided a correct solution or feedback. I thought this was interesting because it seemed to encourage the students to "value-add" their comments. What I mean by this is that students were looking for ways to provide width and depth to their responses as a means to receive a reward.	understanding of the concepts" or students who "provided depth and width to their responses".
	Topic–Highlighting strategies that promote mathematical discourse	
January 14, 2013 at 5:30pm	Roger: In the pre-calculus classes, the students continued to simplify trig expressions, attempting to arrive at an expression with a single trig function. This was accomplished by having the students present problems on the board, and then my teacher lead them through various strategies such as multiplying by the conjugate, or creating a common denominator. In algebra II, the students received a key to the review sheet they had been working on for their test tomorrow and then given the opportunity to ask for help on any of the styles of problems they were struggling with. Class concluded with the students being given time to work in groups, or independently, on a sheet that had problems from the test that they would have to be able to solve without the use of a calculator. During this time, I got to walk from group to group and hear how they were going about solving the problems. Finally, in the all-exciting algebra I class, the students continued their unit on data collection and interpretation. This particular lesson was over labeling and drawing graphs that represent a given situation. What I found most fascinating about this concept is that there are multiple	Roger observed that, in various classes throughout the day, what served to generate mathematical discourse was that students had opportunities to solve and discuss problems that had multiple possible approaches to the final solutions. Robert found that his observation provided him with more insight into how to create mathematical discourse.

	correct ways for the graphs to look; all the students must do is be able to explain why their representation is correct. This is a definite in road to creating mathematical discourse, which has been one of the things I have been focusing on. One of the themes that I took away from today was the idea of multiple approaches that arrive at the same answer. We often times talk about how various methods can be used to solve the same problem, but what felt unique in these instances was that even within the same method, different approaches could still be found. I think this was highlighted in the simplifying of trig expressions. As I began to mention above, these opportunities provided the chance for mathematical conversation in the classroom. Because students followed different paths to arrive at their answer, many times this led to the student having to explain their reasoning. With in this conversation, again with the pre-calculus class in mind, this dialogue led to a discussion about which path was most efficient, or which path was most obvious. It is funny because the focus on many of the comments following my first blogs was trying to find opportunities to encourage student discussion about mathematics, then in my first day back I see opportunities in all five classes. Whether it is just because of the material we are covering, or because I was looking for it, but I definitely will be paying closer attention for opportunities such as these.	
January 14, 2013	US: Well, sounds like it was great day for mathematical discourse. Cool observations and a	US applauded Roger for his

at 9:44pm	foreshadowing of great possibilities for the future. Continue to think about the teacher's role in facilitating classroom discourse. It is true that some topics lend themselves better to classroom discussion and it is true that some students are just better and more willing to communicate/collaborate about mathematics but the way a teacher structures the classroom activities and facilitates /demands/expects/affirms conversation is the real key to creating mathematical discourse in classroom.		attention to strategies that promote mathematical discussions and reiterated that the teacher plays major role in structuring classroom to promote mathematical discourse.
January 16, 2013 at 4:20pm	Roger: The structure is what I really want to focus on as I assume control of the classroom. I think that the structure of instruction is where students see the expectations of a teacher. In that way, I also think it is important for the teacher to lay out their expectation of student involvement. What I plan to do each time I take over a class is to talk to the class about how I try and create an environment of conversation. With that, I want them to know that even if they are not sure their strategy or approach is correct, I still want to hear it because that may be the link someone else needs to discover the correct path or answer.	Roger expressed his plans to structure his classroom in ways that facilitate student involvement in discussion.	
Summary–Highlighting strategies that promote mathematical discourse			
In the conversations above, the student teachers' identification of specific teaching strategies that seemed to generate classroom discussion is the springboard for mentoring conversations focused on the teacher's role in facilitating classroom discussion. The US' mentoring responses served to further underscore and specify the strategies noted by the student teachers and to reiterate that the way a teacher structures an activity or facilitates a lesson is critical for generating classroom discourse.			
Date/Time	Mentoring conversation	ST experiences	Mentoring responses

	Topic–Responding to student teachers' efforts to create mathematic discourse	
January 16, 2013 at 4:12pm	Roger: And now for the most interesting part of my day, my first full lesson. The lesson for algebra II covered how to multiply and divide rational expressions. Because I taught the second of the two classes, I was able to watch what and how Mr. Crawford + did and see which methods or examples worked well for the class. Actually, because of watching his lesson, I did actually change one of the examples the class went over because I felt the example he used better exhibited the concepts we were trying to convey than the problem I had put together. One of the biggest challenges I will face, and already have, with this particular class is how meek they seem to be. I am a big proponent of having notes and examples, but the way my notes work is to highlight ideas and concepts that the students already know, like in this case multiplying fractions and factoring polynomials, and let their discussion make the connection. Today this did occur, but it was like pulling teeth to get them to openly share. One of the ways that I was able to keep the discussion moving forward was to randomly call on one of the students to have them tell me their next step, or explain what the situation looked like. Knowing every students name was vital in making sure that could work. My planning period is 4th block, which happens to immediately following this class. Because of that, I was able to talk with my teacher and instantly reflect on how the lesson	Roger described how difficult it was to get students to share openly during his first full lesson of teaching. To try to engage students in discourse, he called on students randomly to tell the next step or explain. His cooperating teacher noted that one of the strong points of his lesson was the dialogue that he tried to create with the class.

	went. … One of the things that Mr. Crawford highlighted as a strong point was the dialogue that I tried to create with the class. He said it is something that he has slipped away from, but he felt that as the class got accustomed to me that they would open up and become more confident in their having class discussions. All in all though I felt today was a efficient and productive first day of teaching.	
January 17, 2013 at 1:23am	Mona:** Congrats on your first lesson! It sounds like it probably didn't go that bad. I'm glad to hear that Mr. Cromwell gave you some good feedback. Calling randomly on students is a great plan for getting students to talk. Did you just pick names off the roster? You can always do something like drawing names out of a bucket (or popsicle sticks). I know it's a little cliche, but it actually works. I still use that method in my college classes and no one ever complains about it. You can also consider doing "think-pair-share" discussions where they are first required to reinforce the topic with a neighbor, which may actually take away some of the fear that they may say a wrong answer to the class.	Two different university supervisors responded to Robert's post. They applauded his efforts to engage students in discourse and affirmed his strategy of calling on students randomly.
January 17, 2013 at 2:43pm	US: Congratulations on your first lesson. It's great that you were able to create a little dialogue especially if your CT has not been doing so.I agree with Mona about considering doing some" Think-pair-share" I use "TPS" a lot in my college classes and find that it always helps students to feel more comfortable with their classmates and with speaking up in class.Also since you have embraced the challenge /goal of creating classroom discourse in order to prompt students	They also suggested other strategies to foster mathematical discourse. One of suggested strategies was think-pair-share and the other strategies entailed

	to listen to their classmates and feed off of each other, you could ask questions like," Who agrees with Zack's explanation? Why do you agree or disagree? or " What more could you add to Kathy's explanation or diagrams or solution? or Who can repeat Scott's explanation but use more math vocabulary. These are just suggestions. I am sure that you could think of others.		asking questions that require students to comment on and extend contributions from their classmates.
	Topic–Responding to student teachers' efforts to promote mathematical discourse		
January 29, 2013 at 11:21pm	Roger: In pre-calculus, we continued to work on solving trig equations but added a new wrinkle into this by working with the sin, cos, or tan of a sum or difference of angles. This originally befuddled the students because all that they saw was a big list of more identities they would have to memorize. Again though, I reverted back to starting them off with knowledge that they already had. We worked with the reference angles and had the students look over their formula sheet to match a formula to their situation. While they know that they will be responsible for memorizing these formulas, I talked with them about one of the best ways of learning them was by working with them often. At one point, I had the students come up with 4 different ways to express the angle they were wanting to find by adding or subtracting their reference angles. I then picked a 5^{th} way. I had each row in the classroom solve a different "equivalent" problem so they could see that as long as they use the correct formula they will	Roger described how students arriving at three different answers to a problem stimulated a nice discussion about the mathematics content	

	arrive at the correct solution. However, between the four methods I ended up with 3 different answers, all of which were different by a sign. This actually created a very nice discussion about keeping the quadrant in which each of the angles occurred. We then worked the problem as I had laid it out and decided which of their responses were correct and see where the others went wrong. The conversation that this style of class created is exactly how I hope to structure most of my classes.	
January 30, 2013 at 4:35am	US: Interesting observations and experiences today about classroom strategies that stimulated students' mathematical thinking and discourse… another nice discussion-stimulating strategy that occurred, perhaps not intentionally, in your pre-calculus class allowing students to arrive at a slightly wrong answers(in this case wrong sign). I am not sure if you planned or anticipated their errors but sometimes in teaching, you want students to make certain errors or as I call it" fall into a hole" so that you can take advantage of teachable moment. This strategy of "creating a stumble" is another strategy to add to your ever-increasing " bag of tricks" for stimulating mathematical thinking and discussion.	US asserted that Roger's observation that examining students' errors generated mathematical discussion pointed to another strategy that teachers can use to stimulate mathematical discourse. She explained that teacher can create "similar teachable moments by intentionally presenting activities/problems situations where students are likely

			to make errors.
January 30, 2013 at 8:36pm	Robert: I will be completely honest, the discussion that came about in my pre-calculus class was completely unplanned. I really thought my strategy would be a good way for the students to discover the desired concept on their own. However, I am ready to admit that I hope that this kind of mistake does happen, because it gave me a wonderful bridge into a very important element in that chapter. However, this is not a mistake that I can guarantee will happen each time. But if it doesn't, I think that path will still be effective.	.	
	Topic–responding to student teachers' efforts to generate mathematical discourse		
February 4, 2013 at 10:46pm	Roger: Pre-calculus has hit a point that I really enjoy. The unit over trig identities and formulas can be really fun an interesting … What I liked best about the half angles, and had the students work through under some supervision, is that we can use the double angle formula to derive the half angle. On our second example, we were again presented with a problem that used a formula that had two equivalencies. So again, I split the class and had each half solve it a different way. This time both sides came to the same answer, but one side had a much easier path. This opened the discussion to being cautious about which formula too choose, even though sometimes you can't tell until you have started. I am really starting to enjoy this sixth period class because they are buying into the style of discussing their ideas and solution paths	Roger designed lesson activities in pre-calculus that included an opportunity for students to discuss various solution paths.	

February 5, 2013 at 12:56pm	rather than have the example problems solved for them. I have always felt that students achieve strong learning by looking at and making mistakes. But what I have to be careful of while using this strategy is making sure that I am aware of my time management. US: …, You are on roll with this **Split** the class - **Solve** it two different ways- **Share** solution paths (SSS) strategy in pre- calculus. The great thing I heard you say is that "**this class is buying into the style of discussion their ideas and solution paths"** which brings me to something we discussed earlier about how the <u>teacher does things</u> to create environment where students discuss mathematics. So, mathematical discourse doesn't just happen by luck or by having " good talkative students" but rather is cultivated by the way the teacher sets up activities and leads the classroom discussion. Now, I have to ask questions: Are all the students participating in the discussion? Are the students doing most of the talking and summarizing during the discussion. You have done so much to facilitate classroom discourse so far. What more do you want to see in your students in this regard. There is always room for improvement and do you think the same level of discussion that you see in your pre-calculus students is also possible with your Algebra 1 students? Looking forward to your response		US affirms and summarizes Roger's effective strategy for generating classroom discourse and reminds Roger that mathematical discourse is cultivated by the way teacher sets up activities and facilitates dialogue. She asked questions to prompt Robert to reflect on how he could further improve the quality of classroom discourse.
February 7, 2013 at 11:55pm	Roger: As far as the students answering questions goes, if a student raises their hand I will typically	Roger responds to the US questions about the distribution of participation in discussion in his lessons. He acknowledges that allowing students to do more of the talking often takes up more time in his lesson than planned	

February 8, 2013 at 9:14am	try and call on them to answer. However, if one or two students appear to be dominating the conversation I have gone to the random selection (sometimes I just choose someone out of a row, other times I use a random name selector I created in excel). With how the students are participating in class, I like to think that the meat really is coming from the students and I am just providing the skeleton by asking leading questions. I am trying walk that line between telling the students mathematics and letting them do mathematics, but as I have noted a couple of times, the extra time that comes from students providing this substances causes parts of the lesson to go longer than planned. I am hoping that with my experiences, I am working toward not only structuring the time more effectively, but sticking to that structure much much better. US: Yes I understand about the <u>time</u> issue when you allow or try to get students to provide the meat. Time is something that you will learn to manage more effectively with experience and it often boils down to strategically choosing when and what math to tell and when and what math to let students do and still feel like you have done justice to teaching mathematics with meaning. I am curious to hear how your efforts to work on mathematical discussions and discourse will work out when you take over Algebra 1.	US assured Roger that he will learn with experience how to manage and time and still provide opportunities for classroom discourse. She also asked Roger to share how his efforts to promote mathematical discourse play out when he starts teaching Algebra 1 classes.

Summary - Responding to student teachers' efforts to create mathematic discourse
In the conversations above, the US responded to Robert's efforts to generate classroom discourse during his lessons. The US encouraged his efforts, affirmed his strategies and suggested additional strategies. The US pushed Robert to

reflect on how to improve discourse to include even more student participation. The US also prodded Robert to begin to think about how to integrate opportunities for classroom discourses in classes other than pre- calculus.			
Date/Time	Mentoring conversation	ST experiences	Mentoring responses
	Theme- Probing student teachers to attend to student collaboration		
January 12, 2013 at 12:14am J January 12, 2013 at 11:42am	Sam: After the initial lesson on the Pythagorean Theorem, my supervising teacher and I decided the student could use an additional day of work with this information before moving to the next concept. To accomplish this we designed a station activity for use with each class. This activity was made up of nine different stations where students would have between four and five minutes to cooperatively work through two problems applying the Pythagorean Theorem. After a warm-up and review of homework problems we divided students into groups of three or four and set them into moving through the classroom from station to station completing the activity. Throughout the activity my supervising teacher and I walked around and worked with individual groups. … US: …tell me something about how " well" the geometry students worked together in groups. In our interview, you spoke about the importance of student collaboration. Does the group work you have witnessed so far in the geometry classes live up to your vision about student collaborations? Is there something about student collaboration in the geometry class that could be better? Do they stay focused on mathematics? do they express their thinking, ask each other questions, do they	Sam described a station activity where students worked in groups of four and five to complete problems involving the Pythagorean Theorem. During the class, Sam walked around to work with individual groups. In response to the US' questions, Sam described the group interactions in more	US asked Sam several probing questions to prompt Sam to reflect on aspects of group interaction he observed during the station activity. In addition, US asked Sam if there were any pre-established guidelines for

	work independently or interdependently? Have they been given guidelines for group work behavior? Ok enough questions. Looking forward to your response and hearing more about what happens next week. Sam: With regard to your other questions, I do see student collaboration as an important part of an effective mathematics classroom. I believe students can be a powerful influence (both positive and negative) in the classroom and that collaborative work creates opportunities for accelerated intellectual growth. The group work I observed this past week had its strong and weak aspects. First, I noticed that some student groups did not work as intended. These groups usually had a single student completing the bulk of the work while the other group members simply tagged along for the ride. When the "leader" would finish a problem the rest of the group would copy the information down with little explanation. This was frustrating to observe and in a couple of cases I encouraged these groups to work more as a team. Further, I observed some groups simply behave as an opportunity to socialize. However, there were also many groups that worked beautifully together. In these groups the members fed off of one another. I observed many students explaining reasoning and concepts to other students, leading to deeper understanding. In all three of these examples I find that group work only partly meets the ideal I brought into the classroom.	detail and noted that while there were some groups that collaborated well, other groups did not.	group work behavior.
January 12, 2013 at 9:47pm			
January 15, 2013	One thing I really like about how my ST uses		US challenged Sam to think about what strategies he

at 9:08pm	groups is the group assignment method. My teacher writes a number for each student on the board (i.e. 1-30) then randomly collects three or four numbers together in a group. The students do not always like this because it may place them in a group not to their liking. However, it appears to reduce the amount of socializing that occurs during group exercises. I will definitely utilize this approach for assigning groups. US: Thanks for such a complete response to my questions about group work and student collaborations. Your observations reflect the variety of things that can happen when students are asked to work in groups. You noted that watching some groups was frustrating and that you "encouraged these groups to work more as a team." Think about what other strategies you could use to promote the type of group interaction that you would like to see. Students don't naturally know how to work in groups, sometime it happens but most often students have to be " taught " how to work in groups which mean explaining, modeling and providing specifics about effective/expected group behavior. Also students often do what they are rewarded for. How do we reward and affirm "good" group behavior? or do we just reward getting to right answer. Fortunately, in [your CT's] classes you will probably have many opportunities to **faciliate** students work in groups as you walk around and co- teach so you can begin to experiment with what to say and do the promote more effective group work. I am curious	could use to promote more productive group interactions. She encourages Sam to try some strategies and share what he learns from doing so.

	to hear about what you try to do and what you learn by trying. That's what student teaching is all about: trying stuff and learning stuff :)		
	Theme-Probing student teachers to attend to student collaboration and providing strategies for promoting student collaboration		
March 7, 2013 at 10:51pm	Jake: In Algebra II, we learned about multiplication and division of higher ordered radicals, multiplying by conjugates, and multiplying and dividing fractional exponents all in the same block. … I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner.	Jake described a class activity where students were given the option to share their answers with a partner.	
March 7, 2013 at 11:16pm	US: How did the students do with the share with a partner part of this lesson. Did most of of the students share with a partner?		US probed Jake to describe the student collaboration that occurred during the partner sharing part of the lesson.
March 10, 2013 at 10:52pm	Jake: The partner sharing portion whenever I choose to institute has not worked well. Very few share with their table partners, maybe because they are not comfortable with who they are sitting beside. Oftentimes, I get asked questions when I tell them to check with their partner. That is not to say it is all bad, and during this time I don't answer their questions. There are students who do collaborate with each other, but it seems as a whole they are content doing things solo. I don't really know what to do in order to help aid	Jake reported that the partner sharing activities have not worked well in his lessons. He noted that his students, in general, choose to work alone. Jake speculated that his students are just not	

	this process.	comfortable in working with their table partners. Jake admitted that he did not know what to do to remedy the partner sharing situation.	US provided some detailed suggestions about how Jake could foster more student collaboration. US challenged Jake to work on facilitating more student collaboration in his classes.
March 11, 2013 at 9:35am	US: Now about the working with partner issues: I actually expected that there might be a few hitches with your classes and again your experience is not uncommon in classes where students have not been used to/ pushed /taught to work together with a partner from the beginning of the school year. It is usually not enough to simply tell/ ask students to work with a partner- they have to be **taught** how to work together and it is best if the teaching begins during the first few weeks of school - so you can think about that when you begin your first teaching job. **But** there is something you could do now to promote better student collaboration. You will need to 1) be more specific about the collaborate behavior that you expect and 2) you have to reward positive and productive collaborative behavior. So for instance, when you ask students to work together, you might have to tell them exactly who they should talk with e.g. " Larry and Omar, you two should work together" then you have to tell them the exactly what they should do e.g. “Larry you explain, not just show, your answer, to the problem first and then Omar should tell Larry what you think about his explanation. Then, Omar should explain his answer and then Larry should tell what he thinks about Omar's explanation. You could also say " I will not answer any questions until both you have discussed your answers- or I will not answer any questions, you must talk to your partner. I will be coming around and checking on how well you are		

March 13, 2013 at 10:06pm	talking and explaining to each other." In addition to articulating the specific behavior that you want, you need to highlight and praise good collaborative behavior just like we reward and highlight good mathematical work and thinking.. e.g. "Larry and Omar you are doing a good job of working together, I like the way you explained your solution to Omar..." also if students' are working well together, you have to prompt and push them " Omar You've got the right answer on your paper, could you explain what you did to Larry... if you explain something to someone else, you learn it better. or" it seems like both of you have no idea what to do so both of you look over you notes and see if you can find something to help you in your notes, tell each other if you find something... and i will come back and check with you. My major point is that students do not naturllay know how to work to together, you have teach them about what working together sounds like, looks like and you have to reward them when they do it and you might have to motivate them to do so. Once they know what you expect and have done it sucessfully , they will do it more naturally. Challenge yourself to see what progress, you can make in helping your students to work together. There is alot that you can do it does not have to be left to chance. So try to think about what you can do and try it and see what happens. We are always learning to teach. Jake: I completely agree with what you have written. I collected from my failed attempts that	Jake concurred with US' suggestions about facilitating group work and agreed to try some of the suggestions to see what happens.

	it was not a natural tendency for students to be able to collaborate effectively. In fact, while I was at Beaumont for two weeks during the fall, the CT I was with talked about how they had to train their students to work in groups like what is a good group looks like and what a bad group looks like. By the time I was there, I was really impressed by what some of those middle schoolers had to offer. A lot of their class was centered around group work and self investigation which I really liked for the age group. I see what you are saying. Lay it all out there for them, so they know exactly what is expected of them. Students are good at doing what is expected... well most of the time... I will try this and see if it helps improve the classroom dynamic at all. Thanks for the advice.		

Date/Time	Mentoring conversation	ST experiences	Mentoring responses
	Topic–Providing suggestions for promoting student collaboration.		
February 5, 2013 at 5:33pm	Kathy: I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. …. I told them to make sure that they help their group members and work together because the first two groups with correct conclusions would get candy. I also told them that I would call on one spokesperson from each group at random to explain their findings to	Kathy attempted a second a discovery activity and incorporates some of the suggestion from the US: She offers an incentives for groups to complete task and work together but she observed that there was" little group interaction" during the activity.	

	the class which would mean that they would all need to know what was going on. Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction.		The US offered a suggestion about how to promote more group interaction.
February 5, 2013 at 9:32pm	US: Perhaps, you could still incorporate a group component by asking group members to discuss their predictions and write them down as a group.- perhaps you could give every group a white board(Are schools still using mini- white boards or perhaps students have an app that lets them write on their IPADS).		
	Topic–Detailing guidelines for promoting student collaboration.		
February 7, 2013 at 8:58pm	Kathy: In first block, I tried out some stations. Although I have helped with stations in other classes, this was my first time creating and planning the stations on my own. We needed to cover several small statistics topics before the final, so I decided to make it into stations since students could pick up each concept fairly quickly. There were 5 groups: 1.mean, median, and mode, 2. box and whisker plots, 3. correlations, 4. graphing linear equations, and 5. iLearn quizzes. …! Each station had enough slips of paper for each student to read over the basics of the concept. The students each had a front and back notes sheet where they were required to fill in the blanks and work the corresponding problems for that station. They took that paper	Kathy designed a station activity that includes individual worksheets to ensure individual student accountability and to keep students more focused on station tasks. Kathy does not mention any components of the station activity to ensure group interactions. Kathy notes that the students, although disgruntled about doing so, seem to be getting more used to working in groups but does not provide any specific observations about group interactions. She once again hypothesizes that strategically	

February 12, 2013 at 1:54pm	with them to each station and turned it in at the end of class. I think it was a really good way for me to keep them accountable for their work because I have seen stations in our class in the past fail. I think that paper really helped them focus a lot, and because I took it up, it allowed me to see how they were doing…. Although, I don't think I'm a pro at stations just yet, I was pleased with how this turned out. …. In the future, I might think more about strategically picking groups rather than picking randomly. And even though they do complain, it seems like they are getting more used to working in groups. US: Yeah! … I am glad that stations went well- …. Nice ideas to include a worksheet and review station. It's right on target to now be thinking about the next level- how to make group work more productive. You mentioned one thing - strategically picking group members. Another thing to consider how you can establish and communicative expectations and guidelines about how you want groups to work together- this could being more specific than just saying you have to work together and help each other- for example " first work on problem individually, then compare and explain your answers, do not move on until everyone in the group understands" or person A works and explains the problem, Person B asks questions about the solutions, Person C records the solution. Facilitating productive group behavior also includes affirming and praising students when you see good group behavior, or prompting students to ask someone	placing students in groups might improve group work	US praised Kathy for making progress with student participation in the station activity but focused her comments on what more Kathy could do, beyond strategically picking group members, to promote promoting more productive group interactions. US suggested that Kathy provide specific guidelines and expectations about group interactions.

	in their group before asking you.... Students have to be taught how to work in groups like that have to be taught how to do algebra and geometry.			
Summary–Probing student teachers to attend to student collaboration and detailing suggestions				
In the conversations above, the US probed and prompted the student teachers to focus on student collaboration. The US asked the students to teacher to reflect on describe the quality of student collaboration. Although each student teacher was generally satisfied with their overall lesson, the US challenged them to think about and implement strategies to improve the student collaborations. In both cases the US emphasized that teacher's role in teaching students' how to work in groups.				• In response to the US' questions, Sam describes the group interactions in more detail and notes that while there were some groups that collaborated well, other groups did not.
Date/Time	Mentoring conversation	ST experiences	Mentoring responses	
	Topic–Responding to student teachers' efforts to intentionally promote student collaboration			
February 21, 2013 at 6:30pm	Kathy: In advanced, we continued to work on solving systems of linear equations by graphing, substitution, and elimination. … I mainly want them to understand what a system is and that the solution is where the lines cross. If students can use any of the methods to find a solution, that	Kathy planned to have students in her advanced algebra class work in group on solving system of equations. Kathy explained that students would be asked to discuss in their		

	works for me. I don't think questions on tests that specifically ask to use a certain method are necessary. Students should be able to choose the method that they feel most comfortable with. Tomorrow we are going to be doing activities that encourages students to do just that. They will be placed in groups and given different systems. They will need to discuss which method they want to use and why and then use it to solve.	groups which method, graphing, substitution or eliminations, they want to use and why.	
February 22, 2013 at 12:32pm	US: Cool. seems like things are moving along well with teaching systems of equations. Curious to hear about how the group work goes or is going on now as I write this posts. I wonder what kind of conversations the student are having about which method to use to solve the systems. I will check your posts later to find out.		To highlight the importance of attending to details of student to student discourse, the US expressed her interest in hearing about the student conversations that emerge during the group work on solving systems of equations.
February 22, 2013 at 4:56pm	Kathy I had them choose their groups, since they are such a small well-behaved class, for the choosing the method activity. I told them to focus more on talking about what method they would prefer and why rather than actually solving it although I wanted them to do that too if they had time. I heard many good conversations	Kathy reported that she directed groups to focus more on what method and why rather than solving the system and consequently heard many good conversations.	
February	US: ... It's really great that you gave the group		US praised Kathy

22, 2013 at 9:07pm	some direction about what you wanted them to focus on in their talking in the groups- what method and why more so than just finding the answer - this is right in line with your goals to help student work on reasoning and communicating about mathematics Also, stating your expectations for group interaction is a key component in facilitating effective group work.		for providing guidelines for group discussions links her actions with NCTM process standards
	Theme-Responding to student teachers' efforts to promote student collaboration		
March 5, 2013 at 5:14pm	Kathy: We played a game that I made up, which I turned out to really like. I had the class divided into groups of three. Each student had their own whiteboard on which they had to work out the problem I wrote on the board. Then, they had to compare answers with their group and reach a consensus on the right answer and/or help each other figure it out. They could then show me their answer. If it was right, they got a point. If it was wrong, they got one more try to figure it out. It didn't matter which group responded fastest, it just mattered that they got the question right. All groups could earn a point on the same question if they all got it right. The kids were really into it the whole time and I was having fun too. I saw a lot of good discussions going on within the groups. I like playing games, but sometimes I feel like they only emphasize getting the correct answer on the first try and at being the quickest. I like this game because it	Kathy incorporated many elements in a game that facilitate student collaboration and mathematical discourse: 1)explicit directions: think first, compare and come to consensus and or help each other, then show the teacher and 2) rewards for all groups for collaborating to eventually arriving at correct solutions.	
March 6, 2013 at	that they have to cooperate with their group		US praised Kathy for promoting

7:25am	before answering. I definitely want to do this again, especially when reviewing. US: I love everything you mentioned about your game: individual work first, requirement to check and collaborate with group, emphasis not on getting the answer the fastest, lots of good group discussions.... Its great that the students so willingly helped each other figure things out. You might want to think about how you might have to adjust the game for students who do not so willing help each other. Pehaps give an extra point if anyone that you call on in the group can explain the problem. also, of course praise groups that are doing a good job of helping each other.		student collaboration and challenges Kathy to consider ways to motivate similar group collaborations with students who might be less cooperative. US also encouraged Kathy to try similar collaborative game with her general classes.
	Theme-Responding to student teachers' efforts to promote student collaboration		
March 11, 2013 at 10:42pm	Jake: In Algebra 2 we had a review day for our test on Wednesday (and Thursday for A1 and A3). I think I finally figured out a way to involve everyone while not allowing one group to dominate in a review game setting. It is nowhere near perfect, but with tweaks, it might get there (scratch that, nothing will be perfect, but I can dream right?) The class was split into groups of two, chosen by the students so they would be comfortable enough with each other to work together. I created a PowerPoint of review questions, and as the question showed on the screen, the time was started and each group went to work to find the answer. Once the answer was found, the board was flipped over so nobody could see until the time ran out. Once time ran	Jake implemented some intentional strategies to facilitate student collaboration during a review game in his Algebra 2 classes. To promote more student participations, he limited group size to groups of two and he allows students to pick partners with whom they can work comfortably. In contrast to past review games, where only the team who get the correct answer first earns points, he awarded points to every group that arrives at the correct answer. Also having	

March 12, 2013 at 12:15am	out, I would motion for the boards to be raised, those groups with the right answer got a point, those who were wrong didn't. I like this for many reasons: 1. the groups are small so more people are working at one time, 2. it doesn't allow one team from keeping the other teams to succeed, 3. I get a better read of the class as a whole rather than the typical review game that just assesses the fastest students. The one drawback is the inability to make corrections for points, but I will take that for now US: Great !. I also like the game. What an improvement in getting more class participation during a review game - yes, small groups of 2 seems to be a key component here and so nice that you moved away from rewarding the fastest answer, and that you were able to get better read of the class as a whole. Curious to hear how it goes tomorrow.	groups display their answers on white board provides a way for Jake to assess student understanding.	US congratulated Jake for increasing class participation and student collaboration during a review game and highlights that his decision to create small groups of two may have been a key component of his success.
	Theme- Responding to student teachers' efforts to promote student collaboration		
April 8, 2013 at 11:16pm	Jake: Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. In the past, what I have done when introducing new theorems is given them the picture and had them give the words of the theorem. Today I switched it up. The definition of the theorem would come on the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem. Once	Jake integrated a think-pair-share element into his geometry lesson. Students first, had two minutes to think on their own and then, two minutes to converse with their partner and compile one final answer on a whiteboard. The group responses were the catalysts for a class discussion	

April 9, 2013 at 6:22am	the two minutes was up and I everyone had made a solid attempt, they turned to their partner and took another two minutes to converse about the right answer and record a final answer on the board (both picture and equation). Once the second two minutes was up, each group would hold up their boards, we would look around at all the submissions, go over the right ones and talk about what happened with the wrong ones. I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed to understand the material. Instead, I was able to focus more on classroom management, controlling and incentivizing positive dialogue. I like the way it went because it forced them to really understand the words of the theorem in order to draw a picture or formulate an equation. It had a nice group aspect to it as well. Definitely going to keep this in the back pocket for years to come. US: I love it , I love it.. I love it. What' I love about what you did in geometry today is that you progressed a little further in engaging the students in doing the mathematics- but just tweaking something you have already done . You reversed your picture the words strategy and to words to picture strategy- both of which are important aspects of mathematical thinking Also I am really pleased with the group aspect that you introduced today- again its like you took something you have don already with the white boards in review games and took it step further .	about the meaning of the theorems.	US was thrilled with Jake's progress in implementing strategies to invoke students thinking when presenting material. Furthermore, she is also pleased with Jake's progress in facilitating student collaboration in small groups.

	I love the think- pair share element in this learning approach.
Summary–Responding to student teachers' efforts to promote student collaboration	
In the conversations above, student teachers described positive outcomes from implementing specific strategies to promote student collaboration. Many of the strategies reflected suggestions provided by US in previous conversations. The US praised the student teachers efforts to promote student collaboration. The US underscored the specific strategies implemented by the student teachers in effort to, once again, highlight the teacher's key role in planning and enacting strategies that promote student collaboration.	

*Pseudonym for student teacher
+ Pseudonym for cooperating teacher
++ Pseudonym for teacher
** Pseudonym for university supervisor – not researcher
US= University Supervisor/Researcher
[a] Online mentoring conversations excerpts in the table are portions of actual blog posts and responses between student teachers and university supervisors. Sections are highlighted to point out the basis for the comments in the interpretation column.

Table E 6: *Content of online mentoring in relation to using and connecting a variety of representations*

Date/Time	Mentoring Conversations	ST Experiences	Mentoring responses
	Theme-Representing mathematical concepts with "everyday-life" scenarios.		
January 30, 2013 at 10:00pm	Kathy*: Today, we moved on to trying to determine if a relation is a function or not. We had formally defined a function yesterday, although I didn't expect them to fully grasp the concept yet. We repeated this definition today. Then we watched a video which my teacher made several years ago and always uses to teach functions. I got to see her use it two weeks ago in the other class and I really liked it. Basically there is a "function dance" and there are three rules that you must follow. The first rule is that no one can go alone. The second rule is that good kids (x's) can't go with other good kids (x's) and playas (y's) can't go with other playas (y's). Lastly, good kids can only take one playa, but the playas can take as many good kids as they want. Although it seems quite silly, the kids really understand it like this (and it is completely mathematically sound also). And of course they loved to laugh or blush about who was hypothetically going to the "dance" with who. Kids that she had years ago that come by to say hi even remember the rules. After we established the rules, I divided the class into good kids (x's) on the left and playas (y's) on the right. We went through several different scenarios with the students in the class and tried to determine if it would be okay or would violate the rules. After that, we transitioned into putting the names into a mapping. Then we went to using initials, and finally to using favorite numbers to represent the people. This transitioning was modeled to me by my teacher when she taught it before, and it really helped the kids adjust to using	Kathy described how she and her CT used an analogy of "function dance" to help students understand the definition of function, particularly how to determine when a relation is a function. Kathy noted that the "function dance" analogy is appealing to the students and is completely mathematically sound.	

	the numbers. Eventually instead of just saying that it would break the rules, I told them that if it broke one of the rules for the dance then it would not be a function.	
February 1, 2013 at 9:27am	US: I love the "function dance" ! Your CT is so creative. She has really studied her students to develop ways to reach them. Translating mathematical concepts to language that is accessible to students is a part of specialized mathematical work that teachers do because, as you noted, the translation must "be mathematically sound". Its great that you get to work with and learn from a teacher who does this so well. I also like the transition from representing domain and range elements with names, to initials to numbers. It's kind of like moving from concrete to abstract representations	US expressed her admiration for the "function dance analogy and commends the ST for noting mathematical soundness of the function dance" analogy. The US underscored that representing mathematical concepts in concrete ways that are both accessible to students and mathematical sound is an important pedagogical skill for mathematics teachers.

	Theme- Representing mathematical concepts with "everyday-life" scenarios		
March 13, 2013 at 8:30pm	Kathy: Next, we moved on to square roots of non-perfect squares. I used the scenario my teacher came up with (she is so good at coming up with these things), which is talking about the radicand as a couple that splits up and moves into separate houses	Kathy described using a scenario of a couple splitting up and moving into separate houses as an analogy for the procedure for representing radical as product of two radicals.	
March 13, 2013 at 10:36pm	US: …I like the analogy of couple spliting up as a way to think about rewriting a radical as the product of two radicals. Does your CT carry the analogy further to steps for simplifying radicals. For example, like the wife gets all the perfect stuff in her house and husband gets the rest in his house ... or something like that :)?		US questioned Kathy about extending the scenario to encompass the important step of writing the radical to be simplified as product of two radicals where the radicand of one of the radicals is the largest perfect square possible.
March 13, 2013 at 11:04pm	Kathy: Well the ones that we have been working on were where only one of the radicals would simplify and so we would just say the one person moved on, but I do like how you related it back to perfect squares again by calling it "perfect stuff." And you could maybe say that all of the non-perfect or bad stuff gets left behind at the old house.	Kathy uses the US ideas to further extends the scenario to represent additional aspects of the steps involved in simplifying radicals.	
	.		
	Theme-Representing mathematical concepts with "everyday-life" scenarios		
In the conversations above, Kathy and US discussed two cases of using every-day-life scenarios to represent mathematical concepts and procedures. In the first conversation the ST described a "function dance" analogy which was developed by Kathy's cooperating teacher to help students remember the definition of function. Kathy noted that the function dance analogy was "mathematically sound". The US commended Kathy for spotlighting the mathematical soundness of the analogy and emphasized that making sure that representations are mathematically sound is critical in teaching mathematics. In the second conversation above, Kathy described a scenario of a couple splitting up in divorce to represent the process of rewriting radical as product of two radicals in order to simply the radical. The US responded with questions and suggestions about how to extend and elaborate on the scenario to go beyond just writing a radical as product of two radicals but to encompass the important idea that one of the radicals should have radicand which is the largest perfect			

square possible. Kathy liked US' suggestions and used them to further elaborate the "divorce scenario" to include more details of the procedure for simplifying radical. In summary, the conversations above address two important aspects using and connecting mathematical representations . The first conversation highlighted that idea of making sure a representation is mathematically sound. The second conversations addressed how to developing a representation to encompass more aspects of mathematical process.

Appendix F: Data Analysis Figures for Research Question 2

Figure F1. Tracking Kathy's Development in Promoting Student Collaboration and Mathematical Discourse -

Kathy's* Pre-interview Excerpts-		
Pre-interview excerpts- January 14, 2013		Synopsis
What is involved in "good" mathematics teaching? …having students communicating about math, not just being able to do the steps but really understanding what's going on behind the steps and being about to explain it to someone else in an in-depth manner. *Describe a specific time when you have seen "good" mathematics instruction*? "Last semester in an "Algebra 2 class…that had a lot of the lower level kids" where the teachers "incorporated a lot of fun activities and a variety of things where they had group work so the students were getting to communicate with each other about the different things that they were learning about and helping each other to figure out what they are not sure about, to share their strengths and weaknesses" *Which of the NCTM process standards do you specifically want to work on during student teaching?* "I like the communication one a lot, communication because, like I said before, I think it's important to have them understand not just procedural also but conceptual knowledge. I want to do more group work and partner activities in first class that I am going to take over because it is taught more traditionally than her other classes and they don't really move around a whole lot."		Providing opportunities for students to communicate about mathematics was a central goal for Kathy. During observations last semester, she witnessed lower level Algebra students working effectively in groups and she wanted to incorporate more group work in the first class that she would to take over during her student teaching placement. She noted that the students in the class were taught "traditionally" and didn't "really move around a whole lot" Kathy believed that when students communicate about mathematics they gaining deeper conceptual understanding.
Kathy's online posts and responses		
Date	Online mentoring conversation excerpts	Synopsis
January 11, 2013 at 9:07pm	Kathy: Overall, I really enjoyed watching her class. She asked the students lots of questions and let them do most of the thinking and calculating. The students also asked a lot of questions to her, which she didn't always immediately give an answer to. Part of the reason the class was this way was because it is an advanced class, but I still	Kathy observed an advanced class involved in productive mathematical discourse. Kathy wanted to similarly involve students in mathematical discourse in her own teaching and she

	think it can be done with lower level classes as well. I really want to try to involve the students when I am teaching…. In fourth block, I visited a third teacher's College Math class, which is essentially for seniors …The students almost entirely tuned out the teacher for the whole class. … I was a really hard situation because of the fact that it was Friday afternoon and that they are seniors who don't like math. I honestly don't know what a better solution would be to get them to participate, but they teacher did do a lot of lecturing. This could be contributing to their lack of interest	believed that the mathematical discourse that she observed in this advance class could also happen in lower level classes. In contrast, Kathy observed a mathematics class with no student engagement which she suggested may have been due in part to the teacher "doing a lot of lecturing".
January 11, 2013 at 10:00pm	US: I impressed that you think that lower level students can also be engaged in classes where there is constructive mathematical discourse and communication like you observed in the advanced class. Try to hold on to that vision of classroom interaction for all students. It will be tempting when confronted with behavior issues and weak academic skills to abandon any attempts to engage students in ways other than lecture and worksheets.	US encouraged Kathy's desire to engage all levels of students in mathematical discourse
January 13, 2013 at 9:59pm	Kathy: …- I am surely going to try my best!	Kathy is determined to provide opportunities for students to communicate about mathematics

January 15, 2013 at 5:36pm	Kathy: Students were given different scenarios and asked to determine which was the better situation. Of course, students were tempted to say that having a higher number of successes (quarterback pass completions, correct answers on a test, etc.,) regardless of how many attempts were made, was better (Ex. 42/50 would be better than 22/25). After they calculated the percentages and compared, they realized that this wasn't always true. In 4th block in particular, this generated a good discussion about how much data would be needed to rely solely on this percentages etc. This gave me a glimpse of what it could be like to have the lower level students engaged in discussion. I think that having them make predictions and comparing that to results would be helpful in the future	Kathy observed that dissonance between students' predictions and calculated outcomes generated a "good discussion" in lower level class and hoped to use a similar "first- predict-then-compare-to-results" strategy to stimulate discussion in her teaching. .
January 15, 2013 at 9:08pm	US: You make a keen observation about how ' asking students to make a predictions and then comparing the predictions to the results" is nice strategy for engaging the students and perhaps stimulating a conversation. Starting with students' input generally helps to bring students into a lesson	US affirmed Kathy's observations about strategies that generate mathematical discussion and generalizes that eliciting students' input is a strategy for bringing students into a lesson.
Kathy's development: Stage 1-Desire and Determination		
Kathy's online posts reiterated her desire to involve students in mathematical discourse. During initial observations of mathematics classes at her student teaching site, Kathy glimpsed the potential for mathematical discourse for all levels of learners. In addition, from her observations, Kathy also gleaned some potential strategies for generating classroom discourse: asking a lot questions, perhaps not answering students' questions right away, asking students to predict first and then compare results. Kathy seemed determined to work on ways to promote classroom discourse with lower- level students as well as other students. The US affirmed and encouraged Kathy's goal to engage all levels of students in mathematical discourse.		
Date	Online mentoring conversation excerpts [a]	Synopsis
January17, 2013 at 7:20pm	Kathy: This Thursday, all four of the classes participated in stations. ... For the most part the students took it seriously and were working. The typical students who don't usually particpate normally did little of the work. I wonder if this is because they lack such basic skills that they are just lost or if they lack motivation. Also, students were allowed to pick their groups which could have cause the trouble... There were 5 groups with new vocabulary	To learn new vocabulary, Kathy's students participated in a station activity which involved working in groups to read information on cards and make sure everyone in the group understands. For the most part, students succeeded in learning the concepts" quickly" and " on their own"

	words including, domain, range, independent variable, dependent variable, and f(x). At each group, the students had to read the info on the card and make sure their group understood the meaning of the particular word. Overall, the stations were a success because most of the students gained an understanding of the concepts very quickly, and on their own. However, there were other students who were off task and who were not paying attention. I had to keep going around to the groups and reminding them of what they were supposed to be doing and questioning them on their word to see if they understood it or not. It really is very hard to keep these lower level students, many of whom are in special education, to stay focused on their own. In the future, I might need to strategically place students in groups instead of randomly doing so or letting them pick their own groups.	but some groups were off-task and it was particularly hard to keep lower–level students focused. Kathy speculated that strategically placing students in groups might improve help students stay on task.
January 24, 2013 at 7:43pm	Kathy: I had the students work on an independent discovery activity. It walks students through graphing different lines and seeing how they look when graphed and asking students what they notice about the slopes. Students were supposed to reach the conclusion that parallel lines have the same slopes and that perpendicular lines have opposite reciprocal slopes. The students who took the time to read it and follow along reached the appropriate conclusions or something close to it, but there were yet again some students who didn't bother to read it or even try. So when it came to the discussion time for the students to talk about what they found out, there wasn't much discussion at all. I had to give the answer so that I was sure the others who didn't participate knew what it was. I have a similar discovery activity planned for graphing absolute value functions next week. I am not so sure if I want the students to do it independently or not now because most of them didn't do it. I might just lead from the front of the class and have the students follow along instead..	Kathy tried her first " discovery activity" and was disappointed that some students did not bother to read the directions and follow the steps and thus never reached the intended conclusion. Consequently when debriefing the discovery activity there was not much classroom discussion
January 24, 2013	US: Bravo, for trying a discovery activity! Discovery is inductive	The US applauded Kathy for trying a

at 7:43pm	reasoning- making a conclusion or conjecture based on observations of patterns. Inductive reasoning is an important aspect of doing mathematics and you mentioned in you were interesting in students learning about reasoning. It's great that the activity worked for those who were willing to read and do it. Now challenge yourself to think about how to get more students involved in a discovery activity: 1) Perhaps more students might be motivated if they are working in groups and given reward for making a discovery (e.g., the first group to make the discovery gets 10 points or pieces of candy, next group gets 8 points/candy, third group gets, 6 points.. and include in the instructions that you should be able to ask anyone in the group to explain the discovery to make sure that everyone in the group is involved . 2) Perhaps you also want trying lead the activity from the front of the class but insist on everyone write down their observations on small slip of paper that you collect and give a reward to everyone writes down a reasonable conclusion , or maybe you could read some of the conclusions out loud and make big deal about the best conclusions. 3) Perhaps the students might be motivated by the way you introduce the activity- perhaps build in some competitive aspect in the discovery activity since the student seem to "feed off of the competitiveness".. These are just ideas and are not set in stone or perfect but perhaps they can help you come with ideas based on what you now about your students.	discovery activity and reminded Kathy that discovery activities help students develop inductive reasoning skills. The US prompted Kathy to think about ways to modify her approach to discovery lessons and offers suggestions about how to involve more students in doing the discovery activity.
January 25,2013 at 8:21 a.m.	Kathy: Those suggestion sound really good, especially since they seemed to like the competition in the teams with the clicker questions! I will try that when I do the next discovery activity with graphing absolute value functions. I think I could definitely have sold the activity better.	Kathy liked the US' suggestions about motivating participation and committed to trying to incorporate some of the suggestions in the next discovery activity.
February 5, 2013 :33p.m.	Kathy: I had another discovery activity planned for this. This time I put them in groups of 4-5 students to work on the discovery activity together in hopes of raising their participation. Basically, they would graph various transformations of the parent absolute	Kathy attempted a second a discovery activity and incorporated some of the suggestion from the US: She offered an incentive (candy) for groups to finish the

	value function and try to generalize what happens when you add or subtract a number inside or outside of the absolute value bars. I told them to make sure that they help their group members and work together because the first two groups with correct conclusions would get candy. I also told them that I would call on one spokesperson from each group at random to explain their findings to the class which would mean that they would all need to know what was going on. Unfortunately, the activity did not pan out as planned. There were several students that were working very hard, even ones that normally don't, but I saw little group interaction and some students were having extreme difficulty progressing through the steps. I kept having to clarify how to do things on the board even though the steps were very explicit- they just weren't reading the steps. I do think that there was more participation and effort than there was for the last discovery activity, but it did not meet the expectations that I had in mind. Since there wasn't much progress, I chose to stop them where they were and direct their attention to me at the board. I had them graph several different ones and said "Okay, how does this compare to the parent function?" This seemed to be more effective than what they were doing previously. Then, I gave them graphing calculators, .., to graph the functions…. I made them predict how it would move based off of the equation before graphing it and then check it with the graph. They seemed to be doing fairly well, but the left and right shift was the most confusing, as was expected. … In the future, I am unsure about doing discovery activities. I thought for sure that it would go much better this time in groups, but it did not. There is just such a divide between the students who really get it consistently and those who don't-on every new topic. My teacher suggested maybe letting the more advance kids work separately on a discovery while the other kids do something different.	work quickly and incentive (one person from the group will be called on at random) for groups to make sure everyone understands. Kathy observed that although there was "more participation and effort than the last discovery activity", there was" little group interaction" and "some students had extreme difficulty progressing through the steps". She decided to lead the discovery from the board, giving oral directions and asking students to make conclusions .Kathy was disappointed about the group work component of the discovery activity and is skeptical about doing discovery activities in the future. Kathy's CT suggested that perhaps only more advanced students should work on discovery activities.
February 5, 2013 at 9:32pm	US: Congratulations for making some major adjustments to your approach to group discovery activates that probably helped to	US congratulated Kathy for making adjustments that seemed to facilitate more

	generate "more participation and effort than there was for the last discovery activity" So, you are making progress. … The major thing that I hear and have experienced myself is that unfortunately, many student are not use to and not proficient at reading step by step directions especially in relation to mathematics and thus they get really bogged down or lazy when asked to do so. … I think that you made a very appropriate adjustment in graphing the functions in the board and asking them to make conclusions. You still got the students to make discoveries (make observations and draw conclusions) without getting slowed down by having to teach them how to read. Perhaps, you could still incorporate a group component by asking group members to discuss their predictions and write them down as a group.- perhaps you could give every group a white board(Are schools still using mini- white boards or perhaps students have an app that lets them write on their IPADS).	student participation in discovery and offered suggestions about how to promote more productive group discussion.
February 6, 2013 at 6:39am	Kathy: Thanks for the encouragement ... I do like the suggestion to have them discuss and make predictions as a groups. I think they'd definitely be more likely to try when they are just faced with one question at a time. We do still use the mini white boards, but they have a whiteboard app as well …	Kathy appreciated the US' encouragement and liked the US' suggestion of having students discuss and make predictions as groups. Kathy highlighted that perhaps groups will be more likely to try when given just one question at a time as opposed to long task.
February 7, 2013 at 8:58pm	Kathy: In first block, I tried out some stations. Although I have helped with stations in other classes, this was my first time creating and planning the stations on my own. We needed to cover several small statistics topics before the final, so I decided to make it into stations since students could pick up each concept fairly quickly. There were 5 groups: 1.mean, median, and mode, 2. box and whisker plots, 3. correlations, 4. graphing linear equations, and 5. iLearn quizzes. …! Each station had enough slips of paper for each student to read over the basics of the concept. The students each had a front and back notes sheet	Kathy designed a station activity that includes individual worksheets to ensure individual student accountability and to keep students more focused on station tasks. Kathy did not mention any components of the station activity designed to ensure group interactions. Kathy noted that the students, although disgruntled about doing so, seem to be getting more used to working in groups but does not

	where they were required to fill in the blanks and work the corresponding problems for that station. They took that paper with them to each station and turned it in at the end of class. I think it was a really good way for me to keep them accountable for their work because I have seen stations in our class in the past fail. I think that paper really helped them focus a lot, and because I took it up, it allowed me to see how they were doing…. Although, I don't think I'm a pro at stations just yet, I was pleased with how this turned out. …. In the future, I might think more about strategically picking groups rather than picking randomly. And even though they do complain, it seems like they are getting more used to working in groups.	provide any specific observations about group interactions. She once again hypothesized that strategically placing students in groups might improve group work.
February 12, 2013 at 1:54pm	US: Yeah! … I am glad that stations went well- …. Nice ideas to include a worksheet and review station. It's right on target to now be thinking about the next level- how to make group work more productive. You mentioned one thing - strategically picking group members. Another thing to consider how you can establish and communicative expectations and guidelines about how you want groups to work together- this could being more specific than just saying you have to work together and help each other- for example " first work on problem individually, then compare and explain your answers, do not move on until everyone in the group understands" or person A works and explains the problem, Person B asks questions about the solutions, Person C records the solution. Facilitating productive group behavior also includes affirming and praising students when you see good group behavior, or prompting students to ask someone in their group before asking you.... Students have to be taught how to work in groups like that have to be taught how to do algebra and geometry.	The US praised Kathy for making progress with student participation in the station activity but focuses her comments on what more Kathy could do, beyond strategically picking group members, to promote promoting more productive group interactions. The suggested providing specific guidelines and expectations about group interactions.
Kathy's development: Stage 2-Disappointment and Doubt		
Kathy tried two teaching strategies , discovery lessons and station activities that in theory should have been venues for student		

collaboration and mathematical discourse, but the group interactions and discussions spawned by these strategies do not live up to her expectations. Furthermore, some students' unwillingness and or inability to read and work through steps independently derailed the objective of her discovery lessons. Kathy found some success with leading discovery activities in front of the class as whole group but she felt hesitant about doing discovery lessons in the future.

Kathy noted that, during the first station activity, it took a lot effort to monitor groups that were off- task and she found it particularly challenging to keeping lower level students focused. Kathy designed the second station activity to ensure more individual student accountability. She was pleased with student's individual work during the second station activity but did not embrace stations as a teaching strategy. Furthermore, she still expressed some concerns about group interactions during stations activities and suggested that strategically placing students in groups might promote more effective interaction.

The US acknowledged and praised Kathy's efforts and progress in engaging student participation in discovery and station activities. The US responded to Kathy's concern about promoting more effective group interactions and provides detailed suggestion about establishing specific guidelines for group discussions.

Date	Online mentoring conversation excerpts [a]	Synopsis
February 21, 2013 at 6:30pm	Kathy: In advanced, we continued to work on solving systems of linear equations by graphing, substitution, and elimination. …Students should be able to choose the method that they feel most comfortable with. Tomorrow we are going to be doing activities that encourages students to do just that. They will be placed in groups and given different systems. They will need to discuss which method they want to use and why and then use it to solve. This is something that I found on Pinterest, so if anybody is looking for activities, give Pinterest a try or check out my teacher board :).	Kathy planned to have students in her advanced algebra class work in group on solving system of equations. Students will be asked to discuss in their groups which method, graphing, substitution or eliminations, they want to use and why.
February 22, 2013 at 12:32pm	US: Cool. Seems like things are moving along well with teaching systems of equations. Curious to hear about how the group work goes or is going on now as I write this posts. I wonder what kind of conversations the student are having about which method to use to solve the systems. I will check your posts later to find out.	To highlight the importance of attending to details of student to student discourse, the US expressed her interest in hearing about the student conversations that emerged during the group work on solving systems of equations.
February 22, 2013	Kathy:… I had them choose their groups, since they are such a small well-	Kathy reported that she directed

at 4:56pm	behaved class, for the choosing the method activity. I told them to focus more on talking about what method they would prefer and why rather than actually solving it although I wanted them to do that too if they had time. I heard many good conversations.	groups to focus more on what method and why rather than solving the system and consequently heard many good conversations.
February 22, 2013 at 9:07pm	US: It's really great that you gave the group some direction about what you wanted them to focus on in their talking in the groups- what method and why more so than just finding the answer - this is right in line with your goals to help student work on reasoning and communicating about mathematics Also, stating your expectations for group interaction is a key component in facilitating effective group work.	US praised Kathy for providing guidelines for group discussions and placed her actions in context of teaching via the NCTM process standards.
March 5, 2013 at 5:14pm	Kathy: We played a game that I made up, which I turned out to really like. I had the class divided into groups of three. Each student had their own whiteboard on which they had to work out the problem I wrote on the board. Then, they had to compare answers with their group and reach a consensus on the right answer and/or help each other figure it out. They could then show me their answer. If it was right, they got a point. If it was wrong, they got one more try to figure it out. It didn't matter which group responded fastest, it just mattered that they got the question right. All groups could earn a point on the same question if they all got it right. The kids were really into it the whole time and I was having fun too**.** I saw a lot of good discussions going on within the groups. I like playing games, but sometimes I feel like they only emphasize getting the correct answer on the first try and at being the quickest. I like this game because it gives the opportunity to correct mistakes, and that they have to cooperate with their group before answering. I definitely want to do this again, especially when reviewing. I might even try this with the general classes, but I would have to be more careful about the ways I choose the groups.	Kathy incorporated many elements in a game that facilitated student collaboration and mathematical discourse: 1)explicit directions: think first, compare and come to consensus and or help each other, then show the teacher and 2) rewards for all groups for collaborating to eventually arriving at correct solutions.
March 6, 2013 at 7:25am	US: I love everything you mentioned about your game: individual work first, requirement to check and collaborate with group, emphasis not on getting the answer the fastest, lots of good group	The US praised Kathy for promoting student collaboration and challenges Kathy to consider ways to motivate

	discussions.... It's great that the students so willingly helped each other figure things out. You might want to think about how you might have to adjust the game for students who do not so willing help each other. Pehaps give an extra point if anyone that you call on in the group can explain the problem. also, of course praise groups that are doing a good job of helping each other. I do hope that you will try your game with your general classes. US: I love everything you mentioned about your game: individual work first, requirement to check and collaborate with group, emphasis not on getting the answer the fastest, lots of good group discussions.... It's great that the students so willingly helped each other figure things out. You might want to think about how you might have to adjust the game for students who do not so willing help each other. Pehaps give an extra point if anyone that you call on in the group can explain the problem. also, of course praise groups that are doing a good job of helping each other. I do hope that you will try your game with your general classes.	similar group collaborations with students who might be less cooperative. US also encouraged Kathy to try similar collaborative game with her general classes.
Kathy's development: Stage 3-Deliberate Implementation of Strategies		
Kathy progressed in facilitating mathematical discourse within group activities. She established more explicit expectations about the content of group discussions – "I told them to focus more on what method they would use and why rather than solving the problems". She provided explicit guidelines about process for group interactions " first work individually, then compare with your group and come a consensus, then show me the answer to earn a point" She notes several successes in promoting mathematical discourse -"I heard some good discussions". Kathy's successes in facilitating "good discussions" occurred in her advanced classes where she specifically directed groups about how to work together. She commented s that she was considering trying similar activities with her general level classes in the future but she concluded from previous experiences that she stated that she might have to be more strategic about selecting groups for similar activities to be effective in her general level classes The US challenges Kathy to continue to think about strategies to promote productive student discussions for students who might more resistant to working together and encourages Kathy to try similar group activities with general classes.		
Kathy's post-interview responses		
Kathy's Post- Interview Comments Relating online Conversations to her development with Facilitating Discovery Activities & Student Collaboration and Mathematical discourse		Synopsis

"I tried discovery lesson that I did not think was very successful and US gave me some suggestions… and I thought those were good ideas and actually I had another discovery lesson planned for the following week and so I did think those were good ideas and I did try them the next time …	Kathy found an online conversation to be a source for suggestions for refining her teaching strategies for presenting discovery lessons.
. …I think it was good just to hear some other suggestions about how to do it (discovery activity) better. Sometimes all you can focus on is 'Oh, it did not go very good and its' hard to think about right away what could I have done better."	Kathy found an online conversation to be a source of encouragement and affirmation for implementing standards-based teaching practices- in this particular case, facilitating student communication about mathematics.
"It was originally my idea to have them pick and [discuss] a method [for solving systems of equations] My US [said] it was a good idea for facilitating the communication about math which was one of things I wanted to work on. It was reassuring to hear someone say that you are working toward the goals that you have set."	
"My US suggested to ask the group members to discuss predictions and then as a group to put forth their predictions to the class instead of them all …working in isolation and then we would, as a class, talk about each prediction, …I feel like that is something I tried to keep with …There was actually a group activity that I created a little bit later where I had the students in groups where they had to reach a consensus as a group before they could presented it. So it (the group activity)kind of stemmed form that[online]conversations.	Kathy found an online conversation to be a source for a suggestion about how to promoting more student mathematical discourse. Kathy incorporated the suggestion in her design of future group activities. .
"[US] gave me extra things to consider ...you can always make something better… and another thing, you have to be very explicit. in what you want students to do like with the stations, [the US] gave suggestions about how to give the different student in the groups different tasks so that they would all be contributing equally to the group and so It think that is something that is definitely important, getting the students to understand what you want and how it should be done… Like with stations, I actually did those	Kathy found an online conversation to be a source for suggestions about how to promote more student collaborations. The suggestions prompted to Kathy to modify her directions to students in a future station activity.

again with another class and I made the worksheet, that went along with it, a little different, and I think I was more clear about what I wanted them to do at each station… It nice to have someone there to support you with suggestions"	
Kathy's Post-Interview Comments Relating online Conversations to what she has Learned about Teaching.	Synopsis
"I shouldn't be so hard on myself It Ok to have unsuccessful days, you can always refine them and make them better." "You definitely have tweak things multiple times to get it right". "I really push myself to reflect on activities and how to make them better." I have to continuously reflect on everything that I do"	Kathy found that online conversations prompted her to repeatedly reflect on how she could adjust and refine her teaching strategies.

Figure F 1*: Kathy's development in promoting student collaboration and mathematical discourse*.

:

Figure F-2- Tracking Jake's development in eliciting students' mathematical thinking		
Jake's Pre-Interview Responses		
Pre-interview response excerpts(January 11, 2013)		Synopsis
What is involved in "good" mathematics teaching? "One thing, I have looked into is the application side of high school math. It may be easier for kids to learn if they have an incentive to apply it to their own lives. A part of what I feel like would be very effective teaching would focus on applications. *Describe a specific time when you have seen "good" mathematics instruction*? "It seems to me that the big part has nothing to do with math, it came down to relationships and what happened in the classroom." *Which of the NCTM process standards do you specifically want to work on during student teaching?* "I really want to focus on real-world applications and problem-solving. I like the communication section because, in my opinion, if an employer can talk to someone, then there is going to be a job for them. I personally feel that if you can communicate well, there will be a place for you. To take that to the math world, being able to communicate what you are thinking and why you are thinking it and the results … goes to show the importance of communication…"		Jake wanted to make real world connections in his teaching because he believes that students would have more of incentive to learn mathematics if they can see apply it to their own lives. He, also, thought that giving students an opportunity to communicate about math is important because being able to communicate what you are thinking and why you are thinking is an important skill for the job market. Jake believed that the foundation of good teaching is the teacher's relationship with students and the classroom environment.
Jake's online comments and responses		
Date	Online mentoring conversation excerpts [a]	Synopsis
January 15, 2013 at 8:13pm	Jake: The lessons are pretty straight forward. My cooperating teacher teaches off of a document camera. He writes the notes and the students copy them down. He is the form of engagement and he does a great job at that (something I would like to mimic). It is going to be interesting seeing how they respond to differentiated instruction techniques and whether or not they have gotten to used to simply copying notes	Jake described his CT's "straight forward" teaching style and pondered how students would respond when Jake attempted a more varied teaching style.
January 20, 2013	US: Yes, It will be interesting to see how your students respond to	The US encouraged Jake to try teaching

at 10:10pm	your differentiated instruction techniques. Good for you for being determined to do more than have them simply copy notes. It might be a roller coaster ride at first but hang in there. Student teaching is your time to learn and trying different strategies, even strategies that may be different from your CT's	strategies that might differ from his CT's approach and warned Jake that doing so might have its "ups and downs."
January 22, 2013 at 10:34pm	Jake: The day started with Advanced Geometry … The content didn't spark a whole lot of thought, controversy or reflection in my head, but what I do have to say concerns presentation style. All of these geometry lessons are on powerpoints meant to be distributed throughout the geometry teachers for immediate use. They are great at presenting the material in an effective manner. They are nice, neat and clean, but the interaction is left up to the personality of the teacher. Not that I doubt myself in that area or that it isn't an effective way of teaching, but it leaves serious potential for the class to be boring. But I must also say this, sometimes boring isn't bad. If you are serious about school, you have to learn to power through boredom. The workforce isn't always engaging, but that doesn't mean we quit and give up. I don't necessarily have a problem with they way the material is covered. I do want to do things differently, but I realize how this presentation style may be critiqued.	Jake was concerned about how his goal to implement a more engaging teaching strategies might conflict with the prescribed lessons distributed to the geometry teachers at his student teaching site. He observed that when using the prescribed lesson plans, that student engagement was dependent on the personality of the teacher
January 23, 2013 at 8:40am	US: Zack, I see that you are conflicted about what to do with the already-prepared math department lessons. I would encourage you to do as Scott suggested and feel free to incorporate and modify the provided lessons in ways that might stimulate more student engagement. Student teaching is your time to try strategies that you have learned. If you try new strategies and see how they work for you now, it will help you have a few practiced strategies in your teaching repertoire when you start teaching next year. I am afraid that if just go with the flow, you may loose this opportunity to learn at a time when you not trying to handle all the responsibilities of a new teacher. … Having an engaging personality is an important part of being an effective teacher but when it comes to student learning, effective	The US encouraged Jake to try some of the strategies for student engagement that Jake had learned about in his teacher education program, even if it means going against the flow at his student teaching site. Also, the US emphasized that effective teaching is about more than just having an engaging personality. She asserted that effective teaching involves enacting a large array of intentional teaching strategies that facilitate student learning.

	teachers have large repertoire of intentional teaching practices/ strategies-ways to introduce a concept, questioning techniques, face-lifting discussions, designed activities, discovery episodes, integrating formative assessments….	
January 23, 2013 at 10:54pm	Jake: I feel like whenever I step in, I either have to be like him[CT] or completely different but equally as entertaining. …. I will look for little things here and there to throw into presentations because ultimately, the document camera makes things easier when it comes to uploading lessons online, absent students and future planning; but it will take some getting used to… I know it seems like I am stuck on this certain topic of lesson independence, but I guess it is what I have been thinking about as I … teach lessons nearly the exact why my teacher has taught them the block before. I hope I am not kicking a dead horse or anything, but it continues to come up in my thoughts, …	Despite the US' encouragement to do otherwise Jake felt obliged to not stray far from his CT's approach of teaching from the document camera. Jake was also concerned about not being as entertaining as his CT.
Jake's Development Stage 1 Constrained to go with the flow		
Jake's intention to present differentiated and engaging instruction was constrained by two key factors at his student teaching-site: his CT "traditional teaching style and the pre-scribed power point lessons developed and distributed by the school's mathematics department. Jake observed that his CT "teaches off of a document camera ","writes the notes and the students copy them down" but otherwise engaged the students with his personality. He observed that the prescribed power point lessons, although "nice, neat and clean" could easily lead to lessons that are boring but for the personality of the teacher who uses them. Jake felt constrained to mimic his CT teaching style and stick closely to the PowerPoint lessons. US encouraged Jake to "go against the flow" at his student teaching site and try some strategies for student engagement that he has learned about in his teacher education program. US reminded Jake that effective teaching that promotes student learning, involves a teacher consciously implementing effective teaching strategies and does not simply involve a teacher having an engaging personality.		
Date	Online mentoring conversation excerpts [a]	Synopsis

February 20, 2013 at 4:55pm	Jake: I was thinking today about how it is about time to take a risk. I feel like I have reached the point of comfort-ability, at least in the Algebra II classes, and they seem to be needing something a little different. The problem is my creative juices are not leading me to anything interesting. I know the unit coming up is covering radicals, but the theme with so much in Algebra II is wrote. I don't know how to mix up presentation techniques to attract to differing types of listeners. I try to be fun and interactive, but math alone has the ability to turn people off. More than anything, what I have noticed is that my desire isn't necessarily for students to learn math, it is for them to have fun doing math; and whatever we have been doing seems completely opposite of this. I don't have bad students, problem students or students that are resilient. They are obedient, good kids who don't complain much at all, so for their sake I feel it upon myself to make things more interesting; I just don't know how to do it. Add to this their age and anything I come up with seems too childish or gimmicky. I have been reading other posts trying to find ideas, but I am still at a loss.	Jake wanted to take some risks and change his current teaching style to be more engaging and “fun” for students but does not know how to do so. He declared that he had not found any other ideas by reading online posts from other STs in his cohort.

February 21, 2013 at 1:33pm	US: Its great that your have got a comfortable postivie atmosphere going in your Algebra 2 classes.Yes it is hard to make algebra 2 content interesting or fun to do. Perhaps you could make things a little more interesting (intellectually engaging) by doing some things that I have read from other student teachers: For example, 1) do a find the error activity. 2) Show three examples of how to do something without explaining and see if students can discover what you did 3) a group quiz- pair a stronger studnet to tutor weaker student for 15 minutes then quiz the weaker student reward both students if weaker student improves. 4) show examples and counter examples for students to derive definitions or proceedures 5) perhaps even a jigsaw activity. These are just rough suggestions and need to be tweaked for your particular class. I am also wondeing how the student the student interaction is progressing your classes. Are you doing most of the talking during class ? It might be worth your while to take risk and try something different- of course it should be well thought out and discussed with your CT - because student teaching is time to try and learn	US provided Jake with some specific suggestions about how to make his teaching more interesting- that is-more "intellectually engaging." The US noted that her suggestions came from posts that she had read from other student teachers. To prompt Jake to think about the level of student engagement and interaction in his classroom, the US asked Jake if he was doing most of the talking during class.

February 21, 2013 at 10:12pm	Jake: I really like the "find the error" because it gives me the ability to highlight common mistakes I am seeing on a daily basis. … To answer your question, I am still the one that is leading the lessons, meaning I ask a lot of questions and encourage student dialogue, but ultimately it all comes back to my voice. I don't think this is the key to success, however I am a little nervous changing it because it is how my CT teaches and the students do deserve a little consistency. I understand I the importance of taking risks, but I also feel like I am doing an "ok" job as it stands right now. If I take a risk with a group activity, it may very well enhance the learning experience, but what scares me is if it fails because the students aren't used to it. I don't want to be unfair by changing styles with only months left in the semester. But on the contrary, maybe I am being unfair by only presenting lessons in one form or fashion? Haha obviously I have it all figured out! (Sarcasm included) Thanks for your advice, I just had to air out some of what I had been thinking about.	Jake liked one of the US' suggestions. He acknowledged that his voice permeated his classroom but acknowledged that his CT taught the same way. He felt like he was doing "OK" with mimicking his CT's teaching style. He was nervous an uncertain about deviating from his CT teaching style and failing to be effective. On the other hand, he knew that alternate teaching strategies might enhance his students learning experiences Jake concluded that he must try other teaching strategies for the sake of his students.

February 22, 2013 at 12:17pm	US: Yes! I am glad that you figured it out! Take the risk!. Make mistakes! . Learn from them! Do more than "OK". You may want to even tell your students that you are taking a risk to try to something new. You said that they seem to appreciate vulnerability. Student teaching is about trying out new things - things that you have be taught in your methods class so that you can learn about how to make these strategies work in the classroom. • No matter what happens, I've got your back.	US applauded and supported Jake's decision to try something new. She reminded Jake that student teaching was his opportunity to try strategies presented in his methods class and to learn from his mistakes.
February 26, 2013 at 11:58pm	Jake: My lesson in Algebra II today was on the multiplication and division of radicals. The lesson took about 45 minutes, which for me is a short lesson. … So the lesson ended at the time it was supposed to, problem was it felt like pulling teeth to get there. I don't fault the students for not being interested, I mean multiplying and dividing radicals isn't the most intriguing of subject matter…. I have always been told that you can't please everyone, and today I found this to be quite true. My woes have nothing to do with the students, and as I continue to teach, I don't want to be a teacher that constantly complains about their students, but how interesting can you really make radical multiplication? This has been the hardest part to digest for me. And	Jake's decision to try some new strategies did not come to fruition in algebra 2 lesson described to the left. Jake taught a lesson on multiplying radicals that he lamented was painfully, non-engaging for students even though students seemed to" mildly" understand the topic. He regretted that he could not make learning radicals "fun" but also questioned whether or not his focus should be to make math fun.

	it is not even that they weren't understanding. It seemed like they understood mildly what was going on, but they looked miserable, and I am not in this occupation to pull student's teeth… Maybe it's because I doubt my math creativity, but I am not convinced in my ability to make learning radicals fun... but should making it fun be my focus? I don't know, these are just my ramblings. Like I said last night, I am running out of things to talk about on a nightly basis.	
February 27, 2013 at 2:28pm	US: Today's lesson in Algebra ll was similar to the lesson you describe above. Begin to try to do different little things(e.g. show worked examples and ask student to find the rule, think-pair share, use two different strategies to solve a problem, have students present their strategies, show and error and have students 'work in pairs to determine the error, call on students who never talk, insist that stronger student teach weaker students, let students struggle with a problem, ask why, encourage students to ask why, include students who seem to have no voice in the class....) Little things can make learning the mathematics more interesting. The math itself might be dull and irrelevant but learning it can be more interesting. So perhaps in future posts, you will be able to say, " Today I tried something different and this is what happened... so next time I	US watched Jake teach a lesson, similar to the one described in his post above, where Jake just presented example problems on the document camera in the front of the class with very little student interaction. US reiterated, in her post, some suggestions, she made during the post- observation conference, for making his lessons more engaging thus more aligned to standards-based instruction. She highlighted that although some math topics may not be interesting to students, learning math can be made more interesting. She provided Jake with concrete examples of how various strategies to facilitate student collaboration or engage students in thinking play out in real classrooms by copying excerpts from online posts from some of Jake's MIC colleagues describing their experiences trying various strategies.

will...” Trying something different will mean be getting out of your comfort zone and getting your students' out of their comfort zones but I am confident that if you push yourself and push your students, you will able to learn something more about teaching and learning.
I have read some interesting things that your colleagues have tried to do in their classes to make learning more interesting .Following are some excerpts from MIC student’s blog post’s this semester: . I know that you do not have time to read everyone’s posts and neither so I am sure that I have missed a lot of good stuff but I hope the excerpts below help to give you an idea about how doing different little things can play out in the classroom.

Below is part of post from Hannah’s* February 14th post about something she did in Algebra 2 class
…. I had the students get in pairs to do the activity, and within their pairs, one person was the coach and one person was the player for each problem. The player wasn't allowed to write down anything unless the coach directed them to. On each problem, the roles would switch so that each person was actively involved in solving the problems. It seemed to go well from what I could tell, and it inspired students to work together and to think through problems together. ..

	The following is from Kathy's* blog post on February 25th I put up 4 multiplication and 4 division problems with monomials that simplified with the answer written beside it. I asked the students to quietly look at the problems and try to come up with a rule on their own for how I got the answers. To my surprise, no one blurted out. … The student who had the most difficulty with solving systems was the first to raise her hand. I was very proud of her for getting this when she had had so much difficulty on the last concepts. …I really liked this idea of showing the students worked problems and having them come up with the rule on their own (I got it from ideas passed around on here). I want to keep doing this in the future especially with something that is seemingly routine because it makes it more challenging than just telling the students how to do it.
February 27, 2013 at 3:07pm	US: Hey[Jake]. Below is another idea that Kathy* just posted a few minutes ago February 27th- Making Worksheets more Interesting. Below is her post ... I tried a new activity and really loved it. Instead of doing another boring worksheet 1 though whatever number, I cut up the questions and put them in a cup. I put the worksheet on the board with the document

	camera. I asked for volunteers to pick a problem from the cup and come work it on the board in front of the class. Some were eager to volunteer and others were afraid they wouldn't know how to do it. Regardless, I had no trouble getting volunteers to come up. They were really excited about this activity and I was very happy with the response. It is definitely something that I want to continue to do in the future and maybe try with the general classes. Even though it took longer than just working through the problems, it was more fun and it let me see how students were thinking about things and the little mistakes they were making.
February 28, 2013 at 4:52am	US: Ok I know this seems excessive but there is always something more to learn about teaching strategies. Below is another post from Stuart* yesterday that illustrates ways to make classroom more interesting. "I also felt like we had a very good day in algebra II. This was the first day of our new unit that takes the students understanding of trig properties and starts to expand them. … During the course of this lesson, students worked on an example led by me and took notes ... They worked examples that were led by other students, they had individual time to work on .., and then they broke into small groups to work on setting up and solving word problems using this right triangle trig. My goal for this class was to provide them with different means of

	instruction while working on solving these problems."	
February 28, 2013 at 10:09pm	Jake: Today is a day I will never forget. .., I took some risks in the way I presented adding and subtracting rational exponents today. After having my observation with [my US] yesterday, I got a really good idea of where I should direct my emphasis currently to become a better teacher. I need to get the students more involved, and as I thought about it, I think my inability to do this so far has been the reason why I feel such a weight on my shoulder at times. It's as if I am shouldering the load of learning rather than passing it to the students for them to handle. So in response to our discussion, I put together a note sheet that to show on the document camera as we went through the lesson. I didn't do groups or anything like that, but I did use some ideas from some other blogs, namely not saying anything, showing them examples and asking them if they could spot the pattern. Ultimately, that is how I taught the lesson, by not really teaching, more facilitating... and I really think it worked. ... The variety of students who I called was much greater than it has ever been. In A1, it is usually hard to keep their attention, seeing they are still half asleep, but today, there was smiling, talking and much interaction. I, especially, got really into it, which is what I had been waiting to do the whole year. I don't know	Jake finally implemented new teaching strategies. Instead of explaining how to do problems, he showed examples and asked students to derive the pattern/find the rule. He “forced” the students to “walk through the concepts rather than giving them the steps.” Jake was thrilled with the positive student engagement that resulted from his new approaches. Moreover, Jack felt more like a facilitator of student learning. Despite, Jack’s success with implementing new strategies for student engagement in this lesson, Jack expressed doubt that he will be able to ever formulate/facilitate small group activities in the future.

	if it was being able to walk around or what, but man I was getting excited because of how engaged the class seemed. I forced students to walk the class through the concepts, rather than giving them the steps myself, something US pointed out as a tendency of mine. It was the teaching day I had been waiting for… I still don't know if I am the creative type that will formulate small group activities and stations that allow kids to master the content and stay engaged for the whole hour on a lesson by lesson basis, but as of right now I am ok with that, because that isn't who I am. If, though, I can continue with what happened today, and demand student involvement in other areas while being engaged and excited, I can feel the same result occurring, just with my own zest. I am grateful for the words my US spoke to me yesterday, because otherwise, who knows what I would have done today	
March 1, 2013 at 6:13am	**US: Yeah!** I am so impressed that you were able to turn things around in your class so quickly by doing something a little different to engage your students and that you found it rewarding. Keep it up and don't limit or doubt your ability to try **all kinds** of different things somewhere along the line. Don't be afraid to fail, we are always learning to teach. As Scott noted, keep aiming for helping student's to find their voice- to find mathematics inside of them.	US praised Jake for taking steps toward engaging student thinking and participation and encouraged him to continue to do so. She urged him to not doubt his abilities to implement a variety of new strategies.

March 3, 2013 at 5:32pm	Jake: Again I want to thank you for your comments. I appreciate the critiquing because it definitely forced me to change that lesson. Because of that experience, this week I am changing my style to mimic what seemed to work so well. I am going to throw in some other strategies here and there just to see what I can and can't get away with. And as always, I welcome any advice you have to be thrown my way.	Jake attributed the US' critique of his observed lesson as the catalyst that forced him to change his teaching approaches and welcomed any other advice.
Jake's development: Stage 2 –Pushed to turn against the flow		
Jake had become comfortable presenting lessons in a lecture style like his CT. He wrestled with the idea of trying some different approach and finally made a decision that he really should do something different but he doesn't have ideas about how to do so. He blamed his lack of ideas on his lack of creativity. In addition, he still thinks in terms of making lessons "fun" and entertaining rather than implementing teaching strategies that engage students in mathematical thinking and discourse. The US, once again, provided Jack with several general suggestions about how to make his lessons more interactive. To make her suggestions more concrete, the US sends him excerpts of other student teacher's posts describing their implementation of specific strategies. The concrete examples from one of his fellow student teacher's online posts becomes the template from which he designed a lesson activity where he successfully engaged his students interest and thinking in "finding the rule." He credited the US' critique of his observed non-engaging lesson as the impetus for forcing him to change to more engaging strategies. His success at doing so on his first attempt was a watershed moment. He was eager to replicate his positive experience with facilitating a more student-centered lesson, and planned to try some other strategies but he was hesitant about his ability to facilitate lessons that involve group work.		
Date	Online mentoring conversation excerpts [a]	Synopsis
March 7, 2013 at 10:51pm	Jake: In Algebra II, we learned about multiplication and division of higher ordered radicals, multiplying by conjugates, and multiplying and dividing fractional exponents all in	Jake continued his efforts to change his teaching style and implements another strategy to engage student's thinking. He asks students in his Algebra 2 classes to use deductive thinking to complete some ""if... then what is ...?" sentences.. He also gives students the option to share their thoughts with a partner.

the same block. … I continued to streak of making a follow along worksheet to put under the document camera, allowing me the flexibility to walk around the room. I have tried to switch up the way I present things, calling on more people, waiting longer, and today I used "if, then" statements to prove points. For fractional exponents, I had "if... then what is ...?" for multiple examples. I would have the students stay quiet as I unveiled the sentences then after I had uncovered them all, either share to the class what they thought or share with a partner. I really enjoy

	this style better than what I was doing because it is more interactive and it forces them to think on their own, …	
March 7, 2013 at 11:16pm	US: Very interesting , Tell me more about how the" if then" statements work. … How did the students do with the share with a partner part of this lesson. Did most of of the students share with a partner?	US probed Jake to describe the student collaboration that occurred during the partner sharing part of the lesson.
March 10, 2013 at 10:52pm	Jake: The partner sharing portion whenever I choose to institute has not worked well. Very few share with their table partners, maybe because they are not comfortable with who they are sitting beside. Oftentimes, I get asked questions when I tell them to check with their partner. That is not to say it is all bad, and during this time I don't answer their questions. There are students who do collaborate with each other, but it seems as a whole they are content doing things solo. I don't really know what to do in order to help aid this process.	Jake reported that the partner sharing activities have not worked well in his lessons and that his students, in general, chose to work alone. Jack speculated that his students were just not comfortable in working with their table partners. Jack admitted that he does not know what to do to remedy the partner sharing situation.
March 11, 2013 at 9:35am	US: Now about the working with partner issues: I actually expected that there might be a few hitches with your classes and again your experience is not uncommon in classes where students have not been used to/ pushed /taught to work together with a partner from the beginning of the school	US provided some specific suggestions about how Jake could foster more student collaboration. US challenged Jake work on facilitating more student collaboration in his classes.

	year. It is usually not enough to simply tell/ ask students to work with a partner- they have to be **taught** how to work together and it is best if the teaching begins during the first few weeks of school - so you can think about that when you begin your first teaching job. **But** there is something you could do now to promote better student collaboration. You will need to 1) be more specific about the collaborate behavior that you expect and 2) you have to reward positive and productive collaborative behavior. So for instance, when you ask students to work together, you might have to tell them exactly who they should talk with e.g. " Larry and Omar, you two should work together" then you have to tell them the exactly what they should do e.g. “Larry you explain, not just show, your answer, to the problem first and then Omar should tell Larry what you think about his explanation…Once they know what you expect and have done it sucessfully , they will do it more naturally. Challenge yourself to see what progress, you can make in helping your students to work together. There is alot that you can do it does not have to be left to chance. So try to think about what you can do and try it and see what happens. We are always learning to teach	
March 13, 2013 at 10:06pm	Jake: I completely agree with what	Jake concurred with the US’ suggestions about facilitating group work and agreed to

	you have written. I collected from my failed attempts that it was not a natural tendency for students to be able to collaborate effectively. In fact, while I was at [a middle school] for two weeks during the fall, the CT I was with talked about how they had to train their students to work in groups like what is a good group looks like and what a bad group looks like … A lot of their class was centered around group work and self- investigation which I really liked for the age group. I see what you are saying. Lay it all out there for them, so they know exactly what is expected of	try some of the suggestions and see what happens.

	them. Students are good at doing what is expected... well most of the time... I will try this and see if it helps improve the classroom dynamic at all. Thanks for the advice.	
March 11, 2013 at 10:42pm	Jake: In Algebra 2 we had a review day for our test on Wednesday (and Thursday for A1 and A3). I think I finally figured out a way to involve everyone while not allowing one group to dominate in a review game setting. It is nowhere near perfect, but with tweaks, it might get there (scratch that, nothing will be perfect, but I can dream right?) The class was split into groups of two, chosen by the students so they would be comfortable enough with each other to work together. I created a PowerPoint of review questions, and as the question showed on the screen, the time was started and each group went to work to find the answer. Once the answer was found, the board was flipped over so nobody could see until the time ran out. Once time ran out, I would motion for the boards to be raised, those groups with the right answer got a point, those who were wrong didn't. I like this for many reasons: 1. the groups are	Jake implemented some intentional strategies to facilitate student collaboration during a review game in his Algebra 2 classes. To promote more student participations, he limited group size to groups of two and he allowed students to pick partners with whom they can work comfortably. In contrast to past review games, where only the team who got the correct answer first earned points, he awarded points to every group that arrived at the correct answer. Also having groups display their answers on white board provided a way for Jake to assess students' understanding.

	small so more people are working at one time, 2. it doesn't allow one team from keeping the other teams to succeed, 3. I get a better read of the class as a whole rather than the typical review game that just assesses the fastest students. The one drawback is the inability to make corrections for points, but I will take that for now.	
March 12, 2013 at 12:15am	US: Great !. I also like the game. What an improvement in getting more class participation during a review game - yes, small groups of 2 seems to be a key component here and so nice that you moved away from rewarding the fastest answer, and that you were able to get better read of the class as a whole. Curious to hear how it goes tomorrow.	US congratulated Jake for increasing class participation and student collaboration during a review game and highlighted that his decision to create small groups of two might have been a key component of his success.
March 12, 2013 at 10:31pm	Jake: A1 it went great. They were into it, asking questions, everyone was participating … only problem is there are students in there who don't get the content whatsoever so oftentimes …. Its a learning process and I am definitely learning what the optimal learning environment sounds like. But I will definitely keep this idea in my back pocket for future reference.	Jake's new structure for review game worked well in his other algebra 2 classes and Jake welcomed his new review-game to his teaching repertoire.
March 20, 2013 at 11:47pm	Jake: In Geometry, theorems are obviously what most of the teaching centers around, so I was tired of just giving students the theorem and having them memorize (what my CT typically does by PowerPoint), so today I switched things up a little bit. Much like I have been trying with my Algebra 2	While introducing a new theorem in an advanced Geometry class, Jake diverged from the way his CT usually taught. Instead of "just giving students the theorem", Jake asked the students to infer the theorem from a diagram illustrating the theorem. Jake found that the "discovery the theorem

	classes, I tried to get them to discover the theorem on their own, still in a discussion type setting. In this case, though, I gave them a diagram of what the theorem stated (in this specific case, it had to do with central angles, arc measures and chord lengths). From the diagram, I asked the students to infer as to what the theorem was going to establish. B1 worked like a charm, so much so that a student who is typically lost and frustrated with a crap ton of questions along the way, was excited because he/she "understood something on their own." (he/she was the one that was able to state the theorem to the class in her own words). I really liked how this turned out in the Advanced class setting because the students were more eager to answer the questions due to their increased academic drive…I will definitely tailor my lessons whenever possible to showing pictures first, words second to let what is really going on soak in.	activity" engaged his students in thinking and discussion and seemed to enhance their understanding.
March 21, 2013 at 1:06pm	US: It's great that you were able to "switch things up" in Geometry , like you have done in Algebra 2, with such positive results - engaging students in thinking and figuring out things as well as connecting with a student (he or she) who is usually confused. I think you are also to be commended taking the leap to present a few things differently (than your CT might have done) with the aim of engaging students more in the lesson. Perhaps your	US commended Jack for once again, taking a leap to present new material in a way that engaged students in thinking and reasoning. US congratulated Jake for his success in doing so in his advanced geometry classes

	leaps don't always land they way you want but a least you are taking steps toward involving students more in thinking and you are learning about what works and how to make things work better.	
March 28, 2013 at 10:48pm	Jake: As I sit at my desk in my room, reflecting over the day's activities, I have begun to realize more and more that I am in the right spot. Today, I honestly had a lot of fun. The Geometry lesson was over circles. The students were active and participating… I really liked how the theorem presentation has been working. By showing them the picture first, I believe they are increasing their ability to problem solve just by looking. This is exciting because this is life around them.	Jake continued his strategy of showing the picture first, to introduce new theorems. Jake had a revelation that the" picture-first" strategy is a way to increase his students' problem-solving skills.
April 2, 2013 at 1:15pm	US: Hey Zack, I am struck my your comment above " By showing them the picture first, I believe they are increasing their ability to problem solve just by looking. This is exciting because this is life around them." It seems to me that despite your sometimes failed quest to " do some real world applications" , you have perhaps accidentally landed on promoting some "real- world" skills in the way you introduce theorems and defintions with your advanced geometry class. What do you think?	US quoted Jake words to suggest that perhaps in his efforts to engage students in thinking that he has inadvertently made progress in his major goal to integrate real-world applications. (Note: Up until this point Zack had been discouraged by his multiple failed attempts to conduct a real-world application lesson.) .
April 7, 2013 at 4:38pm	Jake: Haha I love it. Teaching this way is so	Jake reiterated how much more he enjoyed

	much more enjoyable than bearing the load like I was the first two times you observed me in Algebra 2. I get to facilitate the learning process rather than feeding them everything they might need to know. I have a lot more fun presenting things this way.	teaching when presenting material in ways that evoked students thinking and reasoning about the content
April 8, 2013 at 11:16pm	Jake: Before we started the notes, I gave pairs of students a mini white board and a dry erase marker. In the past, what I have done when introducing new theorems is given them the picture and had them give the words of the theorem. Today I switched it up. The definition of the theorem would come on the screen, and from that point for about 2 minutes, their goal was to copy the definition and create a picture and equation to represent the theorem. Once the two minutes was up and I everyone had made a solid attempt, they turned to their partner and took another two minutes to converse about the right answer and record a final answer on the board (both picture and equation). Once the second two minutes was up, each group would hold up their boards, we would look around at all the submissions, go over the right ones and talk about what happened with the wrong ones. I did this for the whole class, consisting of 4 theorems and 4 example problems. To be totally honest, I felt as if I wasn't even teaching, yet they still seemed	Jake implemented another strategy to elicit students' thinking when introducing new theorems. He shows students a written statement of theorem and asks students to generate picture or equation that represents the theorem. Furthermore, he integrated a think-pair share element where students first, have two minutes to think on their own and then. two minutes to converse with their partner and compile one final answer on a whiteboard. The group responses were the catalysts for a class discussion about the meaning of the theorems.

	to understand the material. …. I like the way it went because it forced them to really understand the words of the theorem in order to draw a picture or formulate an equation. It had a nice group aspect to it as well. Definitely going to keep this in the back pocket for years to come.	
April 9, 2013 at 6:22am	US: I love it , I love it.. I love it. What' I love about what you did in geometry today is that you progressed a little further in engaging the students in doing the mathematics- but just tweaking something you have already done . You reversed your picture the words strategy and to words to picture strategy- both of which are important aspects of mathematical thinking Also I am really pleased with the group aspect that you introduced today- again its like you took something you have don already with the white boards in review games and took it step further. I love the think- pair share element in this learning approach. What's even more great (I am not sure if that is correct is English) is that you tried similar approach in Algebra 2 where the students are less motivated and not advanced - perhaps with different results but the challenge is to continue to tweak and refine your ideas to a make them work for various student populations keeping in mind that your goal is to engage students as much as possible in doing and communicating mathematics	The US was thrilled with Jake's willingness and success in developing and adapting strategies to invoke students thinking when presenting material. Furthermore, she was also pleased with Jake's progress in facilitating student collaboration in small groups. Finally she praised Jake for introducing strategies that engaged students thinking in both Advanced classes and general Algebra 2 classes. She encouraged Jake to continue on the path of involving students in thinking and communicating about mathematics.

Jake's development Stage 3 Embracing a new flow	
Jake continued on his course of involving students in thinking during his lessons. He developed several variations of his initial find a pattern/ discovery the rule activity and implemented them with success in both his general algebra 2 and advanced geometry classes. Jake found that the outcomes of implementing his new strategies are that his lessons are "more interactive", students are "forced to think" and he felt more like a facilitator of learning. In spite of his initial trepidation, he also progressed in facilitating and integrating small group collaboration in his lessons.	
Jake's Post-Interview Comments	
Post-interview comments in response to the question: *How do you think Ning conversations are related to what you learned and or your growth as a teacher during student teaching?*	Synopsis
"It was good to be forced to put my thoughts on paper…. What I appreciated most was the comments because I was going to beat myself up over it [my teaching] and I needed some else to say something about it and most of time it was my US and she would have positive things and even she would have negative things to say, which I am totally fine with because it was constructive criticism ... I appreciated that kind of dialogue that came about in my reflection I am not a great reflector so I did not always enjoy it during the time but I do think it was helpful."	Jake found the Ning conversations to be venue for helpful feedback and reflective dialogue about his teaching.
My US pushed me to do things outside my comfort zone….. She voiced her displeasure with some things I was doing. And it was like Ok, it's time to do something different because I was tired of not doing things sufficiently …just in her comments she had some good things to say …Take some risks, this is your time to take risks …so I appreciated that about this online stuff.	Jake found that, in online conversations, the US pushed him to get out of his comfort zone and take some risks about presenting material in ways that engaged his students thinking.
• To be able to put my words and then read my words on paper and see that enjoyed what I was writing and saying, gave me incentive to continue to do things this way through the semester- this way meaning " more	Jake found that writing and reflecting in an online post about his initial success and enjoyment in doing more investigative- type presentations, dialogue and questioning techniques provided him with an incentive to continue with the new strategies throughout his student teaching semester.

investigative-type presentations , more questioning techniques, less monologue and more dialogue"	
"It was good to me that my US affirmed my " if then" statements. I appreciated that, otherwise, I might have scraped it…. It gave me another tool that I could use, a different tool in my back pocket. The positive affirmation was good… I used the " if then statements a couple of other times." I used to think that " though lessons are boring, kids could still have fun, if the teacher is fun but, I think that' true but It's harder. But later, I realized that you can be less fun but increase the content fun and students will enjoy it… I was putting not only content but the engagement on my shoulders. If I wasn't funny enough or if the kids were not willing to listen to me for long enough I felt like I was doing something wrong. I thought that engagement was solely on my shoulders [my personality], how naïve was that?	Jake found the online conversations to be a venue for positive affirmation from US about his introduction of a new strategy (completing if - then statements) to elicit students thinking and promote student collaboration. Jake found that the online conversations challenged his initial belief that in order to engage students in learning he, as a teacher, would need to be fun, funny and entertaining. His conception of engagement shifted from concern about being a "fun" teacher to attention to strategies that involve students in thinking about the content.

Figure F 2: *Jake's development in eliciting students' mathematical thinking*

Figure F-3: Tracking Sam's development in promoting student collaboration

Sam's* Pre-interview Excerpts

Pre-interview excerpts(January 11, 2013)	Synopsis
What is involved in "good" mathematics teaching? "Part of good teaching is the students being engaged with the material actively thinking about and working with concept you are teaching, having to think originally" *Describe a specific time when you have seen "good" mathematics instruction*? "A lot has to do with a classroom that encourages dialogue between the instructor and students but also between the students about the concepts… Anytime I have seen real effective teaching, it is a back and forth between instructor and the students and between the students with each other… where they are working these concepts out and making them their own and they are doing it with each other ... there are a lot of good things that happen when you work cooperatively and there is dialogue and you learn from another person and the two can come up with new ideas or better ideas…" *Which of the NCTM process standards do you specifically want to work on during student teaching?* In addition to creating dialogue with the students and between the students "I would like to get better at presenting mathematics in different ways … being able to create different representations and present those in an effective way."	Sam hoped to actively engage his students in mathematics. He believed that effective teaching is when students are engaged in dialogue about mathematics with their instructor and each other. Sam valued collaborative learning as effective means for enhancing students learning.

Sam's online posts and responses

Date	Online mentoring conversation excerpts [a]	Synopsis
January 12, 2013 at 12:14am	Sam: After the initial lesson on the Pythagorean Theorem, my supervising teacher and I decided the student could use an additional day of work with this information before moving to the next concept. To accomplish this we designed a station activity for use with each class. This activity was made up of nine different stations where students would have between four and five minutes to cooperatively work through two problems applying the Pythagorean Theorem. After a warm-up and review of homework problems we divided students into groups of three or four and set them into moving through the classroom from station to station completing the activity. Throughout the activity my supervising teacher and I walked around and worked with individual groups. .	Sam described a station activity where students worked in groups of four or five to complete problems involving the Pythagorean theorem. During the class, Sam walked around to work with individual groups.

January 12, 2013 at 11:42am	US: … Tell me something about how “well" the geometry students worked together in groups. In our interview, you spoke about the importance of student collaboration. Does the group work you have witnessed so far in the geometry classes live up to your vision about student collaborations? Is there something about student collaboration in the geometry class that could be better? Do they stay focused on mathematics? do they express their thinking, ask each other questions, do they work independently or interdependently? Have they been given guidelines for group work behavior?	The US asked Sam several probing questions to prompt Sam to reflect on aspects of group interaction he observed during the station activity. In addition, the US asked Sam if there were any pre-established guidelines for group work behavior.
January 13, 2013 at 3:33pm	US: Thanks for such a complete response to my questions about group work and student collaborations. Your observations reflect the variety of things that can happen when students are asked to work in groups. You noted that watching some groups was frustrating and that you "encouraged these groups to work more as a team." Think about what other strategies you could use to promote the type of group interaction that you would like to see. Students don't naturally know how to work in groups, sometime it happens but most often students have to be " taught " how to work in groups which mean explaining, modeling and providing specifics about effective/expected group behavior. Also students often do what they are rewarded for. How do we reward and affirm "good" group behavior? or do we just reward getting to right answer. Fortunately, .. you will probably have many opportunities to **faciliate** students work in groups as you walk around and co- teach so you can begin to experiment with what to say and do the promote more effective group work. I am curious to hear about what you try to do and what you learn by trying.	The US challenged Sam to think about what strategies he could use to promote more productive group interactions. She encouraged Sam to try some strategies and share what he learned from doing so.
Sam’s development: Stage 1-Noticing less than ideal group work		
Sam monitored students working in groups during a station activity. He observed that some groups worked well together while other groups were off-task. In addition, Sam found it frustrating to observe groups not working together as team-i.e. the students letting one person in the group do all the work and, then copying answers with little explanation. Thus, the group work that Sam observed only “partly met the ideal” that he had visualized. The US challenged Sam to think about strategies, other than simply encouraging groups to work together, that he could use to promote the type of group interactions he envisioned. She encouraged Sam to try new strategies to promote more effective group work and to		

note what he learns.		
Date	Online mentoring conversation excerpts [a]	Synopsis
February 9, 2013 at 9:33pm (in reference to February 6th classes)	Sam: Today's experience brought another first, the first full day of teaching. Today I picked up my first college prep class and with that I taught all three blocks of class. My schedule was A1 Geometry, A2 College Prep, and A3 Geometry. Additionally, today was my observation day by my university supervisor. It was a big day for me, to say the least. In Geometry, we spent our class learning a couple of new vocabulary words/terms in "Angle of Elevation" and "Angle of Depression" and also working through written Trigonometry word problems. This lesson is the culmination of all of the Trig we have been learning these past couple of days. Today was an opporutnity to bring all of these concepts together to solve problems with real world applications. It was also a day to use group work and peer scaffolding in the classroom. This strategy was utilized with both Geometry classes. Additionally, I allowed students to present solutions on the whiteboard and explain these solutions to the rest of the class… Overall, all three classes went well and my objectives for the day were met. The second geometry class went better than the first because I made adjustments to my initial plan.	Sam incorporated a group work component in his geometry classes. After presenting new vocabulary and working through a sample trigonometry word problem with the entire class, Sam asked students to work together to solve similar word problems. In addition, Sam allowed individual students to present their solutions on the whiteboard. Sam did not make specific comments about how well his students worked in groups or about strategies he implemented to promote productive group work but he reported that his geometry classes went well and met his objectives.
February 6th, 2013 US' post- observation comments	Note: US observed the class describe in the post above. She did not provide a response to the post above online but did provide Sam with feedback about this lesson during the post-observation conference. The US' observations and feedback in relation to facilitating student collaboration are summarized in the following comment from the Sam's post- lesson evaluation form: Sam should continue to implement and refine ways to promote student collaboration - continue to model and affirm examples of and articulate guidelines for effective collaborative behavior….Sam should expect and ask for even more in participation and mathematical work., …Expect and insist on all students full participation as much as possible (e.g.…You must participate in working in group even if you do not understand anything.) Sam	The US challenged Sam to implement and refine intentional strategies to promote more student collaboration and mathematical discourse.

	should continue to implement and refine ways to have students communicate their mathematical thinking and refine strategies for reviewing individual student's whiteboard work in ways that include the whole class in critical thinking-(e.g. asks students to identify what is great or not so great about student's work on whiteboard, ask class to ask individual students questions about their work on white board, ask student to present work on whiteboard as a group.	
February 9, 2013 at 10:01pm (in reference to February 8th)	Sam: The geometry class times were very productive as most students successfully worked through the review packet. In addition the beginning of each class started well with questions from students about the concepts learned during the trig portion of our unit. There was a significant amount of "mathematical" discussion occuring during the group work time and many students could be observed providing peer scaffolding to their group members. These classes feel well positioned going into the assessment on Monday.	Sam incorporated a group work component on a review day. Students worked together in groups solving problems from a review packet. Sam reported that a significant amount of mathematical discussion occurred during the group work but once again, Sam does not describe his role in facilitating group work.
Sam's development: Stage 2-Noting the strengths and overlooking the weaknesses		
Sam provided several opportunities for students to work in group during his lessons. Most of group work involved students working together to complete practice problems. In general, group work seemed to be going well but Sam does not describe the quality of his students' group work in detail and does not highlight any specific strategies that he used to promote effective group work. US encouraged Sam to continue to implement and refine strategies to promote more student collaboration.		
Date	Online mentoring conversation excerpts [a]	Synopsis
March 18, 2013 at 8:09pm	Sam: I had planned a little different type of activity for both my geometry classes in an effort to create some deeper connections between polygons in the coordinate plane and the idea of parallel and perpendicular lines. I planned a warm-up which dealt with the concepts of parallel and perpendicular so that the students would get back into the swing of things. We then dealt with a couple of questions over the homework for approximately ten minutes. The activity consisted of the students getting into groups of three or four and each group was assigned a single sheet of paper which contained an xy-coordinate plane, a set of points (either three or four), and a	Sam planned a group activity where students had to work together in groups and complete several mathematical tasks in-order to come to a conclusion about the identity of a figure. Additionally, students had to present and justify their findings as a group to the rest of the class. The group activity worked well in every geometry class except the B2 geometry class where students were "only 50 % engaged

	list of tasks to complete. The groups were asked to plot the points and sketch the graph of the figure. Then they were directed to identify the figure as specifically as possible by using information like the slopes and lengths of the sides and follow up by explaining their reasoning for the identification. Finally, the students were asked to find the perimeter and area of the figure. All in all, the students should have had to use a combination of distance formula, slope formula, Pythagorean Theorem, and counting to find the information required for each figure. For this activity I created eight separate figures (Triangles - scalene, isosceles, right, and equilateral; Quadrilaterals - square, rectangle, rhombus, and parallelogram) and assigned one figure to one group, making eight groups to work together. The final part of the activity was to have each group present their figure to the class and share how they arrived at the solution. I saw this as an opportunity to vary my instructional strategies and also to hopefully create deeper meaning and conncection for the students. The first block of students seemed to connect to this exercise effectively. We were only able to have two groups come up and present their solutions but they were able to effectively communicate the outcomes set for the lesson. The second block of geometry students was another story. Out of the four geometry classes this is the most challenging as far as classroom management. This group seems to take longer to do everything and today was not the exception. The opener took longer than the first block which set the stage for struggle. Then this class was about 50% engaged during the group work time. We were only able to get to one group at the end of class and their presentation lacked a great deal of detail. I believe that the beginning of this lesson was the downfall and that a better start is the answer to a more complete finish.	during the group work time."
March 18, 2013 at 11:25pm	Bravo for trying an ambitious group activity. It will interesting to hear or perhaps see how things go tomorrow	US applauded Sam for planning and facilitating a group activity that involved sustained student collaboration on a multi-facetted task, as well as group presentations.

	Note: US observed the same lesson described in the March 18th post above on the following day, March 19, 2013 and provided feedback, during the post- observation conference. Her observations and feedback in relation to Sam's role in promoting student collaborations are summarized in following comments from post-lesson observation evaluation.	
US post- observations comments March 19,2013	Sam walked around to montior and encourages students working on the group activity (" Make sure you are working together".”Make sure everyone is involved”...) In general, students worked togehter collaboratively in groups and were on task., To ensure productive group work, in the future Sam could establish more specific expectations about group work behavior at the beginning of group work activity (e.g. assign speciific roles/tasks for group members, model prodcutive group conversations…) and provide rewards or consequences for postivie or negative groups behaviors(e.g. verbal praise, points toward/off grade,…)	The US highlighted statements Sam uttered to encourage student collaboration during the group activity. The US recommends that Sam should also proactively promote productive group work by establishing specific guidelines and expectations for group behavior before the group activity begins.US suggests some possible methods for doing so- “assign speciific roles/tasks for group members, model prodcutive group conversations…
March 24, 2013 at 11:42pm	What a difference a day makes! In my previous posting I discussed how the group activity I designed to work with graphing polygons in the coordinate plane just did not work as well with my B2 geometry class. This was mostly due to the issues of classroom management I am experiencing with this particular group. After Monday's class and following my experiences from yesterday I was able to get ideas from both my CT and my [US] regarding how to approach the completion of this activity with my classes today. The outcomes were vastly different from Monday (and that is a beautiful thing)! My focus for today was to take a few minutes at the beginning of class and address the issues of last class and then help the students see the purpose of our activity and lay out clear expectations for the group work and the presentations. What resulted was a completely changed environment, particularly in B2. The students were significantly more engaged with the concepts and the activities and the presentations were effective and complete. I was very impressed with the overall performance of my students and my CT	Sam implemented strategies, in his B2 geometry class, aimed at improving student engagement and participation in the group activity. Specifically, Sam established clear expectations about group work and group presentations at the beginning of the lesson. Sam saw significant improvement in student engagement and student work in the group activity in comparison to first time the B2 geometry students were assigned this activity.

	noted the improvement as well	
US post- observation comments April 22,2013	"After responding to questions about the video, students were instructed to work in pairs to complete practice problems on elimination and substitution. Scott and his CT modeled how students were expected to interact while working together(alternating doing each step…) The students stayed on task while together on assigned problems throughout the last 40 minutes of the class…. Scott thoughtfully and successfully designed all aspects of this lesson with the aim of involving students in various ways throughout the lesson: e.g. The introduction of the topic included eliciting students' input; The video/note taking activity was created to provide a novel way to review material that maintained students attention; The instructions/ model for how to interact during group work was designed to keep every student in group involved."	The US noted Sam's effective use of the modeling strategy to establish guidelines for group interaction and promoting productive student collaboration.
Sam's development–Stage 3:Realizing the efficacy of establishing guidelines		
Sam designed and implemented a group work activity that required students to work together in groups in a more involved mathematical task than in previous lessons While the activity went well in most of his classes, student participation and collaboration on this activity not go well in one class which prompted Sam to seek and reflect on strategies to promote more productive group work in future classes. As a result of discussions with his CT and the US, Sam adjusted his teaching to include providing his students with clear expectations about group interactions prior to beginning group work. In one case Sam, discussed the expectations before beginning the group activity. In another case, Sam and his CT modeled the expectations for group interaction before student's worked in pairs on sample problems. Sam celebrated the positive outcomes from both of these cases as strides in his development as teacher.		
Sam's post- interview comments		
How do you feel you have progressed during student teaching in relation to your initial goals and or any other NCTM process standards?		Synopsis
"About student collaboration and getting students to work together, there were some strategies that I had never tried in the classroom, for example peer coaching … we tried that a couple of times it was very successful. Another one," where I had students actually come up and present their own solutions corporately to the class … giving them an opportunity to display their own abilities, their own knowledge, and their own understanding of concepts I was able to foster that collaboration in the classroom. I learned about how the students worked together, like watching them interact, I figured out really quickly that if groups have bigger than three, you are in trouble sometimes…Also, I tried a few things like how they were grouped…		Sam experimented with different formats for student collaboration and different compositions of groups. Scott learned, from his experiences, how to foster and improve student interaction. Scott attributed his growth in facilitating student collaboration to the fact that he tried various strategies and learning from his experiences. He did not mention any specific teacher enacted strategies for facilitating group work other than choosing composition of groups or limiting the size of

sometimes, I would allow them to choose partners, sometimes, I would randomly assign them a group , sometimes, I would assign them in groups specifically based on what I was hoping to accomplish…All those things were kind of new, just trying things to try and see how it worked in the classroom. But everything that I did helped me to see and learn how these things tie together and how the students interact and how to be maybe help them interact better…"	the groups.
Sam 's Comments Relating Online Conversations to His Development in Promoting Student Collaboration.	Synopsis
The fact that could have this conversation(see January 12, 2013 online conversation) and not be in the same room was fantastic for me because it helped me to formulate even better ideas about what I was doing in classroom, because US asked questions that I might have thought to ask myself. And, her experience in the classroom came out in in her questions because I think US anticipated some of things that I had blogged, things that I was not able to anticipate. ... For me, US asked questions that I may not ever been able to come up with or formulate on my own, which made me think over those posts even more when I did my response. So, I was getting, not just the benefit of reflecting on the activity on my own, but I was then getting a second opportunity to go back and reflect again with additional questions, with another set of lenses. When US keyed in with some of her questions, it gave me, yet, another perspective that allowed me to re-inspect what I had experienced and then talk about it some more."	Sam found that the questions that US asked him in online conversation about student collaboration during group work forced him reflect on aspects of group work that he might have thought about by himself.

Figure F 3*: Sam's development in promoting student collaboration*

Figure F4 Tracking Christy's development in attending to students misconceptions

Christy's* Pre-Interview Excerpts	
Pre-interview excerpts-January 14, 2013	Synopsis
What is involved in "good" mathematics teaching? It's keeping the kids entertained and keeping then interested in the subject and being able to make things fun for them, instead of me lecturing, twenty- four, seven. I just don't think that helps the kids learn. I don't think they retain when you teach that way. … *Describe a specific time when you have seen "good" mathematics instruction*? Just teachers who are more, um… I don't know… like Mrs. Davis** has a lot of rhymes kids remember that. Its little things that stick out to them and make a difference. Any little thing that can make a difference.	Christy thought that "good" teaching involved keeping the kids entertained and interested in mathematics and not lecturing too much. She could not seem to recall specific examples of good teaching. She only mentioned a teacher who makes up rhymes to help kids remember mathematics facts.
Which of the NCTM process standards do you specifically want to work on during student teaching? I think that Connections stand out to me. Students think algebra has nothing to do with geometry. They don't see how everything is actually one big picture. I think, if they would see the big picture , it would make things click more and it would make all of the math concepts a little bit easier for them….So I think Connections is huge thing.	Christy wanted to work on helping her students make connection among various topics of mathematics during student teaching.

Christy's* online posts and responses		
Date	Online mentoring conversation excerpts [a]	Synopsis
January 11, 2013 at 8:35pm(in reference to January 10 classes	Christy: Unfortunatly some of my students still do not know the basics. Like the order of operations or how to type -3^2 iinto the calculator. They do not logically think through the fact that a -*- is always positive. One question which was frrequently missed tdue to the lack of fundamentals was -4(-3)^(14). Most students simplifiieed this to 12^12 or -12^14 ddepending on how they put it in tthe calculator. Anytime I see something like this when I am grading I immediately correct and tell them to think about the order of operations. If I am helping a student and see this I tell them to think	Christy noted students' error's with basic skills, like using the order of operations and using a calculator to perform sequence of operations. Christy responded to errors by reminding students about the order of operations and by trying to help them to think logically.

	of the ordeer of operations. I have also tried teaching them to think -3*-3, is this positive or negative and even teaching them to put (-3)^2. I first teach logically thinking it through and then show them how to putt it in their calculator	
January 11, 2013 at 9:14pm	Christy: My students were working or Series and Sequences today. They had to determine if it was Geomeric or Arithmetic and then find what term the last term was and put it in the summation notation. The students struggleed a little figuring out what to do but when they figurrd it out they did pretty good and were able do it on their own. The most common misstake wwas trying to simplify from 8(10)^(n-1) to (80)^(n-1). I always tell them to think of the order of operations. I am confident that they will remember this soon.	Christy observed similar errors with order of operations in classes the following day. Once again Christy reminded her students to remember the order of operation She felt confident that they would soon remember to do so
January 14, 2013 at 10:53pm	Christy: Today some of my students learned about logarithms and others learned more on series. My students really seemed to struggle with using the sequence formula to solve a series. Others just didn't like the Sigma that was used to represent the summation of a series. Students don't see the connections between the topics. I don't think they understand that a series is just a summation of a sequence. To me this topic seems really easy. You just plug some numbers in, you just have to know how to use the formula. I try to get them to calm down, a lot of them were freaking out, and tell them it's a lot easier than it looks. I understand a_1, a_n, etc. can be a little scary to students. Then I explain what a_1 and a_n are then ask them what number that corresponds to. Then I think they start to understand.	Christy observed students struggling with topics that seem to be easy – just plugging numbers into a formula. Christy thought that her explanation of the meaning of the variables would help students understand how to plug numbers into the formula.
January 15, 2013 at 9:40am	Abby***: I remember that when I first learned about sequences and series, it was a somewhat abstract concept to wrap my head around...even though it does seem simple now. Good luck on your first teaching day! I get to start tomorrow!	A fellow student teacher responds to Christy's post.
January 15, 2013	Christy: I felt like it was a pretty simple concept until I started	

at 6:51pm	presenting it to my students. It is just plugging in numbers to me but they were much slower than I anticipated. Good luck tomorrow with your first day	
January 16, 2013 at 10:43pm	Christy: Today I had my first solo class. I think the class went better than I thought it would. I decided to start with the class that I thought was the hardest… My student's understanding was a little rough. I was expecting them to remember what the different variables meant from the arithmetic series notes. I was wrong. They did not remember anything. So the problems went much slower than expected	Christy taught her first solo class on arithmetic series. She was surprised that students did not retain information about meaning of variables for arithmetic series that she helped to explain in previous classes.
January 18, 2013 at 11:01pm	Christy: During my second day teaching I had a review session. My review was a PowerPoint slide with a printed out note sheet. I also had candy for correct answers. The kids really seemed to respond to the candy. I had much more engagement when there was candy involved…The material was on series and sequences. The students really seemed to be getting better at the material. When some them seemed to be doing other things (phone, reading, coloring, etc.) I started cold call. This really seemed to get their attention. They did not want to be called out and not know the answers.	Christy taught a review class on series and sequences. To motivate student engagement, Christy rewarded correct answers with candy. Christy found that students seemed to be getting better at the material.
January 19, 2013 at 7:36am	US: … Now about your teaching and your students' learning. Describe the design of your ppt review? Was it effective; how might you change it next time? Did getting candy require only involve giving the right answer? Did students have to explain or show how they got their answers? Tell me more, tell me more :)	US asked several questions to prompt Christy to provide more details about the components of her lesson as well as to prompt Christy to reflect on how well her lesson contributed to students' understanding.
February 5, 2013 at 7:14pm	Christy: I found a really cool PowerPoint with super hero's and sound effects on basic probability. We talked about what a sample space is, what Permutations and Combinations are, factorials and how to do things in your calculator…Prior knowledge was basically zero. They remembered very very little about probability and couldn't even make a fraction into a percent.	Christy started teaching a new topic, probability. Once again, Christy noted that students lacked basic skills and prior knowledge.

February 11, 2013 at 9:30pm	Christy: …As far as new mathematical material goes we worked on the same things as yesterday. We worked on multiple events and conditional probability. The students really struggled with the conditional probability. They don't understand what conditional probability is or how you find the probability of two conditional events. I plan on going over this in different ways and reviewing a lot!	Christy continued to teach probability topics. Christy observed that students struggled with conditional probability. Christy hoped that she could remedy their misunderstanding by going over the material again in different ways and by reviewing a lot.
February 12, 2013 at 1:26pm	US: Your students weak writing(probably reading skills)contributes makes teaching topics like conditional probability, permutations and combinations challenging because you have to constantly think about how to simplify language so that concepts are accessible to students which is a big task for novice teacher. During the course of reviewing this material for several days, did you find any ways of explaining things that seemed to have worked for students? Which permutation and combination stories really clicked with your students?	US suggested that Christy might need to think about how to simplify language used in explaining concepts. In addition, US probed Christy to articulate which of her ways of explaining or illustrating probability concepts might have clicked with her students.
February 12, 2013 at 5:34pm	Christy: Honestly it was kind of different for every student. So different things the more I explain and the more examples I use the more the students catch on**.**	Christy could not identify any particular examples that seemed to facilitate her students' understanding. She concluded that the more she explained and gave examples, the more students caught on.
Christy's development: Stage 1-Too preoccupied with students' inadequacies		
In relation to attending to students' mathematical thinking, Christy primarily commented on her general algebra 2 students' lack of prerequisite skills, lack of retention of previous material and their difficulty understanding new material. Christy's singular strategy for addressing students' misunderstandings was to review material again. Other than reviewing material and doing more examples, she did not identify specific aspects of her presentation of material that seem to increase students' understanding.		
Date	Online mentoring conversation excerpts [a]	Synopsis
February 21, 2013 at 6:06pm	Christy: The class I just picked up is like the best classes ever. They are truly advanced. They still don't study for their tests but at least they know what a complementary angle is! (And most of them turn in their homework) Today we reviewed a little geometry and then started probability. It was so much easier teaching them. They didn't	Christy taught her first lesson in an advanced Algebra 2 class and was delighted that, unlike her general algebra 2 classes, students in the advanced had prerequisite skills and knowledge and

	talk much, they answered my questions and they were correct when they answered. I gave them some problems to do from the book for in class work. They did awesome with the probability stuff.	seemed to understand new material easily.
February 22, 2013 at 12:07pm	US: I am really glad you now have an advanced class to teach. Ihope to finally now get a chance to talk with you more about teaching mathematics in NING. SO PLEASE, provide more detail about your lessons- What specific topic did you teach? How did you introduce the topic? What examples do you use? How did your students respond Reflect on students learning and thinking? What were there specific misconceptions? What will you change or do differently based on this lesson- what have learned about teaching - be specific.	US asked Christy for more details about the component of her lessons and more reflection about students learning and thinking
February 26, 2013 at 6:18pm	Sorry about not providing enough detail. We did a PowerPoint on Permutations and Combinations. We did Superheros. So we have superheros getting a ride in the batmobile. Then I asked them if I pulled three names randomly and gaave each person a peice of candy, Is this a permutation or combination. What if I gave the first person three, the second 2 and tthe last 1? The students loved it. I think they really got it becuase they were interested in it. Their exit slip really showed that they understood the material. Almost everyone got perfectt scores. There were only a few miscoceptions. Mainly enteriing it into the calculator. (We aren't teaching the formula and use of formula, although I did show them the formula and how you scoulld use it.)	Christy provided more detail about an example that she used to illustrate the difference between permutations and combinations. She concluded that students understood because her example was interesting. (The example involved Super heros getting a ride in a bat mobile). She did not observe any major misconceptions and did not mention any adjustments that she would make to her lesson in the future
February 26, 2013 at 6:48pm	Today I taught my Advanced class about Unions, Intersections and Compliments. We started with a PowerPoints with definitions and examples of a Union, Intersection and Compliment. I had the students telling me what they thought the answer was and then I went over it. I made sure to take a fffew seconds to let them proocess the question and most tof the time I got answers. I really enjoy that the students seem to remember from previous classes.	Christy taught her advanced algebra 2 class about unions, intersections and compliments and once again, noted that the students' retention of knowledge from previous classes helped them to pick up on new material quickly.

	They said they had heard of Unions, Intersections and Complliments before although they didn't remember perfectly. They picked up very quickly with the new material. I then gave them a worksheet that used M & Ms to do probabilities. I asked them for things I think they really had to think about sometimes. The students seemed to do pretty well with this worksheet only a few questions gave them troubles.	
February 27, 2013 at 2:53pm	US: Yes i think that your worksheet did have problems that they really had to think about. Now, try to recall what particular things on the worksheet students had trouble with and then think about how you might present material differently based on their misunderstandings. Include these details in your reflection about your lesson and in future posts try to include even more details about student's mathematical thinking- doing so will force you reflect more deeply on your teaching. It also will help me understand more about what is going on with your teaching since I cannot be there everyday.	US observed the class that Christy described above. To evoke Christy, to reflect more deeply on students thinking and the nuances of the mathematical content presented during the lesson, US asked Christy to identify worksheet questions where she observed students struggle and to then describe how she might address these misunderstanding in future lessons.
February 28, 2013	Note: Chirsty does not respond to her US in NING but does submit post-lesson reflection that addresses some of her US's requests in the post above. Below is excerpt from Christy' s post- lesson reflection	
	" The strengths of these students are they learn fast, they remember most things from Algebra 1 and they are able to build on old knowledge. Their weakness is they rush through material and make careless mistakes.".. I think my instrucation was very effective. I think the students were cabable of learning and did learn very well… They all struggled with intersections with compliments. I will review this material in my next class and have them do a problem of this type on their own.	Similar to previous comments, Christy' credited students' success to their ability to learn quickly and their retention prior knowledge of algebra 1. (It is interesting to note that algebra 1 skills have little relationship to the mathematical concepts: union, intersection and compliments, presented in the lesson.) She did not provide any details about students' specific misconceptions and

		once again planned to address misconception by reviewing the material again.
March 17, 2013 at 4:50pm	Today we went over the rational root theorem. A lot of people also know it as the P over Q test. The students really didn't like it at first. The Rational Root Theorem has a lot of steps so the students started to tune me out. After going over the steps I gave the students problems to do on their own. I then went around to students individually to see how they were doing. After talking to a few students they said "Oh, that's all you have to do." They thought it was really easy after they tried it… Their mathematical thinking I would say is lazy. It's not that they cannot do the material it's that they are too lazy to try the new material. They don't want to do something if there is more than one step or anything they have to think about.	Christy taught the rational root theorem in her general algebra 2 classes. She described the students' mathematical thinking as "lazy".
March 17, 2013 at 4:50pm	I then had them do a review on factoring and multiplying polynomials. All things they should have seen in Algebra 1. They all seemed to remember everything really well. Then we worked on Algebraic Rational Functions, which was basically just introduction to polynomials. … Their mathematical thinking is well developed but I think they need to be pushed more.	Christy introduced rational algebraic functions in her advanced algebra2 class. She described the students' mathematical thinking as" well- developed."
March 27, 2013 at 8:24pm	Today my students had an exam over polynomials. We gave them a EOC type exam. This exam I thought was pretty hard. My students did not do well. … I think my students are struggling because they don't know basic algebra 1 skills. Some of my students can't solve a one or two-step equation. They don't know what x times x is. They can't add two negative numbers. Their mathematical thinking is very weak.	Christy's algebra 2 students did poorly on an exam on polynomials. She attributed their poor performance to their lack of basic algebra1 skills. She described their mathematical thinking as weak.
Christy's development Stage 2: Broadly generalized students thinking		
Christy comments in relation to students' mathematical thinking contrasted sharply between her advanced algebra 2 class and her general algebra 2 classes. She described the mathematical thinking in her advanced classes as "well- developed" and in general classes		

as “lazy” and “weak”. Christy linked and, perhaps, equated her advanced class’ superior mathematical thinking to their ability to understand new material quickly and their retention of previous learned material. Christy does not seem to be able to think beyond her students’ abilities and prerequisite knowledge to critique her own instruction. US asked Christy to try to identify specific student misconceptions in her advanced class and to articulate plans for addressing those misconceptions. Christy did not identify any specific student misconceptions. To address the problems with which her advanced students had trouble, Christy planned to review topics and have students do similar problems on their own.		
Date	Online mentoring conversation excerpts	Synopsis
March 27, 2013 at 8:31pm	Today we worked on Conics. We went over a brief definition and the equation of each conic. I went over the definition, how a cone needed to be cut in order to make the shapes and what the graph looked like. My students then worked on a worksheet asking them to identify a conic given it’s standard equation. Then I asked them to find the center or vertex of each conic. …I also found the students struggled when it had a center or vertex at the origin. They didn’t like it when there was no number. They also didn’t like it when the formula had a positive but the vertex was a negative. I think I will start doing more misconceptions as bell ringers. I will also work on style of teaching now that the behavior has gotten better.	Christy described a lesson that was observed by her US. In her online post, Christy mentioned specific student misunderstandings that were highlighted during her post lesson conference with her US. Christy declared her intention to carry out her US’ suggestion to use bell ringers to address or anticipate student’s misconceptions.
March 27, 2013 at 8:53pm	Again today we worked on parabolas… This group had a harder time with the example with the distance formula so I did another example of this type. I noticed that they were struggling with the distance formula in general. Tomorrow I think I will do a bell ringer with one problem that is finding the distance given two points and another that is finding the distance given two points that have numbers and variables. I think this will help them understand the problems we did today.	Christy observed a specific misunderstanding that surfaced during her lesson on parabolas. She plans on doing a bell ringer to address the misunderstanding for the next class.
April 22, 2013 at 3:02pm	We started by doing a bell ringer that reviewed Radicals. They have seen radicals but they still needed some work with radicals. So I gave them simple review problems like the square root of 75. I let them work on the bell ringer for a few minutes and then I checked to make sure they did the review. I then went over the bell ringer.	Christy designs a bell-ringer to review and illicit prior knowledge and skills about radicals in a general algebra 2 class. Christy observed that the bell ringer helped students to recall a few things

	After the bell ringer students were starting to recall a few things about radicals. I made a PowerPoint that reviewed the basics of radicals. We went over different facts about radicals and then we did a few example problems. After the PowerPoint I had a 10-minute video on radicals.	about radicals before she presented information about radicals.
April 22, 2013 at 3:53pm	Christy: Today I again taught radicals. We started with a bell ringer. The bell ringer was over misconceptions from last class. Last class we went over Completing the Square. I had students do an Exit Slip on a Sticky Note they then put their sticky note in either a green spot, black spot or green spot. Green meant they thought they definitely got it right, the black meant they thought they got it right but they might've gotten right, the red meant I definitely did not get it right. I had most of my students in the green and just a few in the red. I then analyzed their answers. I found common mistakes and typed them up as a bell ringer. They had to fix the common mistake. I allowed the students to work in groups for this. Most of them came up with the correct mistakes. We went over the mistakes a class. I think this really helped them… I think I will continue doing bell ringers like the one I did today. I really like that and felt it really helped my students	Christy used information compiled from exit slips from a previous class to design a bell ringer for her advanced Algebra 2 class. For the bell ringer, the students worked in groups to identify and fix common misconceptions that Christy selected from the students' actual work on exit slips in the previous class. Christy felt like the bell-ringer activity really helped her students and she planned to continue to do similar bell-ringer activities in future lessons.
April 23, 2013 at 8:04pm	US: I liked how you gave the students an opportunity to assess their own understanding by choosing a green , black or red spot for their exit slip note. I also like how you gave students an opportunity to "find the error" This is nice way to allow students to do some critical thinking. … I suspect that the fact that you used " real errors " that students had made on the exit slips might have made this activity more motivational for the students.	US likes Christy's bell-ringer activity and highlighted the beneficial aspects of the activity: The bell-ringer provided an opportunity for students to do critical thinking , Incorporating students " real errors" served to motivate students to work on finding the errors.
Christy's development: Stage 3- Developed and utilized bell-ringer activities		
Christy embraced her US' suggestion to use bell-ringers to address students' misunderstandings. Christy designed a bell ringer to		

proactively address her general algebra 2 students' probable lack of retention of prior knowledge about radicals. She designed a bell ringer activity to help students in her advanced algebra 2 class to correct their own misconceptions. Designing the bell ringers seems to have prompted Christy to describe student misconceptions more specifically than in her posts in previous stages. Furthermore, using bell ringers to address students misunderstandings actively involved students in thinking and was a shift from Christy's initial efforts to remediate students' errors by simply "reviewing a lot" and showing more examples.	
Christy's post- interview excerpts	
Christy's Post-Interview Comments in Reference to Online Conversation- February 26- 27(See Table 2 above)	Synopsis
"I had not really thought about the misunderstanding too much before this comment(US' comment on February 27,2013) "I thought more about what I could do with misunderstandings and how I can fix them"	Cassie found that the Ning conversation- February 26-27 prompted her to think more about students' misunderstandings and what she could do to fix them.
"Towards the end, I started making bell ringers, that kind of did some of the stuff before; it was mainly for my other classes because they forgot a lot of math like simple things… so it was more for them(general classes) with their misunderstanding and that helped them."	Cassie described how she eventually used bell-ringers to address students' lack of prerequisite knowledge in her general algebra 2 classes.
With this class(the advanced Algebra 2 class), I started doing exit slips and had them rate themselves red, green and yellow whether they did really well or not very well at all , and then I graded them and put them in pile and put in piles based on misunderstandings so like, if 5 of them made the same mistake, I would put them together, and then I made that into a bell ringer and then, they had to fix their mistakes on the next day I saw them. That was kind of cool. They got to figure out what they did wrong and that class did very well with that.	Cassie described how she designed a "find- the- error" bell-ringer in her advanced algebra 2 class(on April 19) to correct their misconceptions
Christy's Post-Interview Post interview comments in reference to online conversations-April 22-23, 2013	Synopsis
"I was really exciting because they really did work on bell- ringer and I did not really help them very much I told them to work with	Cassie was delighted at how diligently and independently the students in her advanced class worked on the find- the- error bell

their friends …. I wanted them to get on their own. I had them really think about it for a while and then we did it together … it really helped them not to make those mistakes again. I think they will not often make those mistakes again."	ringer.
"I learned a new way to help them with misconceptions which was really cool I think if they do it themselves they figure it out on their own instead of me just telling them because if I tell them stuff they don't' really listen but if they figure it out on their own, it's like, 'yes', I did it !" . "It(the online conversation) helped me correct misconceptions and figure out better ways to deal with misconceptions. I guess that if that just told them what misconceptions were they would not remember it them 5 minutes later, but since they figured them out on their own, I think they are more likely to remember what happened and how not to do it again."	Cassie found that online conversations conversation helped her to learn new way to help students with misconceptions. She concluded that allowing students to figure out things on their own is a more effective strategy for addressing students' misconceptions than just telling them their errors.

Figure F 4: *Christy's development in attending to students' misconceptions.*

CURRICULUM VITAE

Landrea Miriti
771 Longwood Rd., Lexington, KY 40503
Home Phone: 859-314-9729 Office Phone: 859-246-6425 Fax: 859-246-4672
Landrea.miriti@kctcs.edu

Education

University of Louisville

Ph.D. Candidate Mathematics Education **2010-present**
Research interests: Pre-service mathematics teachers' development through clinical practicum experiences, mentoring student teachers.

Montclair State University

M.A. Math Education **1987**
Completed comprehensive examination in mathematics education, earned mathematics teaching certificate for grades 7-12.

Seton Hall University

B.A. Psychology **1982**
Suma Cum Laude graduate, minor in math and music

Teacher Educator Experience

Design and teach mathematics courses for pre-service elementary and middle grade teachers at Bluegrass Community and Technical College **2000-present**

Supervise secondary mathematics student teachers enrolled in University or Kentucky Masters with Initial Certification program **2008-present**

Provided year- long content focused coaching for elementary mathematics teachers in Kentucky **2003-2005**

Taught mathematics and mathematics pedagogy, observed teaching and provide feedback for in-service math teachers at the Newark public school's Harold Wilson School of Professional Development. **1990-1997**

Teaching Experience

Bluegrass Community and Technical College Lexington, KY **1999-present**

Instructor, Assistant Professor, Associate Professor, Professor
Teach developmental and, general education math courses, coordinate AAS 2+2 Teacher Prep, AAS Teacher Associate degree and Paraeducator Certificate programs, coordinate math courses for pre-service teachers, coordinate Mathematics and Statistic division " About Teaching Math" Dialogues

Newark Public Schools, Newark, N,J, **1984-1997**

High and middle school mathematics teacher, Project coordinator
Taught various levels of high school math to diverse student population in an urban setting, provided school-site professional development for elementary and middle grade math teachers, write district- wide math assessments, planned and facilitated district-wide math professional development, designed and implemented mathematics teaching and learning experiences at district wide professional development school.

Presentations and Publications

Miriti, L. (2004, May) *Teaching Numbers and Operations Strand*. Presentation at Appalachian Math and Science Project (AMSP) Math for Teachers Workshop

Miriti, L. (2004, September).*Facilitating Effective Communication in Math Classroom Presentation* at the Mathematics Teacher Preparation in Appalachia Third Annual Conference. Huntington, W.V.

McGatha, M., Schack, E., **Miriti, L.,** Lindsey, J., & Murray, S. (2005, September). *Content-focused coaching.* Presentation at the Mathematics Teacher Preparation in Appalachia Fourth Annual Conference. Lexington, KY

Miriti, L. & Ratliff, M (2007, March). *Japanese -style lesson study in higher education.* Presentation at National Council of the Teachers of Mathematics Annual Conference

Miriti, L. (2009, May). *Characterizing feedback: A university supervisor responds to student teachers' experiences.* Poster presentation at ACCLAIM (Appalachian Collaborative Center for Learning and Assessment in

Mathematics) Research Symposium.

Miriti, L. (2010, January). *Using digital literacy to enhance communication and reflection during student teaching*. Presentation at Association of Mathematics Teacher Educators (AMTE) Annual Conference.

Miriti, L. & Mohr-Schroeder, M. (2010). *Using online social networking to connect university supervisors to secondary mathematics student teachers' experiences.* Published in the Associated of Mathematics Teacher Educators (AMTE) 2010 Monograph Journal VII- Mathematics Teacher- Putting Research into Practice.
