

PROFESSIONAL GROWTH THROUGH MENTORING: A STUDY OF
EXPERIENCED MATHEMATICS TEACHERS PARTICIPATING IN A CONTENT-
BASED ONLINE MENTORING AND INDUCTION PROGRAM

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Education

in

Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

August 2008

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ACKNOWLEDGEMENTS

Completing this dissertation has been rewarding and I must extend thanks to those who have assisted me in the process of this research. First of all, I would like to thank my committee chair Dr. Elisabeth Swanson for her critical reviews of multiple drafts of this dissertation and her generous assistance in the development of many of the arguments presented here. Dr. Art Bangert provided invaluable contributions to the quantitative methodology and, similarly, Dr. Carrie Myers to the qualitative methodology used to substantiate the dissertations key findings. I am also grateful to Dr. Maurice Burke for his thought provoking questions and Dr. Jennifer Luebeck for her editorial efforts. Many thanks are extended to fellow graduate student, Genevieve Chabot, for her warm and collegial support; she served as a constant sounding board throughout this process. I would also like to thank Dr. Peggy Taylor whose dissertation I was fortunate enough to reference extensively as a guide.

This research was supported by The Center for Learning and Teaching in the West (NSF Award #0119786), Montana State University, and eMentoring for Student Success (NSF Award #0227184), National Science Teachers Association and Montana State University.

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ABSTRACT

It is well established that early career teacher practice can benefit from participating in effective mentoring and induction programs and experienced teacher practice can be enhanced by participation in successful professional development. But can experienced teachers improve their practice through their role as a mentor in a mentoring program? Although anecdotal evidence suggests that mentor teachers grow professionally through mentoring, there is limited research supporting this claim. Therefore, the purpose of this study was to explore the professional growth of mentor mathematics teachers participating in an online content-based mentoring and induction program, e-Mentoring for Student Success (eMSS). In specific, this mixed-methods study sought to determine what aspects of eMSS contributed to mentor professional growth and over what domains this growth occurred. Because the mentoring program was online, teaching and learning were dialogue driven and text-based. Therefore, this study also sought evidence of the mentor teachers' professional growth in the online dialogue and commentary they provided for analysis. Finally, active engagement in professional development is hypothesized to be a precursor to professional growth and development. Using mentors' activity level as a measure of engagement, this study also sought to determine if activity level was related to mentors' perceived professional growth.

The results of this study indicate that mentor mathematics teachers did grow professionally as a result of participating in eMSS. The experienced teachers reported growth in all assessed domains, particularity in their reflective practices, professional engagement and leadership, pedagogical knowledge, and in their access to instructional resources. Two predominant avenues of professional growth were cited as being important including reflection on practice and communicating with other mathematics educators. Program flexibility was also named as an important facilitator of professional growth. Finally, it seems that a mentor's activity level does positively relate to perceived professional growth and that much growth occurs "behind the scenes" and may not be evident in participants' posts. In conclusion, implications of the findings and how the findings may be used to purposefully design mentoring programs to assist in the professional development of mentor mathematics teachers are offered to program designers. Recommendations for further research are also suggested.

CHAPTER ONE

INTRODUCTION

Background

It takes time, training, and practice for educators to develop the knowledge and skills needed to become highly effective teachers. In fact, research indicates that student achievement is highest only after the students' teachers have been in the profession for a minimum of seven years (Darling-Hammond, 1997). Unfortunately, 40-50 percent of new teachers leave the field within five years (Ingersoll, 2003). This level of attrition makes it difficult for many students to realize their potential achievement in science and mathematics. Efforts are clearly needed to improve beginning teacher practice and to retain educators new to the profession. Electronic Mentoring for Student Success (eMSS) is an asynchronous, content-specific mentoring and induction program designed to meet this challenge.

In 2002 the National Science Teachers Association, the New Teacher Center at the University of California Santa Cruz, and Montana State University's Science/Math Resource Center were awarded a five year National Science Foundation grant to develop a content-specific mentoring program to support beginning science teachers. The program was piloted in California and Montana for two years and was then expanded in 2005 and again in 2006 to eventually include fourteen states. Participants in the program were beginning and experienced science teachers from each of these states and districts and beginning and experienced mathematics teachers from Montana. In 2007/2008, the

NTC was offered a one-year grant from the Goldman-Sachs Foundation to develop a version of eMSS specifically for mathematics teachers in their first three years of teaching mathematics. Participating mentors and mentees are from nine and 27 different states respectively.

In the eMSS mathematics program, experienced mentor teachers are paired or grouped with one to three early career teachers by content area and by grade level. The program allows for mentor-mentee pairs or small groups, who may be separated geographically, to communicate online using the Sakai platform (<http://sakaiproject.org/>). Each pair or group has access to a private discussion area as well as to many public forums, which provide participants with a supportive community of mathematics teachers, as well as to university mathematics educators. The eMSS curriculum was designed to promote learning through a collaborative, dialogue-driven environment and the program design is based on research supporting best practices in professional development (Jaffe, Moir, Swanson, & Wheeler, 2006). The structured curriculum, enacted through facilitated discussion forums, aims to increase the learning curve of these early career teachers by emphasizing quality dialogue focused on deepening content and pedagogical knowledge, while also meeting the participants' immediate needs. Figure 1 represents the logic model of eMSS (adapted from Jaffe et al., 2006).

Statement of Problem

A content-based online mentoring and induction program, based upon the principles of effective professional development, has the potential to promote the

professional growth of both beginning and experienced mathematics and science teachers. The purpose of effective professional development in mathematics and science is to help teachers bridge the gap between their classroom realities and the vision of the standards (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Several research studies have investigated the effectiveness of different components of professional development and have offered up frameworks for designing and implementing high-quality professional development for teachers of mathematics and science (Banilower, Boyd, Pasley, & Weiss, 2006; Cohen & Hill, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 2002; Hill & Ball, 2004).

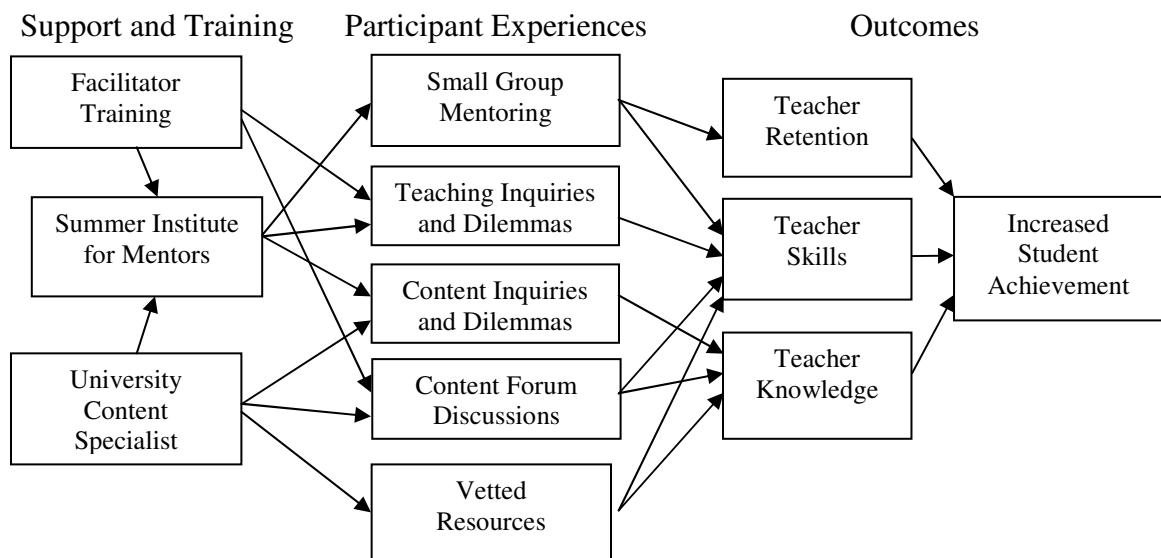


Figure 1. eMSS Logic Model (adapted from Jaffe et al., 2006).

Successful mentoring programs aim to increase teacher retention while also improving teacher practice (Weiss & Weiss, 1999). Through extensive reviews of the research literature, features of successful mentoring and induction programs for

beginning teachers in general have been identified (Bice, 2005; Feiman-Nemser, Schwille, Carver, & Yusko, 1999). Furthermore, several research studies have focused on the components of effective mentoring and induction experiences for beginning mathematics and science teachers in particular (Britton, Paine, Pimm, & Raizen, 2003; Friedrichsen, Chval, & Teuscher, 2007; Luft & Patterson, 2002). Research has also revealed that effective mentoring and induction has the ability to improve the practice of the beginning teacher (Britton et al., 2003; Luebeck, 1998; Luft & Patterson, 2002; Luft, Roehrig, & Patterson, 2003; New York City Board of Education, 1993; Schaffer, Stringfield, & Wolfe, 1992).

Mentoring has the potential to benefit both the early career teacher as well as the veteran teacher (Huling & Resta, 2001). However, mentoring and induction programs intentionally designed to promote the professional development of both the mentee and the mentor require a significant investment of time and resources. Establishing the professional benefits of participating in such a mentoring program for mentor teachers serves to justify this investment. Anecdotal evidence suggests that mentor teachers grow professionally through mentoring (Auton, Berry, Mullen, & Cochran, 2002; Gless & Moir, 2001). With the exception of a few research studies (Clinard & Ariav, 1998; Freiberg, Zbikowski, & Ganser, 1996; Luebeck, 1998), little evidence exists confirming these observations. Furthermore, there is very limited research that has specifically explored how content-based online mentoring has contributed to mentor teachers' professional growth in mathematics (Luebeck, 1998).

Research Questions

The overarching purpose of this mixed methods study is to explore the professional growth of mentor mathematics teachers as a result of participating in a content-based online mentoring program. Through analysis of survey data and case studies the following research questions were explored:

1. How do experienced mathematics teachers perceive their experiences in a content-based online mentor program to have influenced their professional growth?
 - a. In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?
 - b. What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?
2. What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?
3. Is there a relationship between the activity level of the mathematics mentor teacher and his or her perception of professional growth through participation in a content-based online mentoring program?

A mixed methods approach allowed me to look at these relationships from several perspectives in order to better understand the research problem.

Definitions of Key Terms

1. *Cognitive Presence* refers to the extent to which participants construct knowledge through sustained communication in a community of inquiry (Garrison, Anderson, & Archer, 2000).
2. *Content-based Mentoring* is mentoring where the program participants, including the mentees and the mentors, are teaching in the same content area. For the purposes of this study, this content area is mathematics and all program participants are or have been middle or high school mathematics teachers. In addition, the curriculum is focused on mathematics content and pedagogy. Teacher leaders of mathematics and higher education mathematicians and mathematics educators assist in the design and delivery of this curriculum.
3. *Communities of Practice* is a term first used by Lave and Wenger. It describes members of a community who are bound by common interests and goals. According to Lave and Wenger, learning occurs through participation in communities of practice (Driscoll, 2000).
4. *Common Content Knowledge* in mathematics refers to knowledge of the discipline that is not unique to teaching (Hill & Ball, 2004).
5. *Constructivism* is a theory of learning that presumes people actively construct their own knowledge and personal understandings of the world based on their prior knowledge and experiences (Driscoll, 2000).

6. *Content Knowledge* includes the knowledge of facts and concepts in a discipline, how facts and concepts of the discipline are generated and organized, and why facts and concepts are true (Shulman, 1986).
7. *Curricular Knowledge* is a teacher's knowledge of how to use resources and arrange topics over time to organize the study of a discipline (Shulman, 1986).
8. *Distance Education* utilizes technology to provide asynchronous or synchronous learning experiences to participants. Learners and instructors do not need to be physically present at the providing institution (Allen & Seaman, 2006). For the purpose of this study, distance education refers specifically to online learning experiences.
9. *e-Mentoring* is mentoring using electronic communication. For the purposes of this study, e-Mentoring refers to asynchronous, online mentoring using the Sakai learning platform.
10. *Facilitator* is a more knowledgeable person who assists or facilitates the learning process of less knowledgeable learners.
11. *Induction* is a phase in a teacher's career, usually the first three years, where the teacher transitions from preservice preparation to practice. During this phase, teachers are learning how to become professional teachers (Feiman-Nemser, 2001). Induction programs can help teachers to make this transition.
12. *Mentoring* is the act of improving and developing the knowledge, skills, and confidence of a less experienced individual (mentee) through a relationship with a more experienced individual (mentor) (Single & Muller, 2001). Mentees may be

less experienced in the classroom but are often more experienced in other areas (e.g. uses of technology in instruction) and thus can contribute to mentor learning as well.

13. *Online Learning* is a form of distance learning that utilizes web-based technology to provide synchronous and/or asynchronous learning experiences.
14. *Pedagogical Content Knowledge* is content knowledge for teaching and embodies understanding how to effectively represent and teach this subject knowledge to students, as well as understanding what makes the learning of topics challenging or easy for students (Shulman, 1986).
15. *Pedagogical Knowledge* is the knowledge a teacher needs in order to help students grasp new ideas (Shulman, 1987).
16. *Social Constructivism* is the learning theory that emphasizes the social nature of knowledge construction; learning is a process of enculturation into a community where the participants negotiate and establish expectations for each other's activities in this community (Cobb, 1994, 2000).
17. *Social Presence* refers to the extent to which participants reveal the “real person” behind the writing in a community of inquiry (Garrison et al., 2000).
18. *Specialized Knowledge of Content* in mathematics is the knowledge of content unique to teachers. Teachers have specialized knowledge of content that, for example, allows them to understand novel methods of problem solving and provide explanations of common algorithms (Hill & Ball, 2004).

19. *Teaching Presence* refers to the design and implementation of the curriculum in a community of inquiry (Garrison et al., 2000).

Significance of Study

Although anecdotal evidence suggests that experienced teachers benefit both personally and professionally from participating in a mentoring and induction program, very little research with the exception of Clinard & Ariav (1998), Freiberg et al. (1996), and Luebeck (1998) has been conducted to verify this assumption. In addition, there is a lack of research exploring how professional development contributes to teachers' mathematical knowledge (Hill & Ball, 2004). Case study and survey data describes the ways in which experienced mathematics teachers grow as a result of participating in a mentoring and professional development program. This study adds to this limited research base as well as provides mentoring and induction designers and policy makers information about the benefits for experienced teachers of participating in mentoring programs.

Knowledge gained from this study also informs practice and research in professional development, mentoring, and experienced teacher growth. The goal of effective professional development and mentoring is to improve teachers' knowledge and skills to ultimately impact student achievement (Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley et al., 2003; Weiss & Weiss, 1999). Investigating the effects of the various professional development experiences enacted through the eMSS structured curriculum on teacher growth and development supports knowledge of what

factors contribute to high-quality professional development and mentoring. In particular, this study adds to the limited knowledge about the benefits of content-based professional development and mentoring (Britton et al., 2003; Garet et al., 2001; Luft, Roehrig, & Patterson, 2002, 2003).

Finally, each year the number of people in the United States and around the world participating in distance learning including online environments increases (Allen & Seaman, 2006). In online environments, participants communicate asynchronously or synchronously via computer-mediated technology. Given that online learning experiences are offered to a growing number of people each year, it is important to understand how learning occurs in these environments. This study informs the research base on professional learning through investigating an online, dialogue driven learning environment.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This literature review is organized into five sections with each section contributing to understanding an aspect of the research problem:

1. Context: Learning in the Online Environment
2. Experiences: Mentoring/Induction and Professional Development
3. Outcomes: Experienced Teacher Growth
4. Mentoring as Professional Development: An Opportunity for Experienced Teacher Growth
5. Summary: The Need for Further Study

Figure 2 provides an organizational framework for understanding how the sections of the literature review are related to one another.

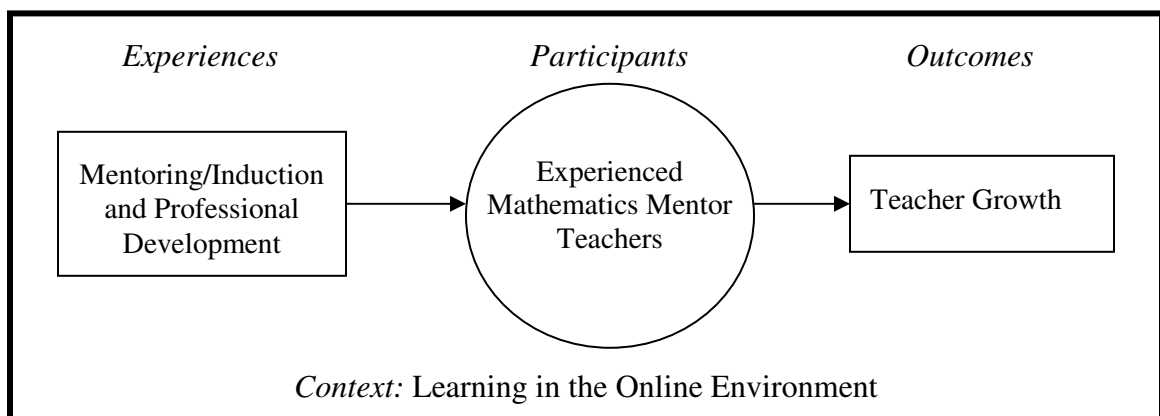


Figure 2. Organizational Framework for the Literature Review.

The first section looks at learning theories in general and attributes of effective online learning experiences in particular. The second section explores the components of effective mentoring and induction and professional development programs, particularly in mathematics and science, in order to situate the experiences of the participants in the content-based mentoring program on which this study focuses. The third section examines the potential domains of experienced teacher growth with a focus on literature related to the knowledge needed for teaching mathematics. The fourth section reviews the limited research exploring the personal and professional benefits of mentoring to the experienced mentor teacher. Finally, the fifth section illustrates how the literature informs the understanding of how mentor mathematics teachers perceive their professional growth as a result of participating in a content-based online mentoring program designed with the principles of effective professional development in mind.

Context: Learning in the Online Environment

Technology provides a medium for the exchange of thoughts as well as the growth and development of knowledge. As such, the technology can all but disappear, as the focus shifts away from it, to the challenge of a good discussion in which the technology is merely the conduit (Bender, 2003, p.24-5).

Online instruction, like face to face instruction, is influenced by research based learning theories. Learning theories that inform the design of online learning environments can be grouped into four categories: behavioral theories, psychological development theories, cognitive theories, and social theories of learning (Gillani, 2003). Depending on the purpose and audience of a given web-based instructional environment, any of these theories may be appropriate for underpinning the design and study of the

learning experiences of the participants. According to Gillani, skill and drill is the hallmark of behavioral based designs such as online mathematics tutorials, practice sets, and assessments. Thematic learning experiences are supported by psychological development learning theories. A unit of study in mathematics organized around planning a trip across the country is an example of a thematic learning experience. The eMSS curriculum and design does not reflect consideration of these theories. Cognitive theories of learning explain how knowledge is individually constructed and these theories support inquiry and discovery learning by individual learners. Social theories of learning acknowledge the role the environment plays in knowledge construction and collaboration with others is the main feature of instruction designed with these theories in mind (Gillani, 2003). Cognitive and social theories of knowledge construction and learning more accurately reflect the design elements of the eMSS curriculum.

As participants in this program, mentor mathematics teachers have the potential to gain new knowledge and grow professionally through mentoring early career teachers and engaging with the eMSS curriculum and learning community. Aspects of cognitive and social constructivist theories of learning are apparent in the design of eMSS and I will use these perspectives of learning as a lens to explore mentor mathematics teachers' professional growth in the program. In the following sections, I first consider the learning theories that explain cognitive and social knowledge construction in general, and then a related framework for studying and designing online learning experiences in particular. In addition, I explore the components of effective online education offered by the

practitioner and research literature. Finally, I describe how the eMSS environment supports these perspectives of learning.

Cognitive and Social Knowledge Construction

Constructivist-based learning theories explain individual, social, and cultural contributions to cognitive development. Broadly, constructivism is a theory of learning that presumes people actively construct their own knowledge and personal understandings of the world based on their prior knowledge and experiences (Driscoll, 2000). Specifically, as an individual acquires new knowledge, a process of cognitive reorganization occurs (Lambert & McCombs, 1998; von Glasersfeld, 1984). Individuals have a set of cognitive rules and models based on prior knowledge and experiences that they use to interpret the world and their experiences in it. As a learner encounters new experiences or new information, he or she assimilates it into his or her personal set of rules and models. If this experience or information is in conflict with prior knowledge, then the learner is in disequilibrium. The learner must adjust his or her cognitive models to accommodate for this new experience. In doing so, the learner reflects on the new information or experience and integrates the knowledge into his or her current cognitive structure. The knowledge can be abstracted and applied to other situations and experiences other than the one in which it was constructed (Lambert & McCombs, 1998; von Glasersfeld, 1984). The newly constructed knowledge does not have to accurately represent external reality. Rather, it must be viable knowledge for the learner (Driscoll, 2000).

In addition to individual construction of knowledge, many constructivist theorists agree with Vygotsky's belief that meaning is socially negotiated (Driscoll, 2000).

Vygotsky believed that mental activity and knowledge construction is the product of social learning and interaction; all learning occurs in the learner's zone of proximal development, the gap between a learner's actual developmental level and potential developmental level, where he or she interacts with a more capable adult or peer (Moll, 1990). Furthermore, Vygotsky believed understanding individual cognitive development is contingent upon understanding the social and cultural context in which the development occurs. Bruner also viewed learning through a constructivist lens. Bruner believes that effective instruction has the ability to accelerate cognitive development (Driscoll, 2000). From his perspective, learning is an active process and learners should be encouraged to discover principles for themselves (Bruner, 1996).

Social constructivism is the learning theory that emphasizes the social nature of knowledge construction. Learning is a process of enculturation into a community where the participants negotiate and establish expectations for each other's activities in this community (Cobb, 1994, 2000). Cobb argues that both individual and social construction of knowledge contribute to learning. From the cognitive and social constructivist perspectives of learning, individuals organize new information in unique ways based on their backgrounds and prior experiences and through social negotiation learners can create shared understandings (Lambert & McCombs, 1998). In order to enhance learning, social constructivists believe learning and instruction should be embedded in complex and authentic environments and educational experiences should provide opportunities for

social negotiation, support multiple perspectives, and encourage ownership and self-awareness of learning (Driscoll, 2000).

Like social constructivists, Lave and Wenger also believe that learning is socially situated (Driscoll, 2000). From their perspective, learning occurs through lived practices of people in a society; learning is seen as participation in a community of practice.

Participants in a community of practice co-construct knowledge because they change and learn through their actions and relationships with one-another. The participants' actions in the community work toward a mutually negotiated goal. Members in a community of practice can participate on a scale from legitimate peripheral participants to full participants. Peripheral participants are newcomers or novices in the community, while full participants are "old timers" or experts (Driscoll, 2000). Lave and Wenger suggest that learning is supported when the community is open to newcomers and allows participants to move quickly and smoothly from peripheral to central roles (Wegerif, 1998). In educational settings, a community of practice is commonly referred to as a learning community, where the role of the instructor is no longer to disseminate knowledge, but rather to work collaboratively with the learners to facilitate progress toward shared goals (Driscoll, 2000).

Effective Online Learning Experiences

A variety of learning theories can inform the design, implementation, and study of online learning just as they do so in face to face learning environments. Many authors concur that cognitive and social constructivist learning theories provide a useful perspective for understanding discussion based online learning (Bender, 2003; Garrison,

2003; Garrison et al., 2000; Granger & Bowman, 2003; Hannafin, Oliver, Hill, Glazer, & Sharma, 2003). From the individual and social constructivist learning perspectives, Garrison, Anderson, and Archer (2000) have developed a theoretical framework for studying meaningful educational experiences specific to text-based online learning (see Figure 3). I have chosen to use this Community of Inquiry model to organize the relevant practitioner and research literature in my review of the effective components of discussion-based online learning environments (see Table 1).

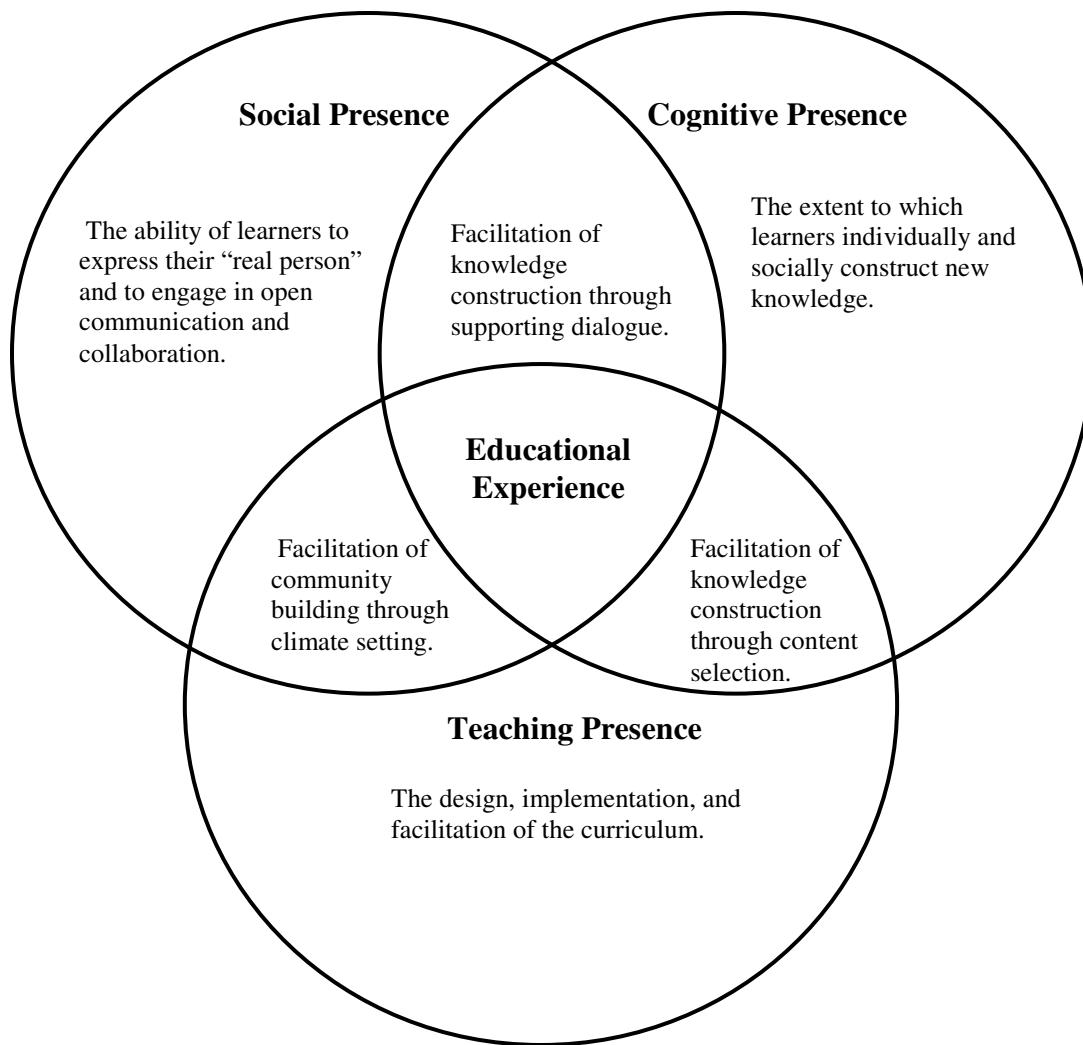


Figure 3. Community of Inquiry Model (adapted from Garrison et al., 2000).

Table 1. Components of Effective Online Learning Environments.

Distance educators can facilitate learning through the interaction of <i>Teaching Presence</i> with:			
<i>Cognitive Presence</i>		<i>Social Presence</i>	
	to promote individual knowledge construction	to promote social knowledge construction	to promote community building
Practitioner Recommendations	Build instruction from students' prior knowledge (Hannafin et al., 2003)	Promote contextual learning through authentic interactions (Granger & Bowman, 2003)	Develop a community of learners (Bender, 2003; Garrison, 2003; Granger & Bowman, 2003)
	Be aware of learners' individual needs and personal goals (Bender, 2003; Granger & Bowman, 2003)		
	Promote flexible, self-directed learning (Garrison, 2003)	Mediate connections between learners' personal experience and the experience of the larger community (Polin, 2004)	
Research Findings	Facilitation promotes self-directed learning and engagement (Richardson & Newby, 2006)	Facilitation is important for collaborative knowledge building (Barbera, 2006)	Individual activity level directly related to one's sense of belonging to the learning community (Wegerif, 1998)
		Collaboration promotes critical thinking, reflection, and deeper learning (Riley & Anderson, 2006)	

In this model, Garrison et al. assume learning is always situated in a social context, and in the online environment, community is built and maintained through written dialogue. A meaningful educational experience is defined as an experience embedded in a community of inquiry where participants construct knowledge through social interactions. There are three necessary and overlapping components that contribute to a worthwhile educational experience, including *cognitive presence*, *social presence*, and *teaching presence*. *Cognitive presence* refers to the construction of meaning through

sustained communication such as information exchange and connecting and applying new ideas. *Social presence* refers to the participants' ability to reveal the "real person" behind the writing and can be indicated by identifying emotions, risk-free expression, and encouraging collaboration. *Teaching presence* incorporates both the design and implementation of the curriculum where implementation includes facilitation roles by the course instructor or other community participants. Defining and initiating discussion topics, sharing personal meaning, and focusing discussion indicate teaching presence. All three components are necessary to promote meaningful individual and social knowledge construction (Garrison et al., 2000).

Many, if not all, of the components of effective teaching and learning influenced by individual and social constructivist learning theories can be applied to discussion based online learning environments. In fact, numerous authors of the professional literature concur that online learning environments should be learner-focused, collaborative environments that support both the individual and social construction of knowledge (Bender, 2003; Garrison, 2003; Granger & Bowman, 2003; Hannafin et al., 2003). In order to support the individual construction of knowledge, instruction should be built upon students' prior knowledge (Hannafin et al., 2003) and related to the students' personal needs and goals (Bender, 2003; Granger & Bowman, 2003). Furthermore, Garrison (2003) explains that much of online learning is self-directed and that learners can benefit from a facilitated curriculum with flexible dialogue, providing learners with support and guidance as well as choices and control over their learning.

In addition to supporting individual construction of knowledge, all of the aforementioned authors agree that instructors should strive to build a community of learners in order to support the social construction of knowledge. Garrison (2003) believes the goal of online education experiences should be to build mutual understandings as a community of learners through questioning, challenging, and addressing misconceptions. In order to allow learners to be central members in this community, Polin (2004) suggests that program designers, instructors, and the curriculum should mediate connections between the learners' personal experiences and the larger professional activity and knowledge in which that experience is embedded. In addition, Granger and Bowman (2003) recommend that instructional design support contextual learning through authentic interactions in the learning community. Finally, Bender (2003) highlights that when discussion based online learning environments are effective, the technology "disappears" and the discussion and collaboration can move to the forefront, promoting higher-level thinking and reflection by the participants. Each of these practitioner-based guidelines reveals the need to recognize the interactions between the *cognitive, social, and teaching presence* in the virtual classroom.

Although understanding the process of individual and social learning in the online environment is an important precursor to designing and delivering high quality learning experiences, less than 20 percent of the research published in the distance education journals was learner focused in the 1990's (Gibson, 2003). Research has more recently focused on learners and learning in online learning environments with the majority of this research focused on the individual mode of learning. However, there has been a shift

toward studying group learning and the community of learners (Gibson, 2003). Nonetheless, Gibson asserts that much of this research has been descriptive and uninformed by theoretical or conceptual frameworks. I have reviewed several relevant research studies which have investigated individual and/or social knowledge construction and community building in the online environment in order to better understand the components of effective online instruction. These studies are described below.

The individual construction of knowledge in the online environment is the focus of a study conducted by Richardson and Newby (2006). In this study, the researchers investigated student cognitive engagement in online courses. The authors define cognitive engagement as the integration of strategies and motivations utilized by students during learning. The Biggs's Study Process Questionnaire was taken by 121 post-baccalaureate engineering and masters level education students enrolled in online degree programs and the students were placed in categories based on their strategy and motivations levels. Results revealed that as students gain more experience with participating online they become more engaged. Additionally, students become more self-directed when instructors take a facilitation role or "guide on the side" approach rather than the more traditional direct instruction or "sage on the stage" model (Collison, Elbaum, Haavind, & Tinker, 2000). The researchers recommend that instructors design interventions such as providing introductory course materials that facilitate active engagement and progression to becoming more self-directed learners at a faster rate.

In order to compare the effects of collaborative and independent learning on knowledge construction in the online learning environment, Riley and Anderson (2006)

researched the development of declarative knowledge, procedural knowledge, and performance on higher cognition tasks (i.e. problem solving and inquiry) between students engaged in cooperative learning and students participating in self-paced, independent learning. Participants in this study included 47 students enrolled in an online masters of public health program. Approximately half of the students were randomly assigned to the independent study course where they only had contact with the instructor. The remaining students learned the content through analyzing case studies in small group discussions. Throughout the course, declarative knowledge was assessed through multiple choice quizzes, procedural knowledge through activities designed to elicit skill development in reasoning and inquiry, and high cognition through case studies. Results indicated that there were no differences between the groups on declarative knowledge; however participants in the cooperative learning group significantly outperformed their independent counterparts on the assessments for procedural skills and higher cognition. These group differences suggest that pedagogy promoting collaboration in the online environment may promote a higher level of critical thinking, reflection, and deeper learning.

Collaborative knowledge building in asynchronous discussion groups was also the focus of a study conducted by Barbera (2006). This study analyzed the nature and dynamics of the dialogue in a formal online discussion related to course content with the purpose of understanding if and how discussions promote learning. The dialogue of 26 students taking part in a Labor Relations course at a virtual university was analyzed over the course of 2 weeks. The researcher identified five sources of knowledge: (a) academic

knowledge found in written materials, offered by the instructor, or from students' prior knowledge of the content, (b) academic knowledge from other disciplines, (c) professional knowledge from experience, (d) common sense knowledge, and (e) procedural knowledge needed to interact in the online activities. Each post in the discussion was coded for the nature of the post and a map of the posts was created to reveal the dynamics of the discussion. In analyzing the dynamics of the discussion, the researcher determined that the discussion was not very rich as many participants did not reference contributions by other participants. In addition, many misconceptions went unchecked. A facilitator was needed to offer more structure to the discussion. Online course designers and instructors need to recognize the importance of facilitating to ensure that the discussions are steered in appropriate directions that enhance collaborative knowledge building.

One study in particular focused on participants' sense of belonging to the online learning community, a precursor to social knowledge construction. In this study, Wegerif (1998) examining the social dimension of asynchronous learning on Lave and Wenger's theory of situated learning as a process of becoming part of a community of practice. In this ethnographic study, Wegerif collected data from students participating in an online course designed to promote collaboration. Results indicated that more active students, determined by the number of posts, felt the course was an environment that promoted collaborative learning. Individual success depended upon crossing a threshold from feeling like outsiders to feeling like members of the community. Based on the findings of his study, Wegerif recommends course designers to take the following actions to help all

students to cross this threshold: overcoming differential access to the internet, overcoming conflicts of discourse by building a sense of community through structured exercises that minimize participant differences, provide scaffolding by moving from more structured to more open-ended exercises, provide learner-led experiences, and allow time for reflection on learning.

Summary

The online environment holds the potential to promote the individual and social construction of knowledge through the interaction of *cognitive*, *social*, and *teaching presence*. To facilitate individual knowledge construction, online instructors should be aware of learners' individual needs and personal goals, build instruction upon students' prior knowledge, and promote flexible, self-directed learning. Through climate setting, the instructor can facilitate community building, which will ultimately affect social construction of knowledge. The online instructor should promote collaboration and authentic interactions with the goal of higher level thinking, reflection, and mutual understandings through effective facilitation and scaffolding. These pedagogical strategies and frameworks for design support the constructivist conditions for learning outlined by Driscoll (2000). Cognitive and social constructivist learning theories can be used as a framework for studying learners' knowledge and skill growth as they participate in online professional learning environments, such as eMSS, designed with these perspectives in mind.

eMSS and Cognitive and Social Knowledge Construction

Many aspects of the eMSS mentoring and induction program are supported by cognitive and social constructivist learning theories. eMSS provides participants with a social network of learners with similar professional needs. This community of practice or learning community is comprised of novice and experienced mathematics and science teachers, discussion facilitators, and university mathematics educators and scientists. Although they are from different parts of the country, the asynchronous environment allows the participants to engage in written dialogue with one another to solve common problems and explore ways to improve their practice. Common participant goals include finding effective ways to meet local and national standards, developing teaching strategies and lessons to best meet the needs of their students, and deepening knowledge of disciplinary content (Jaffe et al., 2006).

As the novice and expert teachers participate in the larger learning community, they are also individually constructing their own meanings of effective practices. Tobin and Tippins (1993) state that “Student thinking needs to be stimulated by providing time to think: students need time to engage in the process required to evaluate the adequacy of specific knowledge, make connections, clarify, elaborate, build alternatives, and speculate” (p. 9). In parallel to this example, the eMSS discussion facilitators and content experts can be thought of as the teachers, and the mentors and mentees can be thought of as the students or learners. eMSS participants engage with the program by reading posts, assimilating their thoughts, then writing a response. Through questioning, facilitators and other participants encourage mentors and mentees to clarify and reflect upon their

statements and teaching practices. The nature of the asynchronous environment allows participants as much time as needed to engage in the writing, reflection, and re-writing circle. Threaded discussions remain accessible for the entire semester, allowing mentors and mentees to continue coming back to them as their experiences change. As participants make meaning from writing and reflecting on dialogue they can, in principle, integrate their learning into their teaching practice.

The eMSS curriculum starts each summer by training facilitators and mentor teachers. In this training, these participants learn to converse through guiding rather than telling, which supports learner-focused instructional strategies (Driscoll, 2000). During the school year, participants engage in a variety of learning activities including dilemmas, inquiries, content-focused discussions, and private mentor-mentee discussions. The dilemmas and inquiries represent authentic tasks contextualized in the participants' teaching experiences, paralleling the recommendations for online learning of Granger and Bowman (2003) and Hannafin et al. (2003), and provide a way to connect the participants' local teaching experiences with a community of practice, similar to the online communities recommended by Polin (2004). Inquiries are also designed to allow participants to investigate their own teaching and to discover effective pedagogical strategies for themselves, which is supported by Bruner's theory of discovery learning (Driscoll, 2000). Through the online relationships such as mentoring and interacting with experts in the content areas, participants have the potential to work with a more knowledgeable peer in their zone of proximal development, corresponding to Vygotsky's recommendations for learning (Moll, 1990).

The variety of discussion areas available on eMSS provide the participants with flexibility to pick and choose the learning experiences that they find personally and professionally meaningful as recommended by Garrison (2003). Because individual and co-construction of knowledge is embedded in social interactions in the eMSS learning community, cognitive and social constructivist learning theories provide the most useful framework for exploring mentor learning and growth as a result of participating in an online mentoring program.

Experiences: Mentoring/Induction and Professional Development

eMSS is a content-based mentoring and induction program for early career teachers of mathematics and science designed with the best practices in professional development in mind (Jaffe et al., 2006). As such, mentor mathematics teachers participate in mentoring as well as in the intentionally designed induction and professional development curriculum. This section is organized into four subsections. In the first two sections I describe effective mentoring and induction and effective professional development for teachers of mathematics and science. I then compare the features of quality mentoring and induction and professional development. Finally, I illustrate the degree to which the design of eMSS reflects these components of quality mentoring, induction, and professional development compiled in the review.

Effective Mentoring and Induction

New teachers are leaving the profession at an astonishing rate. Ingersoll (2007) reports that between 40 and 50 percent of new teachers quit teaching within their first

five years in the profession and although mathematics and science teachers leave the field at approximately the same rates as teachers of other disciplines, it is more difficult to find newly trained and qualified mathematics and science teachers to fill these positions.

Successful mentoring and induction programs not only increase teacher retention, but also improve teachers' abilities and effectiveness (Weiss & Weiss, 1999). Effective teachers, according to Stansbury and Zimmerman (2000), must be able to teach to high standards while meeting the learning needs of a diverse student population. Support such as mentoring and induction is needed for beginning teachers to achieve this tall order.

Figure 4 highlights these relationships.

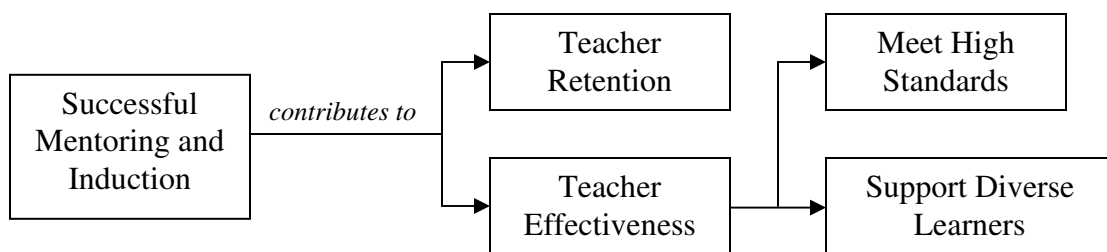


Figure 4. Effects of Successful Mentoring and Induction.

Induction programs can take many forms depending on the specific goals of the school or district and the level of funding available. Regardless, most successful induction programs have mentoring as a key component (Stansbury & Zimmerman, 2000; Villani, 2002; Weiss & Weiss, 1999). Danielson (2002) outlines features of a well-designed induction program in Villani's practitioner based guide for developing mentoring programs. Induction programs should be more than a buddy system for emotional support, should go beyond simply offering guidance about school policies and procedures, and should move past providing generalized support. Effective induction

provides new teachers with trained mentors who have the ability to offer instructional support as well as the ability to encourage the novice teacher to clarify goals and explore options that can ultimately lead to improved practice. Like any well-designed learning experience, induction programs should also provide teachers with opportunities to self-assess and reflect on their practice. In order for mentors to appropriately support beginning teachers, they should receive compensation and scheduled time for working with the new teacher (Danielson, 2002).

Adding to the list of components of successful mentoring and induction, Weiss and Weiss (1999) stress that mentors should not only meet with their mentees regularly but should also provide high quality support. In order to do this, mentors should themselves participate in high quality mentor training. The ideal mentor-mentee relationship is collaborative, allowing both the mentor and the mentee to learn from the experience. Finally, in order to move beyond generic mentoring experiences, mentors in effective induction should teach the same discipline as their mentee; content-based mentoring allows for early career teachers to gain an understanding of pedagogy specific to their discipline (Britton et al., 2003; Luft, Bang, & Roehrig, 2007).

In the following sub-sections I have reviewed several research studies which support and extend this list of features of successful mentoring and induction. Because others have previously reviewed and organized the mentoring and induction literature, I have summarized three of these comprehensive reviews. In addition, I have reviewed the research specifically addressing content-based mentoring and induction in mathematics and science. Thus, the following review of the research literature is organized into two

sections: 1) Comprehensive Reviews of the Mentoring and Induction Literature and 2) Mentoring and Induction for Teachers of Mathematics and Science. Table 2 summarizes the components of effective mentoring and induction recommended by the practitioner and research literature. This table is organized into *structural* components, *experiential* components, and *outcomes* of effective mentoring and induction. *Experiential* components are just that, experiences in which participants of mentoring and induction engage. The *structural* components are all of the other contributing characteristics that influence the design and implementation of mentoring and induction.

Comprehensive Reviews of the Mentoring and Induction Literature. Several comprehensive literature reviews have been conducted to explore mentoring and induction. One such review by Feiman-Nemser, Schwille, Carver and Yusko (1999) approached the literature using a conceptual framework. They identify three ways to define new teacher induction: 1) induction as a phase in teacher development, 2) induction as a process of teacher socialization and 3) induction as a formal program for new teachers. In their review of formal programs, Feiman-Nemser et al. found that mentoring was synonymous with, or a major component of, induction. Using evidence from both empirical and practitioner literature the authors were able to identify characteristics of quality programs. Because learning takes time, induction programs should be sustained over several years. Furthermore, new teachers need a supportive environment in which to work along with a supportive mentor who is trained in effective practices and has time to meet with his or her mentee. Finally, quality induction requires adequate resources to succeed. Human capital can be tapped by promoting collaboration

Table 2. Components and Outcomes of Effective Mentoring and Induction for Teachers of Mathematics and Science.

Recommendations	Source of Recommendation
<u>Structural:</u>	
Content- based	Britton et al., 2000; Friedrichsen et al., 2007; Luft et al., 2002, 2003, 2007
Intensive and sustained	Feiman-Nemser et al., 1999; Friedrichsen et al., 2007; Luft et al., 2002, 2003, 2007; Weiss & Weiss, 1999
Trained mentors	Britton et al., 2000; Danielson, 2002; Feiman-Nemser et al., 1999; Weiss & Weiss, 1999
Adequate resources	Britton et al., 2000; Feiman-Nemser et al., 1999
Developmentally appropriate	Eisenman & Thornton, 1999; Luft et al., 2002, 2003, 2007; Odell, 1986; Upson, 2004
Structured curriculum	Mariage & Garmon, 2003; Ralph, 2002; Wollman-Bonilla, 1997
<u>Experiential:</u>	
Active learning	Danielson, 2002; Luft et al, 2002, 2003, 2007
Collaboration	Athanses & Achinstein, 2003; Feiman-Nemser et al., 1999; Luft et al., 2002, 2003, 2007; Weiss & Weiss, 1999; Wollman-Bonilla, 1997
Peer networking and support	Britton et al., 2000; Friedrichsen et al., 2007
Opportunities for reflection	Danielson, 2002; Luft et al, 2002, 2003, 2007
<u>Outcomes:</u>	
Increased teacher retention	Lopez, et al., 2004; Odell & Ferraro, 1992; Weiss & Weiss, 1999
Improved teacher quality	Britton et al., 2002; Lopez et al., 2004; Luft et al., 2002, 2003; Ralph, 2002; Stansbury & Zimmerman; Weiss & Weiss, 1999

among districts and institutions of higher education and completing ongoing program evaluation can serve to continuously improve the program. Throughout the review, Feiman-Nemser et al. stress that more research is needed to explore the effective components of new teacher induction and the impacts of induction on teacher quality.

Taking a different perspective than Feiman-Nemser et al., Bice (2005) organized his extensive review around the induction curriculum. The findings in his review indicate that a structured curriculum is a key component of many successful mentoring programs (Mariage & Garmon, 2003; Ralph, 2002; Wollman-Bonilla, 1997). The curriculum should acknowledge that beginning teachers have changing knowledge needs during their first years in the field, starting with a need to develop their pedagogical knowledge and then their pedagogical content knowledge (Eisenman & Thornton, 1999; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Odell, 1986; Upson, 2004). Although general teaching and emotional support is needed (Gratch, 1998; Whitaker, 2000), successful mentoring and induction programs also provide new teachers with support in developing and adapting resources for instruction (Mariage & Garmon, 2003) and opportunities to enhance their pedagogical content knowledge (Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003). Finally, collaboration is a major component of a successful induction program (Athanses & Achinstein, 2003; Feiman-Nemser, 1998; Wollman-Bonilla, 1997). Bice's review also determined that mentoring and induction has been successful at increasing teacher retention (Odell & Ferraro, 1992) and improving teacher practice (Britton et al., 2003; Ralph, 2002; Stansbury & Zimmerman, 2000).

The third review of the mentoring and induction literature explored here took an empirical approach to reviewing the literature. Lopez, Lash, Schaffner, Shields, and Wagner (2004) of SRI International reviewed experimental and quasi-experimental studies and program evaluations to investigate the impact of beginning teacher induction on teacher retention and quality. In their review, they were only able to identify twelve

studies that met their criterion of rigor. The review found that mentoring was a hallmark feature in all but one of the studies, and in most cases, mentoring occurred in conjunction with induction and professional development activities. In the set of retention studies, measured by the number of teachers either remaining in their positions or by self-reported plans to remain, three studies reported a positive relationship between participation in induction and teacher retention, two showed mixed results, and one found no impact. The researchers in the studies reviewed aimed to measure teacher quality by student performance, however, most relied on classroom observations. In the set of teacher quality studies, four reported a positive relationship between participation in induction and beginning teacher quality, four indicated mixed results, and two revealed no impact. The authors stress that overall the set of quantitative studies were weak in rigor and many did not show statistical significance.

Mentoring and Induction for Teachers of Mathematics and Science. Although there is an abundance of literature related to mentoring and induction in general, only a few studies focus on content-based mentoring of teachers of mathematics and science in particular. Luft and associates, however, have conducted several research studies on a university associated, content-based mentoring program in Arizona, Alternative Support for Induction Science Teachers (ASIST) (Luft & Patterson, 2002; Luft et al., 2002, 2003). Framing these studies is the view that beginning science teachers need logistical, instructional, conceptual, psychological and philosophical support in order to help them develop learner-centered reform-based instructional practices. Mentoring and induction programs need to be cognizant of the stages through which beginning teachers transition.

New teachers first need teacher- and instruction-centered support (e.g. finding laboratory materials or writing a lesson plan) followed by learner-centered support (e.g. developing content that is appropriate for the students). Mentoring and induction should recognize the developmental needs of the teacher and provide content-based assistance at the new teacher's need level in order to be most effective (Luft et al., 2007). Furthermore, induction programs should provide sustained professional development opportunities for beginning teachers. These activities must be conducive to standards-based science instruction, providing participants with active learning experiences and time for reflection as well as examples of standards-based lessons and teaching practices. Finally, induction should promote collaboration between universities, school districts, and experienced teachers (Luft & Patterson, 2002).

The ASIST project was designed to ease the transition between teacher preparation and the first three years of teaching for beginning science teachers, bearing in mind the needs of all beginning teachers and the unique needs of early career secondary science teachers. Components of the induction program included content-specific mentoring, Saturday meetings, electronic communications, classroom visits by project staff or peers, and a trip to state or national teacher conferences with the aforementioned features in mind. Program evaluations conclude that over 90% of participants in the ASIST project reported more confidence in their science teaching and greatly improved ability in using inquiry based instruction. Additionally, 75% of the participants claimed that the program challenged their ideologies about science teaching (Luft & Patterson, 2002). In a later study, Luft et al. compared the supports teachers received in the ASIST

program with beginning science teachers in school-based induction programs and those with no formal induction. Through observations and interviews, the researchers determined that teachers in the ASIST program used significantly more student-centered inquiry lessons and significantly less worksheet and textbook lessons than their peers in the other two groups, suggesting the importance of school district and university collaborations on the practices of beginning science teachers (Luft et al., 2003).

Like Luft and associates, Friedrichsen, Chval, and Teuscher (2007), were interested in understanding the support needs of early career mathematics and science teachers. In response to teacher turnover, the authors developed the Beginning Teacher Institute (BTI) to support beginning teachers of mathematics and science. However, through informal conversations, they learned that BTI participants had frustrations with state mandated support programs. In order to inform policy and practice of new teacher induction, Friedrichsen et al. investigated the support structures used by beginning mathematics and science teachers participating in a BTI through qualitative case studies of 18 teachers. The new teachers participated in a summer institute before the start of the school year. During the school year participants communicated in an online discussion board and worked with mentor teachers.

Results of the study indicate mixed mentoring experiences. Mentors were viewed as more supportive if they initiated regular meetings, were paired with mentees in the same content area, shared a common planning time, and offered curricular resources. Additionally, district professional development experiences were more likely to be reported as useful if they were subject-specific. Building level support included favorable

teaching assignments, such as teaching the same course as the previous year, and interacting with other teachers in the building, specifically teachers who taught in the same subject area. New teachers also expressed that communicating with other beginning teachers was an important source of emotional and social support. In addition to networking with beginning teachers in their buildings, beginning teachers were also able to meet in the summer institutes and communicate together online.

In order to understand the characteristics of successful mentoring and induction programs, specifically for teachers of mathematics and science, Britton et al. (2000) used a broader scope than Luft and associates (2002, 2003, 2007) and Friedrichsen et al. (2007) through a program comparison approach. Britton et al., in a report to the National Commission on Teaching Mathematics and Science in the 21st Century, identify elements of effective induction practices supported by their ongoing research on induction programs in the United States and abroad. In this report, the authors explore the mentoring and induction practices from 15 countries that performed well in the Third International Mathematics and Science Study and from their research, they make the following recommendations: teacher induction should be subject-specific and should focus on professional skills; both school-wide systems and carefully selected and thoroughly trained mentors should support new teachers; new teachers should be provided with improved teaching assignments and should receive and participate in observation of teaching; induction should provide new teachers with facilitated peer support groups; induction should be systemically coordinated, make fluid connections

with pre-service and professional development, and should have adequate resources; and finally, programs should participate in formative and summative evaluation.

Summary – Mentoring and Induction. The empirical evidence supports the “best practices” in mentoring and induction outlined in various practitioner guides. Successful mentoring and induction programs aim to increase teacher retention and improve teacher practice by bridging the gap between pre-service and professional development (Feiman-Nemser et al., 1999). To these ends, the characteristics of quality programs identified in the literature can be grouped by *structural* as well as *experiential* components. Quality programs share several structural features. These programs are standards- and content-based (Britton et al., 2000; Friedrichsen et al., 2007; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003), have a structured, content oriented curriculum (Mariage & Garmon, 2003; Ralph, 2002; Wollman-Bonilla, 1997), and provide beginning teachers with content-specific, carefully selected, and highly trained mentors (Britton et al., 2000; Danielson, 2002; Feiman-Nemser et al., 1999; Weiss & Weiss, 1999). In addition, these programs offer support to meet the teacher’s immediate needs as well as their long-term professional needs (Eisenman & Thornton, 1999; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Odell & Ferraro, 1992; Upson, 2004). In order to prove effective, mentoring and induction programs need to be supported by policy and school administration and be allotted adequate resources (Britton et al., 2000; Feiman-Nemser et al., 1999) and should be sustained over several years (Feiman-Nemser et al., 1999; Friedrichsen et al., 2007; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Weiss & Weiss, 1999).

Participants in quality mentoring and induction programs also share many of the same broad experiences. These effective programs engage participants in active learning experiences that model standards-based instruction (Danielson, 2002; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003) and provide opportunities for collaboration among new teachers, between new and experienced teachers, and between schools and outside supports such as universities which provide a supportive emotional and professional network (Athanses & Achinstein, 2003; Britton et al., 2000; Feiman-Nemser et al., 1999; Friedrichsen et al., 2007; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Weiss & Weiss, 1999; Wollman-Bonilla, 1997). For teacher improvement to occur, early career teachers need ample time and opportunity to reflect on their practice throughout mentoring and induction (Danielson, 2002; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003). When mentoring and induction programs are successful, they have been shown to increase teacher retention (Lopez et al., 2004; Odell & Ferraro, 1992) and improve teacher practice (Britton et al., 2000; Lopez et al., 2004; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Ralph, 2002). However, more empirical evidence is needed to connect the components of mentoring and induction with teacher outcomes (Feiman-Nemser et al., 1999; Lopez et al., 2004).

Effective Professional Development

The mathematics and science standards developed by the National Council of Teachers of Mathematics (2000), the National Academy of Science's National Research Council (1996), and the American Association for the Advancement of Sciences (1993) have created a new vision for school mathematics and science. In this vision, all students

shall engage in exploring important ideas in mathematics and science through investigating complex mathematical problems and participating in scientific inquiry within a community of learners (Loucks-Horsley et al., 2003). Loucks-Horsley et al. (2003) provide a framework for designing professional development experiences for teachers of mathematics and science, keeping student learning central. From their perspective, professional development is deemed effective if it helps teachers to bridge the gap between their classroom realities and the vision of the standards, using student learning outcomes as the ultimate measure of success (Loucks-Horsley et al., 2003).

Figure 5 demonstrates these relationships.

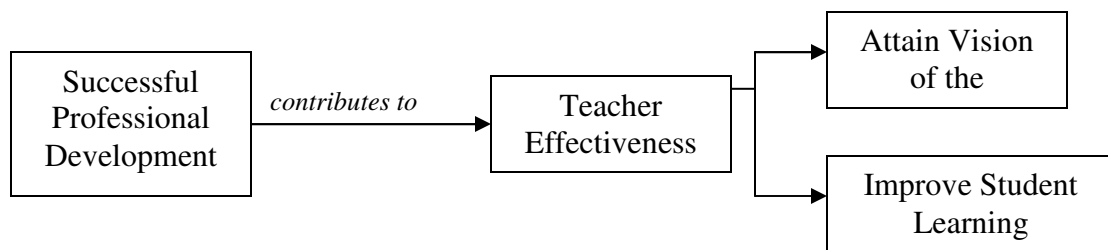


Figure 5. Effects of Successful Professional Development.

Drawing on research linking professional development experiences to student learning outcomes in mathematics and science and research exploring the influences of contextual factors on professional development, Loucks-Horsley et al. (2003) conclude that effective professional development:

- Is driven by a well-defined image of effective classroom learning and teaching.
- Provides opportunities for teachers to build their content and pedagogical content knowledge and examine practice.

- Is research based and engages teachers as adult learners in the learning approaches they will use with their students.
- Provides opportunities for teachers to collaborate with colleagues and other experts to improve their practice.
- Supports teachers to serve in leadership roles.
- Links with other parts of the education system.
- Has a design based on student learning data and is continuously evaluated and improved (p. 44).

These characteristics of effective professional development in mathematics and science support the visions outlined by Darling-Hammond and McLaughlin (1995) and Corcoran (1995). These educators believe professional development must encourage teacher and site-based initiatives, promote collaboration among teachers, be connected to school change and must be sustained, ongoing, and intensive. The learning experiences should model constructivist-based teaching strategies and offer intellectual and social engagement with content and peers (Corcoran, 1995) as well as engage teachers in acts of investigating teaching and learning and promote inquiry and reflection (Darling-Hammond & McLaughlin, 1995).

Historically, professional development experiences have been additive in nature, simply providing teachers with additional materials and strategies to use in their classrooms (Loucks-Horsley et al., 2003) and were often chosen by policy makers or district and school administrators (Corcoran, 1995). Research has shown that these types of traditional, information delivery experiences are too isolated from teachers' real

classroom practice and have frequently proven to be a waste of time (Corcoran, 1995). To support reform, the design and implementation of professional development should shift from this “top-down” approach to one that recognizes and values the views and experiences of the teachers (Darling-Hammond & McLaughlin, 1995).

Professional development should be tailored to the way teachers learn. Like students, teachers learn from doing, reading, reflecting, collaborating, analyzing and sharing (Darling-Hammond & McLaughlin, 1995). Effective professional development should reflect best-practices in teaching by providing teachers with these types of constructivist based learning experiences (Corcoran, 1995). This is critically important because teacher learning is shaped by prior knowledge and experience. Most teachers have not experienced standards-based instruction, which in turn makes it harder to enact these new reforms (Ball, 1996). Finally, if real standards-based reform is going to occur in the classroom, teachers must also engage in “transformative” learning experiences. With these types of experiences, teachers experience changes in deeply held beliefs, knowledge, and practice (Loucks-Horsley et al., 2003).

In the following subsections, I have reviewed the research on professional development. The findings in this review support the recommendations of the practitioner literature and confirm that quality programs have the potential to improve teacher practice and student achievement. Although much literature exists documenting components of quality professional development in general, I have limited this review to studies focusing on content-based professional development in mathematics and science. The following review of the literature is organized into three sections: 1) Components

and Outcomes of Effective Professional Development, 2) A Comprehensive Literature Review: Teacher Knowledge and Professional Learning, and 3) A Systemic Approach to Understanding Professional Development. Table 3 summarizes the components of effective professional development recommended by the practitioner and research literature. This table is organized into *structural* components, *experiential* components, and *outcomes* of effective professional development, where *experiential* components are the experiences in which participants of professional development engage and *structural* components are all of the other contributing characteristics that influence the design and implementation of mentoring and induction.

Components and Outcomes of Effective Professional Development. Several research studies have investigated the effectiveness of features of professional development and have offered up frameworks for designing and implementing high-quality professional development. The first large scale, comprehensive study exploring the components of effective professional development in mathematics and science was conducted by Garet, Porter, Desimone, Birman, and Yoon (2001). The study used a national sample of 1,027 mathematics and science teachers who participated in an Eisenhower assisted professional development experience. Specifically, the study examined the relationships between a variety of professional development features identified in the literature and the self-reported enhancement in teachers' knowledge, skills, and classroom practices. The authors divided these identified features into two categories, structural features and core features.

Table 3. Components and Outcomes of Effective Professional Development for Teachers of Mathematics and Science.

Recommendations	Source of Recommendation
<u>Structural:</u>	
Content- based	Banilower et al., 2006; Garet et al., 2001; Hill & Ball, 2004; Loucks-Horsley et al., 2003; MSP, 2007
Intensive and sustained	Banilower et al., 2006; Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Hill & Ball, 2004; MSP, 2007
Trained providers	Hill & Ball, 2004
Coherent	Darling-Hammond & McLaughlin, 1995; Cohen & Hill, 2000; Corcoran, 1995; Garet et al., 2001; Loucks-Horsley et al., 2003
<u>Experiential:</u>	
Active learning	Darling-Hammond & McLaughlin, 1995; Corcoran, 1995; Garet et al., 2001; Loucks-Horsley et al., 2003
Collaboration	Darling-Hammond & McLaughlin, 1995; Corcoran, 1995; Garet et al., 2001; Hill & Ball, 2004; Loucks-Horsley et al., 2003
Opportunities to work with reform materials	Banilower et al., 2006; Cohen & Hill, 2000
Opportunities for reflection	Darling-Hammond & McLaughlin, 1995; Corcoran, 1995; Loucks-Horsley et al., 2003
Opportunities for leadership development	Loucks-Horsley et al., 2003
<u>Outcomes:</u>	
Improved teacher quality	Banilower et al., 2006; Cohen & Hill, 2000; Garet et al., 2001; Hill & Ball, 2004
Enhanced teacher knowledge	MSP-KMD, 2007
Student achievement	Banilower et al., 2006; Cohen & Hill, 2000; Guskey & Sparks, 2002

The structural features included the *form* of the activity categorized as traditional or reform (e.g. embedded within the regular school day), the *duration* of the experience determined by the total number of contact hours, and the extent of *collective participation*

measured by the level of engagement participants had with the teachers from their school, department, or grade level. The analyzed core features included the degree to which the activity had a *content focus* on disciplinary content knowledge, provided opportunities for *active learning*, and promoted *coherence*. *Coherence* was measured by the degree to which the experience connected to teacher goals, aligned with national, state, and local standards and assessments, and promoted ongoing professional communication. In other words, the extent to which professional development was integrated into the “daily life” of the teacher.

Results of this study found the following: (a) activity type influenced duration, where reform type activities were typically longer and exhibited modestly more influence on enhanced knowledge and skills than traditional activities; (b) both time span and contact hours had a positive influence on opportunities for active learning; (c) longer activities tended to promote coherence; and (d) activities with longer duration tended to focus more on mathematics and science content. Furthermore, all core features positively influenced enhanced knowledge and skills, which in turn had a substantial positive influence on change in teaching practice.

Two studies (Banilower & Shimkus, 2004; Hill & Ball, 2004) investigated the components of effective standards-based professional development in mathematics and science and how these components connected with teacher growth. In the first study, Hill and Ball (2004) explored whether teachers gain mathematical knowledge for teaching from professional development experiences. Participants in this study included 398 teachers participating in California’s Mathematics Professional Development Institutes

(MPDIs) who completed a pre-and post- test of mathematical content knowledge using an instrument developed by the authors. The study found that the length of the institute was a significant predictor of the institute's effectiveness. Programs that had a focus on mathematical content, provided opportunities for teachers to work together on problems that arise when teaching math, and/or were taught by mathematically knowledgeable individuals (i.e. university mathematicians) were more likely to enhance teachers mathematical knowledge.

In the second study Horizon Research evaluators (Banilower, Boyd, Pasley, & Weiss, 2006) evaluated the effectiveness of the Local Systemic Change (LSC) program in improving student achievement through enhancing teacher knowledge and skill through professional development. In 1995 the National Science Foundation initiated the LSC program, which aimed to offer approximately 70,000 mathematics and science teachers 130 hours of professional development. Using "best practices" identified in the literature, the LSCs strove to train well-prepared professional development providers, create a collegial learning environment for teachers, provide learning opportunities centered on content, pedagogy, and high-quality instructional materials, and provide teachers with sustained support. Data collection for the evaluation occurred in the following ways: observations of the professional development activities, classroom observations, teacher questionnaires, principal questionnaires, teacher interviews, LSC principal investigator interviews, and project ratings and strategies questionnaires completed jointly by the evaluators and principal investigators. Effectiveness was measured by the extent of teacher involvement in the LSC professional development

activities. The evaluation determined that although there were many barriers to success, such as teacher turnover and teacher attitudes toward the instructional materials, the program was successful; high quality professional development did improve instruction and student outcomes.

A Comprehensive Literature Review:

Teacher Knowledge and Professional Learning. A recent comprehensive review

of empirical research literature related to teacher knowledge and learning in mathematics and science was conducted by the Math and Science Partnership (MSP, 2007)

Knowledge Management and Dissemination (KMD) project. The purpose of the knowledge review was to synthesize the current findings in the area of teacher content knowledge, teacher leadership, and teacher induction in mathematics and science. This summary focuses on the portion of the literature review related to deepening content knowledge for teaching mathematics through teacher engagement in professional learning. In order to be included in this review, 1) the research needed to empirically study teachers' mathematics or science content knowledge, 2) the participants needed to be practicing in-service pre-K-12 teachers, and 3) the study needed to be published since 1990.

The KMD project has classified the findings of the professional learning and teacher knowledge review into categories based on the types of interventions. Findings from two types of interventions are currently available: *Engaging Teachers with Challenging Mathematics* and *Engaging Teachers with Student Thinking in Mathematics*. The KMD project is ongoing at the time of this writing and further summaries of the

research findings will soon become available to the public. Of the studies reviewed, six studies linked professional learning experiences involving engaging teachers with challenging mathematics to positively impacting teacher content knowledge (Basista & Mathews, 2002; Clark & Schorr, 2000; Garner-Gilchrist, 1993; Geer, 2001; Sowder, Phillip, Armstrong, & Schappelle, 1998; Swafford, Jones, & Thornton, 1997; Swafford, Jones, Thornton, Stump, & Miller, 1999). Although the learning experiences varied in duration, all six programs attempted to connect the mathematics content to the teachers' classroom instruction. In addition, all six programs were intensive in time and mathematics content and all involved university mathematics or mathematics education faculty.

Nine studies connected professional learning experiences involving engaging teachers with student thinking to positively impacting teacher content knowledge (Basista & Mathews, 2002; Clark & Schorr, 2000; Empson, 1999; Featherstone, Smith, Beasley, Corbin, & Shank, 1995; Franke, Carpenter, Fennema, Ansell, & Behrend, 1998; Miller, 1991; Sowder et al., 1998; Stecher & Mitchell, 1995; Swafford et al., 1997; Swafford et al., 1999). The professional learning experiences included in these studies were varied in duration and form (i.e. summer institutes, semester-long courses). In addition, the strategies for engaging teachers with student thinking in mathematics were varied (i.e. analyzing prepared student work, analyzing own students' writing). However, there were some commonalities beyond engaging in student thinking. All of the studies mentioned trying to connect what the teachers were learning about student thinking and mathematics content to their own classroom practice. Seven of the studies also engaged participants in

programs that were time intensive and focused on mathematics content and teaching and involved university mathematics or mathematics education faculty. A goal of each of the programs in these studies was to develop teachers' pedagogical content knowledge in mathematics.

The aforementioned studies were all a part of a more inclusive summary of the research on professional learning experiences designed to deepen teachers' disciplinary and pedagogical content knowledge in mathematics. The reviewers report that in all nine studies reviewed, participating teachers' content knowledge for teaching mathematics increased (Basista & Mathews, 2002; Clark & Schorr, 2000; Franke et al., 1998; Garner-Gilchrist, 1993; Geer, 2001; Hill & Ball, 2004; Sowder et al., 1998; Stecher & Mitchell, 1995; Swafford et al., 1997; Swafford et al., 1999).

A Systemic Approach to Understanding Professional Development. Two studies (Cohen & Hill, 2000; Guskey & Sparks, 2002) explored professional development for teachers of mathematics and science and offered frameworks for understanding professional development from a systemic perspective. Cohen and Hill (2000) devised a model of the relationships among reform policy, teaching, and learning to aid in investigating the classroom effects of California policy aimed at reforming mathematics teaching. This proposed model connects policy to practice via professional learning opportunities for teachers, which lead to reform teaching and indirectly to student achievement. To explore these connections, the authors investigated the teacher learning opportunities in mathematics professional development to see which components were related to reform-minded classroom practices recommended by the California

mathematics framework. Collecting survey data from elementary school teachers at 250 schools in California, the researchers found that teachers who had more opportunities to engage in curriculum-related professional development were more likely to teach according to the California framework. Furthermore, student achievement as measured by the California CLAS mathematics assessment was higher for students of these teachers. Ultimately, professional development that exposes teachers to reform ideas, is grounded in reform curriculum, and is extended in time, is an important avenue for reform to occur.

Guskey and Sparks (2002), extending the work of Cohen and Hill, developed a model of the relationship between professional development and student learning. In this model, *content characteristics* represent the “what” of professional development including the knowledge, skills, and understandings to be conveyed. *Process variables* represent the “how” of professional development and refer to both the form of the activity and how the activity is planned, carried out, and followed-up. The “who”, “where”, and “why” of professional development are all *context characteristics*. The content, process, and context all directly influence the quality of professional development, which in turn impacts the knowledge and practices of not only teachers, but also administrators and parents. Teachers and parents, along with the policies developed by administrators, influence student learning outcomes. Using case-studies, Guskey and Sparks (2002) confirmed the validity and appropriateness of the model. Their study revealed that effective professional development is complex, but neither random or chaotic. The authors urge using a systemic approach to designing effective professional development,

which considers the complex relationships between professional development and student learning.

Summary – Professional Development. The research indicates that effective professional development in mathematics and science should be driven by a well-defined image of teaching and learning supported by the standards; the outcome of effective professional development is a shift of teaching and learning toward the vision of the standards (Loucks-Horsley et al., 2003). In parallel with the organization of components of effective mentoring and induction, the characteristics of quality professional development have been grouped by *structural* as well as *experiential* components. Effective programs have several structural features in common. They are intensive and sustained (Banilower et al., 2006; Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Hill & Ball, 2004; MSP, 2007) and focus on mathematics and science content and pedagogy (Banilower et al., 2006; Hill & Ball, 2004; Loucks-Horsley et al., 2003; MSP, 2007). Additionally, professional development providers should be well-trained and have strong content knowledge (Hill & Ball, 2004). In order for programs to succeed, they must be coherent with teacher's personal goals and supported by school, district, and state standards and policies (Cohen & Hill, 2000; Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Loucks-Horsley et al., 2003).

A variety of experiences provide a common thread to link the characteristics of quality professional development. These experiences include opportunities for active learning and collaboration (Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Loucks-Horsley et al., 2003), reflection on practice (Corcoran, 1995;

Darling-Hammond & McLaughlin, 1995; Loucks-Horsley et al., 2003), and leadership development (Loucks-Horsley et al., 2003). Furthermore, using curriculum materials that support reform promotes teacher change toward standard-based instruction (Banilower et al., 2006; Cohen & Hill, 2000). Professional development based on “best practices” has been shown to improve teacher quality (Banilower et al., 2006; Cohen & Hill, 2000; Garet et al., 2001; Hill & Ball, 2004), enhance teacher content knowledge (MSP, 2007), and ultimately student achievement (Banilower et al., 2006; Cohen & Hill, 2000; Guskey & Sparks, 2002).

Mentoring, Induction, and Professional Development: How Are They Related?

According to Feiman-Nemser et al. (1999), reform-minded educators aim to create a “seamless bridge” between preservice programs and professional development. Mentoring and induction programs serve as this bridge and the authors claim that “by conceptualizing induction as a form of professional development, we are moved to consider how emerging principles of effective professional development apply to learning opportunities for new teachers” (p. 12). Furthermore, Luft et al. (2002) assert that “developing such programs will require a process that is similar to the designing and enacting of professional development programs for science teachers, yet able to address the unique developmental needs of beginning teachers that align with preservice education” (p. 227).

Through reviewing the mentoring and induction and professional development literature, clear parallels emerge. In fact, successful mentoring and induction programs

incorporate almost all of the components of effective professional development (Feiman-Nemser et al., 1999). Both are designed to help develop the knowledge, skills, and practice of the classroom teacher. Mentoring and induction, however, must go beyond professional development to meet the needs of novice science and mathematics teachers. Mentoring and induction must view new teacher growth from a developmental perspective, understanding that new teachers' immediate needs must be met in addition to their long-term professional needs (Luft et al., 2002). In addition to high quality professional development experiences in induction, new teachers should work with highly trained, carefully selected content-based mentors (Britton et al., 2000; Luft et al., 2007) and have the opportunity to network with other beginning teachers (Friedrichsen et al., 2007). The experienced teacher, on the other hand, should be provided opportunities for leadership development as part of an effective professional development experience (Loucks-Horsley et al., 2003). The combination of professional development and mentoring can facilitate both new and experienced teachers in moving their practices forward. Figure 6 summarizes the overlap between the features of effective professional development and successful mentoring and induction.

The eMSS Experience

eMSS is a mentoring and induction program designed on the research-based principles of effective mentoring, induction, and professional development (Jaffe et al., 2006). Like most effective induction programs, eMSS contains a mentoring component where early career teachers are paired with carefully selected, highly trained mentors. Mentors and mentees are matched by the content area they teach and work together in a

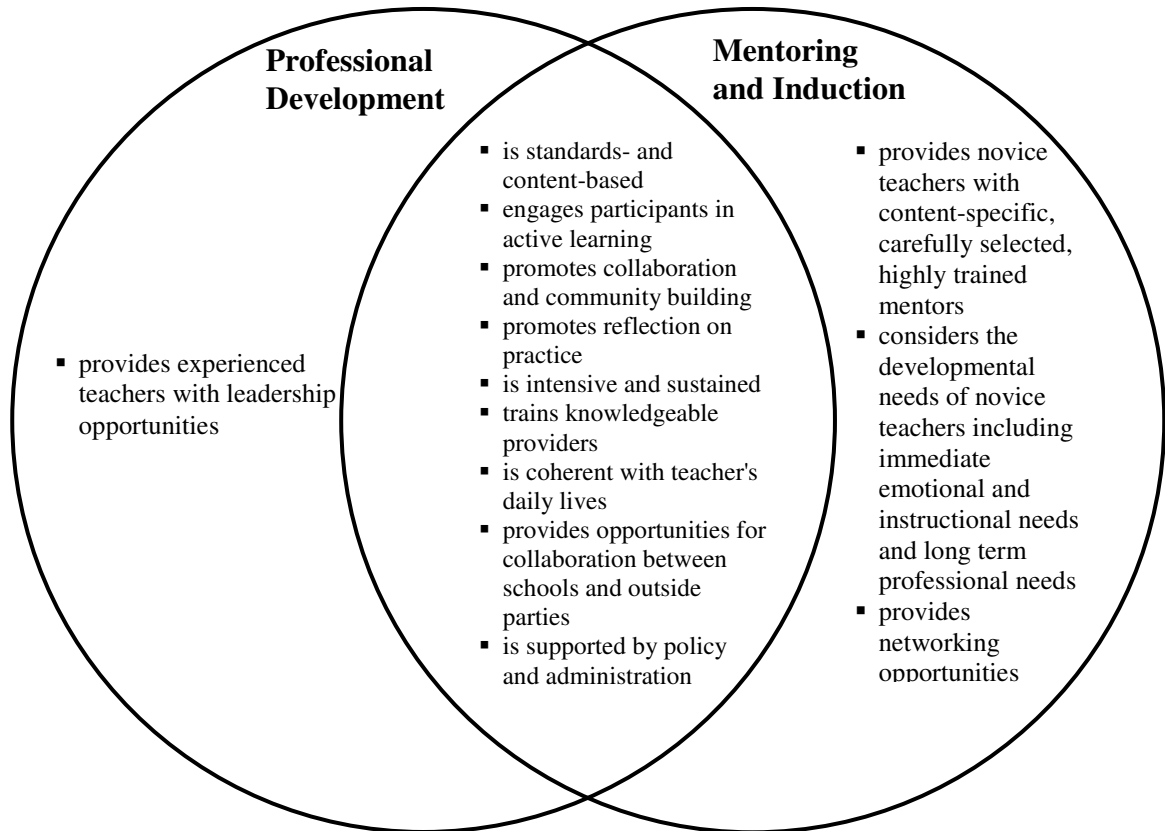


Figure 6. Components of Effective Mentoring and Induction and Professional Development for Teachers of Mathematics and Science.

private, small group discussion area. In addition, mentees have access to a supportivenetwork of both early career and experienced teachers in the various discussion forums. The structured curriculum, enacted through facilitated discussion forums, emphasizes quality dialogue focused on deepening content and pedagogical knowledge, while also meeting the early career teachers' immediate emotional and instructional needs. This structured curriculum, including the dilemmas and inquiries, promotes collaboration, active learning, and reflection on practice. For example, in an inquiry participants engage in a cycle of planning, practicing, and reflecting on the implementation of a new teaching strategy of their choice. Through the process,

participants collaborate with other novice and experienced teachers. Because teachers choose an inquiry of personal and practical interest, the inquiry is coherent with their daily teaching lives.

In addition to mentoring, mentor teachers also engage in the structured curriculum as well as un- or semi-structured discussion areas such as the content forums. Thus, they have the ability to collaborate and communicate with other experienced teachers and with trained facilitators and university scientists and mathematics educators. Because the various content and teaching oriented discussion forums utilize trained facilitators, opportunities for reflection on practice are frequently promoted. Finally, mentor teachers have many opportunities to act as leaders, informally through working with early career teachers, and formally through becoming facilitators themselves. It is hypothesized that engaging in a content-based mentoring and induction program enhances and deepens mentors' knowledge needed for teaching mathematics as well as develops their reflective practices and promotes their professional engagement. This study sheds light on what ways experienced mathematics teachers grow and develop professionally as a result of participating in eMSS.

Outcomes: Experienced Teacher Growth and Development

We have little sense – save the collective and negative self-reports of generations of teachers about traditional in-service programs – of what exactly it is that teachers learn and by what mechanisms that learning takes place. What knowledge do teachers acquire across these experiences? How does that knowledge improve their practice? These questions are left unanswered (Wilson & Berne, 1999, p.174).

What a teacher knows influences what happens in his or her classroom and ultimately impacts student learning. Although no one questions this statement, there is no agreement about what knowledge a teacher needs to hold in order to influence teaching and learning in mathematics (Fennema & Franke, 1992). Historically, the knowledge needed for teaching mathematics was measured by the number of content courses teachers have taken or teachers' computational ability as opposed to measuring content knowledge as it is needed for teaching (Fennema & Franke, 1992; Hill & Ball, 2004). Theoretical work (Shulman, 1986, 1987), followed by research indicating that U.S. teachers lack essential knowledge for teaching mathematics (Ball, 1990; Ma, 1999), has instigated recognition of the need to focus research, policy, and practice on content knowledge for teaching (Hill, Rowan, & Ball, 2004; Hill, Schilling, & Ball, 2004). As a result, teaching standards such as the National Board for Professional Teaching Standards (NBPTS) (2005) reflect the understanding that subject-matter knowledge cannot be separated from pedagogical knowledge and knowledge of student thinking. Teachers need all of these competencies to be successful.

Nonetheless, there still exists a lack of agreement on what teachers need to know in order to provide quality instruction. This is likely because components of teacher knowledge represent a complex and integrated system. Various authors have attempted to make sense of teacher knowledge and have offered up frameworks for understanding the competencies needed for teaching. It is the intent of this section to review the theoretical frameworks of knowledge and competencies needed for teaching in general, and for teaching mathematics in particular. From this review, I have developed a framework for

understanding the potential domains of teacher growth and development. I will use this framework to inform my understanding of experienced mathematics teacher growth and development as a result of participating in a mentoring and induction program aimed at improving teachers' mathematical knowledge, skill, and practice. Subsequently, I have reviewed the limited research that has evaluated teachers' mathematical knowledge and connected this knowledge to student learning.

Theoretical Frameworks: Domains of Potential Teacher Growth and Development

Effective teachers need to be proficient across a variety of domains regardless of the subject they teach. The NBPTS (2005) describes what a professional teacher should know and be able to do and is a useful framework for describing the competencies of professional teachers. According to these standards, professional teachers have a broad and in-depth understanding of their subject and knowledge of how to best organize and effectively teach the content to diverse learners. Additionally, professional teachers are committed to teaching all students and know how to engage students in learning and to assess their progress. Systematic thinking and reflection on practice are continuous processes for the professional teacher. Finally, professionals work collaboratively with colleagues, administration, and the larger educational community to improve teaching and learning.

In order for teachers of mathematics and science to grow and develop as professionals they need to engage in a coherent continuum of teacher learning from their pre-service years, through their induction years, and throughout their careers (Feiman-

Nemser, 2001; Mundry, Spector, Stiles, & Loucks-Horsley, 1999). For the experienced science or mathematics teacher who has already developed a professional identity and a repertoire in curriculum, instruction and assessment, the purpose of professional development is to extend and deepen content knowledge and pedagogical knowledge, refine his or her ability to teach a diverse body of learners, and take on leadership roles. Leadership is particularly important if educational reform is to take place; the experienced teacher should be an agent for change and as such must understand the context in which he or she teaches (Feiman-Nemser, 2001; Loucks-Horsley et al., 2003; Mundry et al., 1999).

The competencies of professional teachers and the goals of professional learning depicted by the NBTS (2005), Feiman-Nemser (2001), and Mundry et al. (1999) have been informed by theoretical frameworks of teacher content knowledge. The theoretical work of Shulman (1986) lead this effort of understanding the domains of subject-matter knowledge for teaching. Shulman recognized that a teacher's effectiveness is influenced both by the teacher's subject matter knowledge and knowledge of how to teach that content. In his framework, Shulman distinguishes three categorizes of content knowledge for teaching including subject specific *content knowledge*, *pedagogical content knowledge*, and *curricular knowledge*. Subject specific *content knowledge* includes the knowledge of facts and concepts in a discipline, how facts and concepts of the discipline are generated and organized, and why facts and concepts are true. *Pedagogical content knowledge* is content knowledge for teaching and embodies understanding how to effectively represent and teach this subject knowledge to students, as well as

understanding what makes the learning of topics challenging or easy for students.

Curricular knowledge is a teacher's knowledge of how to use resources and arrange topics over time to organize the study of a discipline. Each of these components contributes to a teacher's effectiveness.

In part of their synthesis of findings in the area of deepening teacher knowledge in science and mathematics, the Math and Science Partnership (MSP, 2007) Knowledge Management and Dissemination (KMD) project, reviewed a substantial body of work related to content-specific knowledge for teaching. As a result of their review, the authors extend upon the work of Shulman and propose three categories for understanding teacher content knowledge: (1) disciplinary content knowledge, (2) ways of knowing in the discipline, and (3) pedagogical content knowledge. Disciplinary content knowledge is the knowledge of the subject matter and the authors assert that teachers must understand the subject matter at three levels. They must first understand the content at the student-level; they must know the content they teach. Teachers should also have an advanced understanding of the content beyond what the students are expected to learn. This includes at least content several grade levels past the grade level the teacher teaches. Finally, teachers should have a "profound knowledge" (Ma, 1999) of mathematics. According to Ma, a "profound knowledge" of mathematics is a "deep, broad, and thorough" understanding of fundamental mathematics which allows the teacher to break down concepts into key understandings that influence pedagogical decisions. Like Shulman, the authors KMD project also emphasize the importance of understanding the discipline of mathematics which incorporates the knowledge of how mathematics is done

(e.g., trial and error, finding counterexamples, using inductive and deductive reasoning) and how knowledge is generated in the field of mathematics (e.g., what constitutes an adequate proof).

The KMD project's categorization of pedagogical content knowledge is composed of knowledge of student thinking, knowledge of implications for instruction, and knowledge of the curriculum. Understanding student thinking involves knowing students' preconceptions and misconceptions as well as their ways of thinking about ideas in mathematics. Combining this knowledge with knowledge of mathematics has a direct implication for instruction; teachers need to understand how to appropriately engage students with mathematical experiences that build on their understandings. Finally, teachers need to have knowledge of the curriculum which includes understanding how concepts are sequenced through the curriculum, how connections are made across the curriculum, and how instructional materials are used in support of the curriculum.

Categorizing the knowledge needed for teaching in a slightly different manner than Shulman, Fennema and Franke (1992) and Friel and Bright (2001) present two very similar models of teachers' knowledge needed for teaching mathematics. Fennema and Franke developed a model based on their comprehensive review of the teacher knowledge literature. In this model, teachers need to understand mathematical content, mathematics pedagogy, and how students think about and learn mathematics. Likewise, Friel and Bright present a model that shows these aforementioned components as a framework for planning professional development experiences for mathematics teachers. The authors define pedagogical knowledge of mathematics as the knowledge of effective

strategies for teaching mathematics (Fennema & Franke, 1992) such as the knowledge of how to use mathematical representations (Friel & Bright, 2001). Knowledge of student thinking is the knowledge of how students' reason about mathematics (Friel & Bright, 2001) and what difficulties or successes students might have (Fennema & Franke, 1992). Both sets of authors stress that the three components are interrelated and filtered through teachers' personal beliefs. Fennema and Franke also situate teacher knowledge in the context in which it is used, the classroom. Figure 7 is an integration of these models.

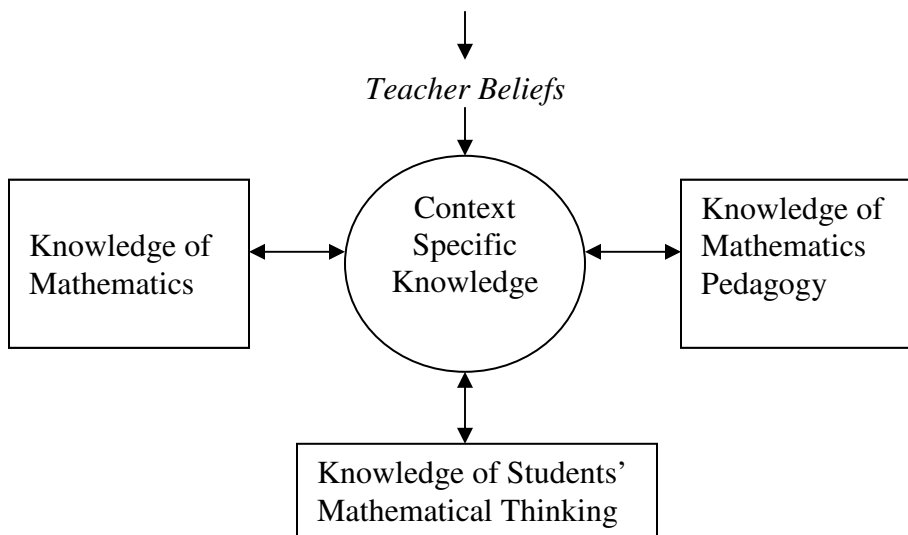


Figure 7. Components of Mathematics Knowledge for Teaching in Context (adapted from Fennema & Franke, 1992 and Friel & Bright, 2001).

Investigating content knowledge needed for teaching mathematics through extensive work with elementary school teachers, Hill and associates (2004) describe two categories of mathematical content knowledge: *common content knowledge* and *specialized content knowledge*. *Common Content Knowledge* in mathematics refers to knowledge of the discipline that is not unique to teaching (Hill & Ball, 2004). In other words, this is the knowledge of mathematics, such as the ability to do arithmetic and

solve word problems, held by other adults. On the other hand, *specialized knowledge of content* is the knowledge of content unique to teachers. Teachers have specialized knowledge of content that, for example, allows them to understand novel methods of problem solving, provide explanations of common algorithms, and using alternative representations (Hill & Ball, 2004; Hill, Schilling et al., 2004). It is important to note that tasks are mathematical and not pedagogical in nature (Hill, Rowan et al., 2004).

In her doctoral dissertation, Welder (2007) synthesized the literature on the domains of teacher knowledge using many of the same sources presented here with an emphasis on the work of Hill, Ball, and associates. Based on the review, she presents a theoretical framework of knowledge for teaching mathematics. In her framework she distinguishes between general pedagogical knowledge and mathematical knowledge. Mathematical knowledge is comprised of common content knowledge and pedagogical content knowledge. Pedagogical content knowledge is further divided into four components including specialized content knowledge, knowledge of students' conceptual thinking, knowledge of content and teaching, and curricular knowledge. Welder used a recent unpublished version of Ball's (2006, as cited in Welder, 2007) framework to develop her own.

Combining the competencies of experienced teachers depicted in the NBPTS (2005) and by Feiman-Nemser (2001) and Mundry et al. (1999) along with the theoretical frameworks presented by Fennema & Franke (1992), Friel & Bright (2001), Hill, Ball, and associates (2004), the KMD project (MSP, 2007), Shulman (1986), and Welder (2007), I have created a framework for the domains of potential teacher growth and

development as seen in Table 4. Definitions for each category follow. I have used this framework to inform my understanding of the mathematics teachers' reported growth and development as a result of participating in eMSS.

Table 4. Framework for the Domains of Potential Teacher Growth and Development.

Domains of Potential Teacher Growth and Development	Source of Contribution
I. Knowledge for Teaching Mathematics	
A. General Pedagogical Knowledge	Feiman-Nemser, 2001; Mundry et al. 1999; NBPTS, 2005; Shulman, 1986
B. Content Knowledge	Fennema & Franke, 1992; Feiman-Nemser, 2001; Friel & Bright, 2001; MSP, 2007; Mundry et al. 1999; NBPTS, 2005; Shulman, 1986; Hill, Ball, and associates, 2004
C. Pedagogical Content Knowledge	Feiman-Nemser, 2001; MSP, 2007; Mundry et al. 1999; NBPTS, 2005; Shulman, 1986
i. Specialized Content Knowledge	Hill, Ball, and associates, 2004
ii. Knowledge of Content and Teaching	Fennema & Franke, 1992; Friel & Bright, 2001; Welder, 2007
iii. Knowledge of Student Thinking	Fennema & Franke, 1992; Friel & Bright, 2001; Welder, 2007
D. Curricular Knowledge	Shulman, 1986
E. Knowledge of how to support diverse learners	Feiman-Nemser, 2001; Mundry et al. 1999; NBPTS, 2005; Shulman, 1987
F. Knowledge of educational policies, practices, and objectives	Feiman-Nemser, 2001; Mundry et al. 1999; NBPTS, 2005; Shulman, 1987
II. Engagement and practices	
A. Professional engagement and leadership	Feiman-Nemser, 2001; Mundry et al. 1999; NBPTS, 2005
B. Reflective practices	Feiman-Nemser, 2001; Mundry et al. 1999; NBPTS, 2005

1. *General Pedagogical Knowledge* – Non-content-based teaching knowledge such as general teaching strategies, managing student behavior, classroom procedures, etc.
2. *Content Knowledge* - Knowledge of facts and concepts in a discipline, how facts and concepts of the discipline are generated and organized, and why facts and concepts are true (Shulman, 1986). This definition incorporates disciplinary/common content knowledge and ways of knowing in the discipline (Hill & Ball, 2004; Hill, Rowan et al., 2004; Hill, Schilling et al., 2004; MSP, 2007).
3. *Pedagogical Content Knowledge* – Content knowledge for teaching that embodies understanding how to effectively represent and teach the subject knowledge to students, as well as understanding what makes the learning of topics challenging or easy for students (Shulman, 1986).
 - a. *Specialized Knowledge of Content* – Knowledge of content unique to teachers. Teachers have specialized knowledge of content that, for example, allows them to understand novel methods of problem solving, provide explanations of common algorithms, and using alternative representations (Hill & Ball, 2004; Hill, Schilling et al., 2004).
 - b. *Knowledge of Content and Teaching* – Knowledge of effective strategies for teaching mathematics such as using illustrations, demonstrations, manipulatives, etc. to explain and/or represent mathematical concepts and to use mathematical representations (Welder, 2007).

- c. *Knowledge of Student Thinking* – Knowledge of how students reason about and comprehend mathematics. This includes common student pre-conceptions, misconceptions, and what students find easy or difficult.
- 4. *Curricular Knowledge* – Knowledge of how to use resources and arrange topics over time to organize the study of a discipline (Shulman, 1986).
- 5. *Knowledge of how to Support Diverse Learners* – Knowledge of students' individual differences, including knowledge of students' interests, abilities, skills, knowledge, family circumstances, peer relationships, and racial, ethnic, cultural, and socioeconomic backgrounds, as well as knowledge of how to support students' unique learning needs based on these differences (NBPTS, 2005).
- 6. *Knowledge of Educational Policies, Practices, and Objectives* – Knowledge of educational policies, practices, and objectives at the local, state, and national levels, which allows the teacher to access resources and engage collaboratively with various members of the educational system.
- 7. *Professional Engagement and Leadership* – Involvement in professional activities or leadership positions beyond regular classroom and school duties expected of a teacher.
- 8. *Reflective Practices* – Thoughtful or purposeful contemplation of one's knowledge and skills or practices needed to teach mathematics.

Findings: The Effects of Teacher Knowledge of Mathematics

There exists little research linking teacher knowledge with teacher practice and student learning in mathematics. Hill, Ball, and associates have done much work in this

field in order to help fill this void. Through their work with elementary school teachers, they have developed a framework for understanding and instruments for assessing teachers' mathematical content knowledge (Hill & Ball, 2004; Hill, Schilling et al., 2004). In a recent study aimed at exploring teacher knowledge and student achievement, Hill, Rowan, and Ball (2004) analyzed data from the Study of Instructional Improvement (SII). The SII is a detailed study of the impact of comprehensive school reform programs on instruction and student achievement. Part of the SII assessed teachers' *common* and *specialized mathematical knowledge*. In specific, the SII measured elementary teachers' ability to represent numbers and operations, provide mathematical explanations for common rules and procedures, and examine and understand student solutions. The authors investigated the SII data of 334 and 365 first and third grade teachers respectively. Student achievement was measured by the Terra Nova standardized assessment. Using linear mixed models, the authors determined that teachers' content knowledge is a significant predictor of student achievement gains and the authors recommend that teachers with weak mathematical content knowledge for teaching be recruited into content-based professional development programs.

In their comprehensive review of the empirical research literature about teacher knowledge, the Math and Science Partnership (MSP, 2007) Knowledge Management and Dissemination (KMD) project was also able to make claims connecting teacher knowledge to instruction and student learning. Consistent findings across the reviewed studies reveal that:

- “Teachers’ mathematics/science content knowledge influences how teachers engage students with the subject matter,
- Teachers’ mathematics/science content knowledge influences how teachers evaluate, create, and use instructional materials (based on 7 references),
- Teachers’ mathematics/science content knowledge is related to what their students learn” (MSP, 2007).

In mathematics, teachers with stronger content knowledge were better able to build off of students’ prior knowledge, use multiple representations, and approach students’ questions collaboratively in order to further student understanding. In addition, knowledgeable teachers were more proficient at selecting coherent instructional materials. Finally, the KMD project reports mixed findings after examining two studies exploring the relationship between teacher knowledge and student learning; in three occurrences teacher knowledge was positively related to student learning and in one occurrence no relationship was found.

Summary

Mentoring and induction and professional development programs designed for teachers of mathematics are based on the premise that teachers need a strong understanding of the content they teach. Although documents such as the NBPTS (2005) outline the competencies of professional teachers, there is no consensus about what teachers need to know to effectively teach mathematics. In addition, with the exception of very few studies (Hill, Rowan et al., 2004; MSP, 2007), there is little evidence

connecting teacher knowledge in mathematics with effective instruction and student learning gains.

Many authors have offered frameworks for understanding teacher content knowledge. I have used these theoretical frameworks (Fennema & Franke, 1992; Friel & Bright, 2001; Hill & Ball, 2004; Hill, Rowan et al., 2004; Hill, Schilling et al., 2004; MSP, 2007; Shulman, 1986; Welder, 2007) along with the competencies of experienced teachers (Feiman-Nemser, 2001; Mundry et al., 1999; NBPTS, 2005) to develop a framework for the domains of potential teacher growth and development. This framework is divided into two categories: (1) knowledge and (2) engagement and practices. In the knowledge category, experienced mathematics teachers can potentially extend and deepen their general pedagogical knowledge, content knowledge, pedagogical content knowledge, curricular knowledge, knowledge of how to support diverse learners, and their knowledge of educational policies, practices and objectives. In addition, experienced mathematics teachers participating in professional learning through engagement in an induction curriculum have the potential to refine their reflective practices and develop leadership skills which may lead to more active engagement in professional activities.

It is the intent of this study to shed light on how engagement in eMSS promotes professional development and growth for the mentor mathematics teachers. Results from preliminary pilot interviews and surveys reveal how eMSS promotes professional growth in general and in the domains identified in my framework in particular. These findings will be discussed in the next section.

Mentoring as Professional Development:
An Opportunity for Experienced Teacher Growth

“Mentoring is a powerful experience for master teachers who remain passionate about classroom teaching and are ready for an additional challenge” (Villani, 2002, p. 21).

In this section I have reviewed the limited literature exploring the professional benefits of mentoring on the experienced mentor teacher. I have also presented a summary of preliminary pilot interview and survey findings. These findings uncover the relationship between engaging in a content-based mentoring and induction curriculum that was designed to incorporate many best-practices in professional development and experienced mathematics teacher growth.

Mentoring has the potential to benefit both the early career teacher as well as the veteran teacher. Huling and Resta (2001), in their review of the practitioner and research literature, describe the many benefits of mentoring. Through supporting and collaborating with beginning teachers, mentors’ teaching abilities can be positively influenced (Yosha, 1991). For example, mentors may learn to be better listeners or learn new teaching strategies from their mentees (Clinard & Ariav, 1998). Additionally, talking about teaching with their mentees promotes mentors to be more reflective on their own practices (Ganser, 1997). For many experienced teachers, the role of mentor provides them with a new self-worth and confidence as a professional and has promoted many mentors to seek leadership positions (Freiberg et al., 1996). Finally, veteran teachers often feel re-energized and find a sense of professional renewal that may strengthen their commitment to teaching (Ford & Parsons, 2000).

Anecdotal evidence exists to support the notion that mentoring promotes the professional development of mentor teachers. For example, through their work with nearly 2,000 beginning teachers in the Santa Cruz New Teacher Project, Gless and Moir (2001) have witnessed that high-quality induction programs have done just that. Regular collaboration with the beginning teachers, which includes both the mentee and mentor setting professional development goals, reviewing observation data and student work, and documenting evidence of growth, provides mentors with a powerful form of professional development that has the potential to enhance pedagogical knowledge. Furthermore, veteran teachers become reinvigorated through mentoring, which changes their attitudes toward teaching and challenges them to become professional leaders.

Auton, Berry, Mullen, and Cochran (2002) report similar benefits of mentoring in a Virginia based mentoring program, Great Beginnings. In this program, designed with best practices in mentoring in mind, veteran teachers serve as coaches for a group of early career secondary teachers in their content area. Gathering evidence from focus groups and reflective journals, the authors found four areas of benefits for the coaches. Through learning alongside beginning teachers, the coaches reported that they gained an increased appreciation for reflective practice and felt that they were more effective teachers as well. According to the coaches, working and planning with other coaches provided the veteran teachers with a new perspective on professionalism and leadership. Experienced or even “jaded” teachers felt a sense of renewal that strengthened their commitment to teaching.

Although much anecdotal evidence exists suggesting that mentor teachers grow professionally as a result of mentoring an early career teacher, only a few research studies

have connected mentoring to the professional growth of experienced teachers. Through interviews, Freiberg, Zbikowski, and Ganser (1996) explored the experiences of five mentor teachers in an urban school district. The mentor teachers were full time mentors, working with beginning teachers across the district. These mentors reported a strong positive personal and professional growth. Many of the mentors expressed an increased confidence in working with adults, a more objective reflection on their own teaching as well as a clearer vision about teaching and learning. They also had a better understanding of the educational system in which they worked, both locally and nationally. All of the mentors in the study showed an interest in furthering their professional growth by seeking more professional development and leadership experiences and all of the mentors were rejuvenated by the experience.

Clinard and Ariav (1998) also studied the effects of mentoring on mentor teachers. The mentor teachers supported student teachers as they participated together in a University of California Professional Development School, which was developed to promote standards-based instruction. Using qualitative and quantitative analysis of survey results, the researchers identified the following benefits gained from working with student teachers: greater enthusiasm, more opportunity to collaborate, increased knowledge of subject matter, increased reflective practices, greater technological expertise, more insights about their students, and more assessment strategies. Additionally, mentors' classroom practices changed in the following ways: increased reflection in planning and implementation, use of cognitive coaching with students, altering classroom management strategies, using more technology, and collaborating

more with colleagues. Finally, mentors' professional life was positively influenced. Mentors became more committed to quality teacher education, gained a sense of validation, renewal, and investment in the profession, and had more respect for university faculty.

In her investigation of the effectiveness of a distance-mediated mentoring program for rural mathematics and science teachers in Montana, Luebeck (1998) uncovered various benefits of mentoring. Beginning mathematics and science teachers worked with mentor teachers in their content area in the Systemic Teacher Excellence Preparation Project. Mentors and mentees used telecommunication to communicate at distance and also participated in face to face professional development experiences. Survey data and interviews with mentors determined that they grew professionally in similar ways as their mentees. Additionally, through working with mentees and the greater community of Montana mathematics and science teachers, mentor teachers had a renewed enthusiasm for teaching.

Pilot Interviews

Three eMSS facilitators who have experience in mentoring were interviewed to explore the ways they have grown professionally as a result of participating in eMSS as well as to identify how the different features of eMSS have contributed to this identified growth. These interviews were informal conversations using prompts when necessary to extend the conversation and deepen the responses, and the interviews were conducted separately. Each facilitator has participated in eMSS for a total of five years. Facilitator 1 is a middle school science teacher who mentored for three years, Facilitator 2 is a high

school mathematics teacher who mentored for four years, and Facilitator 3 is a middle school science and math teacher who mentored for three years.

Each of these facilitators expressed that eMSS significantly promoted their personal and professional growth. One goal of eMSS curriculum is to strengthen and deepen participants' content and pedagogical content knowledge. For all three facilitators, this goal was met. In their own words, each facilitator expressed that participating in non-judgmental discussions where participants felt free to ask "dumb" questions allowed them to brainstorm teaching ideas, learn about resources and activities, and expand upon and deepen their disciplinary content knowledge. In specific, Facilitator 3 stated that she previously taught primarily through lecturing but has instituted more hands-on activities and inquiry in her science classes and also uses these types of activities to develop algorithms in her math classes as a result of her eMSS experience. Facilitator 2 also mentioned growth in her curricular knowledge because she has participated in discussions about what should and should not be included in the high school math curriculum. All of these facilitators credited the content discussion areas to their largest growth in content, pedagogical, and/or curricular knowledge because of the nature of the discussions. It is important to note that each of these facilitators facilitate in one of the content discussion areas and are perhaps more active in these discussions than regular mentors.

Although all of the facilitators agreed that the content discussion areas promoted their professional growth, they disagreed about the value of Our Place and the inquiries and dilemmas. Facilitator 1 and 3 stated that the inquiries and the Our Place have not

been very useful for them because they both had mentees that did not participate actively in either area. Facilitator 3 mentioned that in the Our Place, she answered questions, but ongoing, thoughtful dialogue did not occur. Although Facilitator 2 found the inquiries powerful for her mentees, she stated that participating in the inquiry area was a “hand-holding” role. The power of the inquiries for her lay in the related Our Place discussion; this was a time when her best mentoring occurred because she was able to get her mentees to reflect on their practice. Both Facilitators 1 and 3 were huge fans of the dilemmas, finding the dilemmas to provide many opportunities to share experiences, learn about resources, and brainstorm solutions to problems. Facilitator 1 likened the dilemma discussion to sitting around a coffee table with her colleagues and discussing solutions to a problem, but better because you had the chance to really hear everyone’s opinion. In their current state, Facilitator 2 does not find the dilemmas to be a venue where powerful learning occurs.

Networking proved to be a very valuable benefit of participating in eMSS for these facilitators. For Facilitator 1, networking opened up resources such as access to other teachers in state and out of state. As a result, she is aware of policies and procedures and curriculum used in other districts, which influences her understanding of the wider Montana educational system and informs some of her school level decision making. Likewise, Facilitator 3 has learned more about state-wide programs such as Indian Education for All and Facilitator 2 has learned about other states’ tests, standards, and teaching conditions. Facilitator 2 also expressed that interaction with other professionals outside the niche of her school allowed her to discuss philosophies of

teaching, strategies, best practices, etc., which she was not able to do with teachers in her building. Through participating in the eMSS community, each of these facilitators discovered that many teaching situations and problems are universal.

When prompted, all of the facilitators expressed that their leadership skills have been greatly enhanced as a result of participating in eMSS. Facilitator 1 stated that because of her participation in eMSS, she is more optimistic and confident and as a result, is now on the Montana Science Teachers Association (MSTA) board. The networking opportunities afforded by participation in eMSS allowed Facilitator 3 to become more involved in leadership positions, such as working with the Montana Office of Public Instruction and also becoming an MSTTA board member. Facilitator 2 attributed her leadership development to watching how role-models in eMSS lead as mentors and facilitators. From these experiences, she has improved her ability to handle difficult situations and is more “politically savvy”, be it on eMSS or in the classroom.

Participating in eMSS has caused each of these facilitators to become more reflective on their practice and become more aware of their teaching. Facilitator 2 compared mentoring to teaching: When you teach a student a new concept, you understand the concept better yourself. Likewise, when you mentor a new teacher, you gain a better understanding of your own teaching practice and philosophy. Facilitator 3 expressed that she did not reflect much on her practice before participating in eMSS and attributed her reflective practices to the reflection assignments built into the eMSS curriculum. Facilitators 1 and 2 asserted that writing promoted reflection. Posting allows more time to think about and edit responses, producing more thoughtful, succinct, and

encouraging posts. As a result of writing, Facilitator 2 has become more aware of her tone both online and in the classroom.

In summary, one or more of the facilitators identified or agreed that they grew professionally in the following areas: they enhanced their content, pedagogical, and curricular knowledge, gained knowledge of the wider educational system, developed of leadership skills, and became more reflective practitioners. The only category identified in the practitioner and research literature that these facilitators did not identify as an area of growth as a result of participating in eMSS was their knowledge of students as diverse learners; They felt that their experiences in eMSS did not particularly enhance their understanding of how to meet the needs of diverse students.

Finally, Facilitators 1 and 2 expressed a sense of validation of their teaching practice and a feeling of increased self-confidence as additional benefits of participating in eMSS. In particular, Facilitator 2 felt like her participation and contributions to the teaching community contribute to her professionalism as a mathematics teacher. The pilot interviews confirm that eMSS has the potential to provide both professional and personal benefits.

Pilot Surveys

Like the interviews, pilot surveys reveal that mentors have grown professionally as a result of participating in eMSS. The surveys were distributed online to 20 eMSS mathematics and science facilitators who were either currently participating or have participated as eMSS mentors in the past. Fifteen surveys were returned and 12 surveys were completed in their entirety.

The surveys indicate that eMSS is consistent somewhat (20.0 percent of respondents) or to a great extent (66.7 percent of respondents) with the facilitators' personal goals for professional development. In addition, 50.0 percent or more of the facilitators found that their knowledge and skills have been enhanced in a variety of areas as a result of participating in eMSS. These areas include curriculum, instructional methods, approaches to assessment, use of technology in the classroom, strategies for teaching diverse student populations, deepening knowledge of mathematics or science content, leadership development, adapting teaching to meet state assessment requirements, adapting teaching to meet state standards or curriculum framework requirements, and understanding educational policies and practices.

Changes in classroom practices have also been made by 50.0 percent or more of the facilitators in the following areas: curriculum content, cognitive challenge of classroom activities, instructional methods, types or mix of assessments, increased involvement in professional activities, and more reflection on practice. The way technology is used in instruction and approaches taken to student diversity were the only areas that less than 50.0 percent of the facilitators reported a change in practice.

Of 14 respondents, 12 reported that student learning and engagement has improved in their classes as a result of their participation in eMSS and two main themes emerged. The most prevalent theme was gaining new and more varied ideas, resources, and strategies for teaching mathematics and science. For example, one participant wrote: "I have incorporated ideas from teachers all over the country and gained an enormous variety of resources to use with my students." A second theme focused on improving

student engagement and creating a student-centered classroom. Statements supporting this theme include: “engagement is always high when I do hands-on activities, and now I do more and better ones” and “encouragement of emss inquiries to use authentic assessment activities improves the engagement of my students.” Finally, one facilitator expressed feeling more enthusiastic and having a fresh outlook towards his or her teaching practices. Two others discussed how their experience indirectly affected student learning through affecting their mentees and other teachers that they work with.

The purpose of the next section of the survey was to investigate how the facilitators perceived the various discussion areas of eMSS promoting their professional growth across the eight domains of potential professional growth and development. Table 5 provides an overview of the findings from this section of the pilot survey. At the end of the survey, the facilitators were asked to consider if and how their involvement in eMSS has contributed to one of the domains of potential growth and development the most. Five of participants expressed that their leadership skills and professional engagement was most impacted, three participants stated that their content knowledge was most impacted, one participant expressed that his or her pedagogical knowledge was most impacted, one participant said that his or her reflective practices was most impacted, and one participant stated that his or her knowledge of how to support diverse learners was most impacted through participation in the program. Finally, one participant expressed that he or she could not name one area. Table 6 summarizes some of the insightful mentor feedback.

The survey results indicate that these facilitators who have been, or are currently, mentor teachers have reported growth in some or all of the domains of potential teacher growth and development. This growth occurred in all of the discussion areas through interacting with facilitators, content experts, networking and collaborating with other experienced teachers, and engaging with beginning teachers of mathematics and science. In addition, the facilitators have reported changes in instructional and professional practices and student learning.

Summary

The anecdotal and research evidence is clear; mentors grow both personally and professional as a result of working with early career teachers. Mentoring has the potential to increase self-confidence, improve pedagogy, develop reflective practices, promote collegial collaboration and professionalism, provide a clear vision of teaching and learning, broaden perspectives of education, promote leadership, and reinvigorate the veteran teacher. In the context of eMSS, mentor teachers reported growth across all of the domains identified in the potential teacher growth and development framework, albeit the reported growth was different for each teacher and varied across the domains. In addition, some mentors gained a sense of validation and increased self-confidence as a result of engaging in the program. Gless and Moir (2001) sum it up best; well-designed mentoring and induction programs can support the development of both the novice and veteran teachers resulting in “teacher quality squared.”

Table 5. Influence of eMSS Discussion Areas on the Domains of Potential Teacher Growth and Development.

Domain	Influence on Domain: Somewhat to a Great Extent	Insightful Mentor Feedback
Mathematics or science content knowledge	Our Place (25.0%) Content Forums (92.4%) Inquiries (83.3%) Dilemmas (75.0%)	Content areas offer direct access to many experts. Amazing! Content forums have always impacted my own content knowledge most significantly because of the experts on board and the strong focus on content itself. The information also comes from a diverse array of learners and educators and that has created a productive and vibrant learning community.
General pedagogical knowledge	Our Place (36.4%) Content Forums (41.6%) Inquiries (81.8%) Dilemmas (81.9%)	Inquiry-Looking at Student Behavior (06-07). This inquiry helped to open new venues of dealing with behaviors of students in which we moved students from less negative to more positive behaviors. I always benefit most from the dilemmas because I find this is where the actual "nuts and bolts" of teaching are shared, questioned, and discussed. It not only prompts critical self-reflection, but also provides further resources, information, and lively discussion about the pros and cons of each.
Pedagogical content knowledge	Our Place (33.3%) Content Forums (77.0%) Inquiries (66.7%) Dilemmas (63.7%)	I would have to say that the inquiries have enhanced my pedagogical content knowledge more than the others again because of the way they are structured with practice then reflection. If a teacher does not reflect on his/her practices and how it affects students, then the lessons become more play acting than serious instruction. Chem Content forum....it has been greatly affirming to have teachers from across the nation express cutting edge beliefs and practices that I hold myself. Being in a rural area, I often feel I am a lone wolf, even in my own science department but I am making headway.
Curricular knowledge	Our Place (16.6%) Content Forums (75.0%) Inquiries (75.0%) Dilemmas (66.7%)	In the Content Forums, we can compare our curricular knowledge with other seasoned and new teachers. The variety of input from teachers in other communities and other states is so very important for finding ideas that will work in our own districts and communities. This is not a focus for most mentees, they focus on management and content, particularly science labs and activities. Curricular knowledge as defines above is not a focus of theirs, and mentors follow their lead. Both the content forum and dilemma area have impacted my curricular knowledge; the content areas have provided concrete direction with handling specific curricular content questions and connections, while the dilemmas have enhanced my understanding and use of resources as well as the structuring of cohesive, effective learning experiences.

Table 5 Continued.

Domain	Influence on Domain: Somewhat to a Great Extent	Insightful Mentor Feedback
Knowledge of how to support diverse learners	Our Place (18.2%) Content Forums (33.3%) Inquiries (58.4%) Dilemmas (58.3%)	As someone who works in probably one of the most diverse schools in Montana, I would have to say that the sharing of experiences in the "Diverse Learners" inquiry is the one that contributed any enhancement to my knowledge of supporting my students. My mentee worked in a Title 1 school with an ELL population that exceeded the "regular" population. We brainstormed methodology, pedagogy, and management a lot in Our Place.
Knowledge of wider educational policies, practices, and objectives	Our Place (25.0%) Content Forums (53.9%) Inquiries (33.3%) Dilemmas (41.7%)	This is one of the weaker areas for me. My state does not fully participate in eMSS now and I am independently involved with the continuing work. I have been exposed to the discussions that spring from the groups from other states, but it hasn't affected my knowledge about my own state policies. However, due to ongoing discussions, there has been insight into national policy. Hearing what policies, practices and objectives are salient in other areas of the country has enormously enhanced what I know about what is going on in science education and I am encouraged that so many people are on the "cutting edge train."
Reflection on practice	Our Place (63.7%) Content Forums (92.3%) Inquiries (100.0%) Dilemmas (83.3%)	I think the OUR PLACE and the Inquiry itself because they worked hand in hand for the participants-mentees and mentors. Our Place enabled the mentee/mentor to discuss what would occur, refine it, try it out in the classroom, discuss, report back. The inquiry allowed the mentee/mentor team to report back what occurred and ask for feedback from other participants. The inquiries ask us to reflect and also to see how other teachers reflect on their own teaching practice. This is an excellent way to incorporate reflection and to really make us think about how things went and how we can improve our practice.
Involvement in professional activities or leadership	Our Place (54.6%) Content Forums (69.3%) Inquiries (66.7%) Dilemmas (83.3%)	All areas have allowed me to get a feel for what is happening in other schools, cities, states, and even other countries as pertains to education or science education. As soon as one thinks beyond the classroom one is enhancing his professional involvement and providing for preparation for leadership positions should they enter the picture. The inquiries and Our Place enabled me to demonstrate my capabilities as a veteran teacher who had a wealth of knowledge regarding teaching and share it with others. I was able to pass on the torch of educational knowledge that I received from professional workshops thru the ____ Science Department.

Table 6. Insightful Mentor Feedback: Areas of Most Growth through eMSS Participation

Domain of Potential Growth and Development	Insightful Mentor Feedback
Mathematics or science content knowledge	i personally have expanded on my content knowledge by participating in the Life Science content area. Having access to university content specialists and highly qualified mentors and mentees from various backgrounds added to the depth and breadth of my content knowledge.
Pedagogical content knowledge	I think the biggest contribution has been in pedagogical content knowledge. I am pretty comfortable with the content I teach, but am always looking for new ways to get that content across to my students. The mentors and experts in this program have been excellent is assisting in this area.
Involvement in professional activities or leadership	I would have to say that my professional growth in the last few years has mostly been in leadership because of my mentoring and facilitating roles. My knowledge has been enhanced in all the areas for participating, but my leadership and confidence in what I say has strengthened most. As a veteran teacher coming into the program, I feel that eMSS has most impacted my leadership position and potential beyond the regular classroom. While I have enhanced and improved content, pedagogical, and curricular knowledge and skill, I have seen the greatest growth professionally. I have moved beyond the classroom and even the teaching of teachers into administration where I feel I am in a position to affect further change. And even in such a short amount of time, the results have been prominent and extremely rewarding.

Summary: The Need for Further Study

We know that mentoring and induction has the potential to improve early career teacher practice (Britton et al., 2000; Lopez et al., 2004; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Ralph, 2002) and professional development can positively affect the quality of teacher instruction (Banilower et al., 2006; Cohen & Hill, 2000; Garet et al., 2001; Hill & Ball, 2004) and ultimately student learning (Banilower et al., 2006; Cohen & Hill, 2000; Guskey & Sparks, 2002). Unfortunately, even when professional development experiences have the intent to improve knowledge for teaching,

learning cannot be mandated. For deepening and extending knowledge needed for teaching mathematics, teachers much come to the professional development experiences ready to engage in learning that goes beyond acquiring new teaching strategies and lesson plans (Wilson & Berne, 1999). Additionally, Hill and Ball (2004) assert that “there has been little success in determining whether and when teachers develop mathematical knowledge from professional development, and if so, what features of professional development contribute to such teacher learning” (p. 330). Although eMSS was designed to improve the practice of the mentee, pilot interviews and surveys reveal that mentor teachers have reported professional growth through participation. Thus, this research study sought to explore the professional growth of mentor mathematics teachers as a result of participating in eMSS, a content-based mentoring program designed with the components of effective professional development in mind. The findings from this study add to the limited research on both professional development through mentoring and how professional learning affects experienced teacher growth and development.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

In this chapter, the research procedures used in this study are described. An overview e-Mentoring for Student Success (eMSS) mathematics mentoring and induction program and its participants is provided in order to provide the context in which this study is situated. Subsequently, the rationale for conducting a mixed-methods study that is made up of surveys and case studies is explained. The survey data collection and analysis methods are reviewed, followed by a review of the case study participant selection and data collection and analysis methods. Data in the case studies came from an online focus group, surveys, interviews, and portfolios. Also included in this chapter is a discussion of the study quality and the potential limitations of the study. Finally, my research perspective is presented in order to give the reader a sense of the personal “lens” that I brought to the research.

Context of Study

The eMSS mathematics mentoring and induction program was designed to support and improve the practice of early career mathematics teachers through small group mentoring and participation in a structured curriculum. Experienced mathematics teachers (mentors) participating in the 2007/2008 eMSS program included approximately fifty teachers from the states of Arizona, California, Hawaii, Maine, Massachusetts,

Michigan, Montana, New Hampshire, and North Carolina. All mentor teachers volunteered to be in the eMSS program and were compensated by stipends. Mentor teachers participated in a facilitated online summer institute during the summer of 2007. The focus of the institute was to develop and enhance the mentors' online mentoring practices. First year mentors participated in a beginning mentor institute and returning mentors participated in an experienced mentor institute. With the exception of mentor teachers from Montana and one mentor from California, the mentors were first year eMSS mentors.

Approximately 120 mathematics early career teachers (mentees) from across the country also participated in the 2007/2008 eMSS program. Each mentor teacher generally worked with one to four mentees who were matched by their grade level and/or content area of instruction and by the state they were teaching in when possible. Mentor teachers worked with their group of mentees in a private discussion area, Our Place, and had access to a variety of structured and unstructured discussion areas. The structured and formally facilitated discussion areas included the Content Forums, Dilemmas, and Inquiries, and the unstructured discussion areas included Sakai Q and A, Cyber Lounge, Mentor Place or Mentee Place, and the State Forums. Facilitators in these discussion areas were experienced mathematics teachers and university mathematics educators who participated in a three week online summer facilitator training. Figure 8 provides an overview of the 2007/2008 eMSS design (adapted from Taylor, 2007).

The purpose of the content forums is to provide participants with a place to discuss issues uniquely related to teaching mathematics as well as to provide resources to

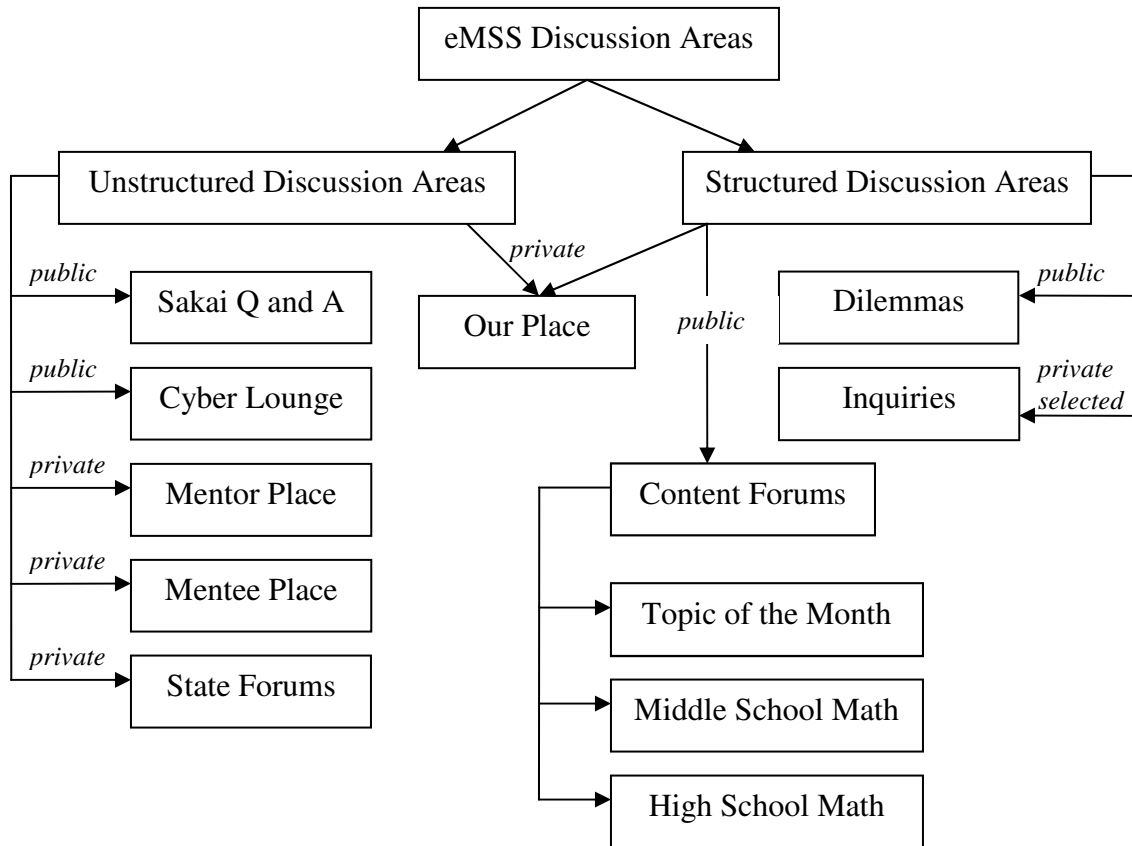


Figure 8. Overview of the 2007/2008 eMSS Program (adapted from Taylor, 2007).

use in the classroom. The content forums are divided into three distinct areas: (a) Topic of the Month which focused on topics related to the *NCTM Principles and Standards* (NCTM, 2000), (b) Middle School Math, and (c) High School Math. In the Dilemmas, participants brainstorm and discuss ways to solve short, open-ended hypothetical dilemmas surrounding a mathematics teaching issue. Inquiries are considered the core of the eMSS curriculum and are conversation guides designed to help mentees enhance their teaching practice. With the help of their mentor, mentees plan, practice, and reflect on an issue related to the mentee's personal teaching situation. The eMSS induction and professional development curriculum is enacted through these facilitated discussion

forums and aims to extend teachers' understanding of mathematics content and improve teachers' discipline-specific pedagogy through online collaborative activities. The unstructured discussion areas provide teachers with a space to ask questions related to state issues (State Forums), get technology support (Sakai Q and A), ask questions related to mentoring (Mentor Place) or the about their mentor (Mentee Place), or to simply socialize with other participants (Cyber Lounge). All of the discussion areas provide participants with a supportive and collaborative community of educators and learners.

Research Procedures

The purpose of this study was to explore the professional growth and development of mentor mathematics teachers as a result of participating in an online content-based mentoring and induction program, eMSS. In specific, the research sought to determine what aspects of eMSS contributed to mentor professional growth and over what domains this growth occurred. Because the mentoring program was online, teaching and learning were dialogue driven and text-based. Therefore, this study also sought evidence of the mentor teachers' professional growth in the online dialogue and commentary they provided for analysis. Finally, active engagement in professional development is hypothesized to be a precursor to professional growth and development. Using mentors' activity level as a measure of engagement, this study also sought to determine if activity level was related to mentors' perceived professional growth.

A concurrent mixed-methods design was utilized in order to collect diverse types of data and to converge both quantitative and qualitative findings (Creswell, 2003). In

this study, participant surveys were used to gather descriptive data about all of the mathematics mentor teachers' perceptions of their professional growth and development as well as to (1) measure the relationship between activity level and perceptions of enhancement in knowledge and skills and changes in teaching practices and (2) measure the contributions of various discussion areas to perceptions of professional growth across various domains. At the same time, professional growth through engaging in eMSS was explored in-depth through the perceptions of six participants using focus group, survey, portfolio, and interview data employing a case studies approach. The combination of surveys and case studies is complementary; "case studies are used to gain insight into causal processes, whereas surveys provide an indication of the prevalence of a phenomenon" (Yin, 2003, p. 151). The mixed-methods approach provided both broad and detailed data which contributed to a better understanding the research problem.

The framework for potential teacher growth and development that I developed was used to inform this study and influence both quantitative and qualitative data collection and analysis. Based on the practitioner and research literature, experienced teachers' professional knowledge may be enhanced or deepened across a variety of domains including general pedagogical knowledge, mathematics content knowledge, pedagogical content knowledge, curricular knowledge, knowledge of how to support diverse learners, and knowledge of the wider educational system. In addition, experienced teachers' have the potential to develop and refine their reflective practices and leadership skills as well as become more engaged in professional activities (Feiman-Nemser, 2001; Hill & Ball, 2004; Hill, Rowan et al., 2004; Loucks-Horsley, Stiles, &

Hewson, 1996; NBPTS, 2005; Shulman, 1986). Definitions for these eight domains can be found in Chapter 2 (p.61-64). As additional themes emerged from the qualitative data, new domains were created and data collection instruments were changed accordingly.

Table 7 provides an overview of this study.

Table 7. Overview of Research Design Exploring the Professional Growth of Mentor Mathematics Teachers as a Result of Participating in eMSS.

Research Questions	Data Collection and Analysis	Participants and Timeline
1. How do experienced mathematics teachers perceive their experiences in a content-based online mentoring program to have influenced their professional growth?	eMSS Teacher Growth Survey – online – quantitative and qualitative analysis	All mentor teachers – April 2008
a. In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?	Focus group – online, asynchronous – qualitative analysis	Six purposefully selected mentors – February through June 2008
b. What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?	Interviews – audio-taped, phone – qualitative analysis	
	Portfolios – case samples of dialogue exhibiting growth – qualitative analysis	
2. What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?	Portfolios – case samples of dialogue exhibiting growth – qualitative analysis	Six purposefully selected mentors – February through May 2008
3. Is there a relationship between the activity level of the mathematics mentor teacher and his or her perception of professional growth through participation in a content-based online mentoring program?	eMSS Teacher Growth Survey – online – quantitative analysis	All mentor teachers – April 2008

Participant Surveys

Data Collection. The eMSS Teacher Growth Survey (Appendix A) was designed to reveal the ways in which eMSS promotes the professional growth of mentor mathematics teachers, and which features of the eMSS program contributed to this growth. This survey consists of three sections. Section I elicited background information, Section II elicited information about mentor teachers' enhancement in knowledge and skills and changes in practices as a result of participation in eMSS, and Section III elicited information about the effect of the structured eMSS discussion areas on the pre-identified domains of teacher growth and development.

Portions of eMSS Teacher Growth Survey (Section I question 8 and all of Section II) were adapted from the mathematics Teacher Activity Survey (TAS) (Garet et al., 1999; Garet et al., 2001). The TAS was designed as a national evaluation tool to evaluate the Eisenhower Professional Development Programs, a Title II of the Elementary and Secondary Education Act, which aimed to further the knowledge and practice of classroom teachers. For the purpose of this study, portions of Sections III and IV of the TAS focusing on the coherence and effectiveness of professional development were used to elicit Likert-style responses. Each prompt was modified to refer to participation in eMSS specifically. Questions to elicit participant background information (Section I) and additional Likert-style prompts and open ended questions to gather information about the effectiveness of the various structured discussion forums (Section III) were added for this study. The unmodified survey items from the TAS measuring teachers' self-reported enhancement in knowledge and skills (Section II, question 1) and change in teaching

practice (Section II, question 2) have internal consistencies indexed by Cronbach's alpha, of .78 and .87 respectively (Garet et al., 1999). Although instrument validity was not reported, S.K. Yoon (personal communication, October 24, 2007), one of the TAS designers, asserts that the researchers "believe a strong to moderate relationship of those 6 key measures [content focus, active learning opportunities, coherence with other learning activities, form of the activity, collaboration, and duration] of [professional development] quality with teachers' self-reported measures of [professional development] outcomes demonstrates some predictive validity."

Expert feedback was provided in the design process of the eMSS Teacher Growth Survey. A university statistician, as well as colleagues in the eMSS program familiar with the goals of this research and the goals of eMSS, read and helped me develop the survey, which contributed to the content validity of the instrument. Furthermore, the survey was piloted with 20 eMSS mathematics and science facilitators in February 2008 using an online format. These facilitators had all been participants in eMSS for over one year and had all once been or were mentor teachers at the time of the survey. Fifteen piloted surveys were returned. Modifications for clarity and relevancy were made based on the facilitators' feedback. The final version of the survey was administered online in late March 2008 to all 43 mathematics mentor teachers participating in the 2007/2008 eMSS program, 30 of whom returned the survey in the online format by the end of April. Three reminder emails were sent throughout March and April to try to reach non-respondents. At the end of April, those who had not yet responded were sent a paper version of the

survey and asked to return it via mail. Four more surveys were returned, resulting in a response rate of 79 percent (34 of 43 surveys).

Data Analysis. Survey responses were intended to reveal the ways in which eMSS promotes the professional growth of mentor mathematics teachers and which features of the eMSS program contribute to this growth. All of the survey responses were analyzed to produce descriptive statistics revealing the ways in which these experienced mentor teachers' knowledge, skills, and practice have been enhanced or changed.

Using results from Section II, a multivariate analysis of variance (MANOVA) (Gliner & Morgan, 2000) was conducted to determine if a relationship exists between the activity level of the mathematics mentor teacher and his or her perception of enhancement of knowledge and skills (question 1) and changes in teaching practices (question 2). The activity level of the mentor teacher was not only measured by the number of posts from September 2007 through May 2008, but also by the average time spent online per week as self-reported on the survey. Bice (2005), in his doctoral dissertation, found that teachers participating in eMSS may be contributing relatively few posts, but are engaging through reading and reflecting on posts. Therefore, it was important to capture time spent both reading and posting when measuring activity level. Four MANOVAs were conducted to compare groups across the dependent variables as follows:

- a) The differences between people who posted high and low levels of posts in their perceptions of enhanced knowledge and skills.

- b) The differences between people who posted high and low levels of posts in their perceptions of changes in teaching practices.
- c) The difference between people who reported spending a high and low amount of time online per week in their perceptions of enhancement in knowledge and skills.
- d) The difference between people who reported spending a high and low amount of time online per week in their perceptions of changes in teaching practices.

Furthermore, a multivariate analysis of variance (MANOVA) (Gliner & Morgan, 2000) was conducted using results from Section III questions 1, 3, 5, 7, 9, 11, 13, and 15 to determine if there were any significant differences between the effects of the different discussion forums on the mentors' perceptions of their professional growth across the various teacher growth domains. Table 8 provides a summary of how the research questions and methods of quantitative analysis align with the questions of the eMSS Teacher Growth Survey, which can be found in its entirety in Appendix A.

Finally, the open ended survey questions were analyzed qualitatively and provided detailed information to support the Likert style prompts and further described how the participants perceived the process of their professional growth as a result of participating in eMSS. Inductive analysis (Patton, 2002) was utilized to discover significant patterns, themes, and interrelationships from the open ended responses to reveal the avenues of growth across the eight growth domains. Specifically, the open ended responses were read, reflective notes were made alongside the open-ended responses, and the data was coded within and across each growth domain assessed in

Table 8. Concordance of Research Questions, Methods of Analysis, and eMSS Teacher Growth Survey Questions (see Appendix A for entire survey).

Research Question and Methods of Analysis	eMSS Teacher Growth Survey questions
Research Question: 1.a. In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program? Analysis: Descriptive statistics and qualitative analysis	II.1. To what extent do you feel that your knowledge and skills have been enhanced in each of the following areas as a result of your participation in eMSS? (Circle one response for each line.) <i>There is a list of 11 categories such as curriculum, instructional methods, approaches to assessment, etc. that elicit Likert style responses from “not at all” to “great extent”.</i> II.2. To what extent have you made each of the following changes in your teaching practices as a result of participation in eMSS (Circle one response for each line): <i>There is a list of 9 categories such as mathematics curriculum content, cognitive challenges of activities, instructional methods, etc. that elicit Likert style responses from “no change” to significant change” or “not currently teaching”.</i>
Research Question: 3. Is there a relationship between the activity level of the mathematics mentor teacher and his or her perception of professional growth through participation in eMSS? Analysis: MANOVA	

Table 8 Continued.

Research Question and Methods of Analysis

eMSS Teacher Growth Survey questions

Research Question:
1.b. What aspects of the content-based online mentoring program contribute to experienced mathematics teachers’ professional growth?

Analysis:
Descriptive statistics, MANOVA, and qualitative analysis

III.1. To what extent do you feel that your mathematics content knowledge has been enhanced as a result of participating in the following discussion areas?

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

III.2. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your mathematics content knowledge? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

Subsequent questions follow the above format and address the following domains of growth:

III.3-4. general pedagogical knowledge

III.5-6. pedagogical content knowledge

III.7-8. curricular knowledge of mathematics

III.9-10. knowledge of students as diverse learners

III.11-12.knowledge of local, state, and national educational policies, practices, and objectives

III.13-14. reflection on your practice

III.15-16. involvement in professional activities or leadership positions

Section III. Using the assistance of word processing technology, the open-ended responses were then rearranged by grouping quotes or parts of quotes with the same or related codes, and the collections of quotes were reduced into theoretical categories (Maxwell, 2005) that aided in capturing how eMSS contributed to the participants' professional growth. Insightful mentor feedback is reported for each theme that emerged.

Case Studies

Using case studies, the professional growth of mentor mathematics teachers was explored through the perspectives of the participants. Yin (2003) provides the following technical definition of a case study:

1. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.
2. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis (p.13-14).

In addition, Creswell (2007) states that the case study methodology “involves the study of an issue explored through one or more cases within a bounded system” (p. 73). For the purpose of this study, case studies provided an appropriate methodology to understand how the contextual conditions of participation in eMSS related to the professional growth of the mentor teachers. Multiple sources of data collection were utilized in order to provide a rich description of the phenomenon and to look for any convergences in the findings. In addition, multiple cases were studied; each case was an individual mathematics mentor, and each case study focused on his or her participation in eMSS

from the start of the individual's participation through the 2007/2008 eMSS program year. The use of multiple cases provided more convincing data than the use of an individual case (Yin, 2003). In addition, Stake (2005) explains that a multiple instrumental case study permits the researcher to gain insight into a pre-determined phenomenon across several purposefully selected cases. Thus, the six case studies were used to gain an understanding of the following research questions:

How do experienced mathematics teachers perceive their experiences in a content-based online mentoring program to have influenced their professional growth?

a. In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?

b. What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?

What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?

Case Participants. Purposeful sampling (Creswell, 2007) was used to select relatively actively engaged mentors because these mentors were likely to reap greater benefits from the program and have the ability to provide more insight about their professional growth than less active mentors. Mathematics mentors were selected in February 2008 based on the following criteria: 1) the participant was actively engaged and posted at least 45 posts in Fall 2007 and 2) the participant mentored at least one active mentee who had posted at least 15 posts in Fall 2007. Eight mentors who met these criteria were contacted to participate in the study and six agreed to participate. This sample was selected because it had the potential to reveal how mentor teachers benefit

professionally through actively engaging in mentoring early career teachers and interacting with the eMSS mathematics community.

This sample was a representative sample in terms of eMSS mentoring experience. Five of the case participants were first year eMSS mentors and one case participant was in his fifth year of mentoring during the 2007/2008 eMSS program. Of the mathematics mentors who remained in the eMSS program through the school year, 39 were first year eMSS mentors while eight were returning mentors. Thus 16.67 percent of the case participants were experienced eMSS mentors compared to 17.02 percent overall. In addition, the male to female ratio of case participants (16.67 percent male) was similar to the ratio for the mathematics mentors overall (12.77 percent male). All case study participants were experienced mathematics teachers and also had experience with face to face content-based mentoring.

All requirements were met for the protection of human subjects. This research study was approved by the Institutional Review Board of Montana State University. All case study participants agreed to be in the study and signed a letter of informed consent (Appendix B). Additionally, all names and identifying information of the case participants were changed to protect their identities in the case narratives.

Data Collection. Case data was collected from multiple sources and multiple cases in order to provide an accumulation of the data and enhance the validity of the study (Yin, 2003). Thus, data was collected through a focus group, participant portfolios, surveys, and open-ended, semi-structured interviews for each of the case participants. Refer to Table 7 for an overview of the study.

A three week asynchronous online focus group served as the first source of case data and was conducted from late February through early March. The focus group was set up as a private discussion forum on eMSS where each case participant and I had access. The prompts were open ended in order to allow participants freedom in their responses. During the first week, the participants introduced themselves and discussed their mathematics teaching background and weekly experiences in eMSS. During the second and third weeks, participants discussed their growth in knowledge needed to teach mathematics as well as any changes in teaching practices and their perceptions of the profession as a result of participating in eMSS. They also talked about the ways in which their experiences in eMSS influenced this identified growth or change. See Appendix C for the focus group prompts and questions. One advantage of the focus group over one-on-one interviews is that it allowed the participants to engage in dialogue with one another and to generate ideas as a group, which may have promoted more reflection on their experiences and professional growth as a result of participation in eMSS. Each case participant contributed to the focus group with engagement ranging from only joining the discussion once to posting multiple times per week.

For the second source of data, each case participant created a portfolio with dialogue selected from the various eMSS discussion areas which he or she believed evidenced or described an aspect of his or her professional growth as a result of participating in eMSS. See Appendix D for the Teacher Growth Portfolio. All dialogue selections were accompanied by a justification for the selection and case participants used the eight domains of potential growth and development identified in the literature to

guide, but not limit, their selections. The participants received the instructions for the portfolio in late February and submitted their first three to four entries in mid March, their second set of three to four entries in mid April, and their last set of three to four entries in mid May. The final portfolios for each participant consisted of at least 10 samples of posts and accompanying labels and justifications.

Finally, the third source of data was the interviews. Each interview was conducted over the phone and was audio-taped and transcribed. The first round of interviews occurred in early April after the completion of the eMSS Teacher Growth Surveys. After analyzing the focus group and survey data, an open-ended, semi-structured interview guide was developed around the pre-defined domains of potential growth and development and other themes that emerged in the analysis. See Appendix E for the interview prompts and questions. The interview protocol was reviewed by individuals who are familiar with eMSS and who have experience with interview techniques and was revised based on their suggestions. The questions were provided to case subjects in advance in order to provide time for the participants to reflect on and think about the questions (Patton, 2002).

Date Analysis. Patton's (2002) guideline for constructing case studies was used to guide the data analysis process. This process occurred in three steps: 1) assembly of the raw case data, 2) construction of a case record, and 3) writing of the final case narrative. After the individual case studies were created, a cross-case analysis was conducted to highlight similarities and differences in the experiences and perceptions of growth and development of the participants across the six individual cases. Analysis of the case data

(i.e. the focus group dialogue, surveys, individual interviews, and portfolio data) was ongoing and through reading and note taking, patterns and themes were identified as they surfaced within and across cases (Creswell, 2003, 2007; Maxwell, 2005).

The raw case data consisted of transcripts of the focus group discussion and transcripts of the interviews along with the portfolio entries submitted electronically by the case participants. The survey data of the case participants was also included. All data was saved electronically and hard copy prints were also made. The data was organized by each individual case. In order to condense the raw data, a case record was created. According to Patton (2002), “the information is edited, redundancies are sorted out, parts are fitted together, and the case record is organized for ready access chronologically and/or topically” (p. 449). For this study, individual cases were analyzed separately and the case data was sorted categorically (e.g. background information, experiences, domains of growth). Categorical aggregation was used in creating codes from “a collection of instances in the data” and the codes were then reduced into a smaller number of themes (Creswell, 2007). Insightful quotes or excerpts from dialogue or the portfolio entries were marked for use in the case narratives.

A case narrative is a “readable, descriptive picture” of the case (Patton, 2002) and a preliminary case narrative was constructed for each case after collecting, inductively analyzing, and consolidating the data from the focus groups, surveys, portfolios, and the first round of interviews. The raw data for each case was also read and coded by another researcher familiar with eMSS and this study. After taking notes and forming their own understanding of the case, this researcher read the case narrative I had written to

determine the accuracy of the interpretations. If discrepancies existed, the second researcher and I discussed them and the case narrative was edited accordingly. In addition, each case participant was given the case narrative about their individual case and was asked to read and comment about the narrative to ensure that their case was accurately presented. The participants' feedback and any additional insights gathered from the member checks were incorporated into the final case narrative.

A cross-case analysis was conducted and patterns and themes related to the research problem were inductively generated across cases. Similarities and differences were found in the mentor teachers' experiences in eMSS as well as in their areas of perceived professional growth. From this cross-case analysis, a list of effective eMSS experiences and benefits of engagement in the program was created. See Chapter 4 for the individual case narratives and the findings of the cross-case analysis.

Study Quality

Both qualitative and quantitative research methods have their advantages and disadvantages. Quantitative data collection through surveys allowed me to collect data through a greater number of participants, in this case all mathematics mentor teachers participating in eMSS. Furthermore, quantitative methods afforded more objectivity and methods can be replicated by other researchers in investigating teacher growth and effective teacher professional development. However, the quantitative instruments primarily captured areas of professional growth pre-determined by me and the professional development and teacher knowledge literature and thus may have provided a skewed representation of participants' perceptions. Qualitative methods, while using

fewer subjects and producing findings that are more difficult to generalize, provided a much richer description of the participants' perceptions. The multiple qualitative methods used in this study allowed for themes, attitudes, and perceptions to emerge that were unique to the eMSS setting and not identified in the literature. A mixed-methods approach allowed me to converge the quantitative and qualitative data (Creswell, 2003), which increased the internal validity of this study.

In specific, triangulation was used to increase the validity of the findings and triangulation occurred in several ways (Patton, 2002). Data triangulation involved comparing findings from the various sources of data, including the survey, focus group, interview, and portfolio data. Methodological triangulation involved investigating and understanding the research problem using quantitative and qualitative methods. In the case studies, data and methodological triangulation involved generating themes across and within cases respectively. Theory triangulation involved comparing the survey and case study findings to findings in the professional development and teacher knowledge literature. Finally, researcher triangulation involved comparing the interpretations of two researchers on the same set of case data. Triangulation did not always result in convergence. Differences also emerged highlighting the complexity of the research problem.

For the quantitative portions of the study, namely the eMSS Teacher Growth Survey, instrument reliability was established through calculating the internal consistencies of the Likert style questions and prompts. In addition, content validity was enhanced through receiving expert feedback during the survey design process and by

piloting the survey. Refer to the participant survey data collection section for more detailed information on survey reliability and validity. Sampling error was not a concern for the quantitative portion of the study because the survey was given to all of the mathematics mentors participating in the 2007/2008 eMSS program.

Measures of quality and verification accompanied qualitative data collection and interpretation (Creswell, 2003, 2007). To ensure dependability, clear descriptions of the eMSS site structure, discussion forums, and participants were provided. This detailed description of the eMSS program and the philosophies framing its design allows others to adequately judge the transferability of the findings. Credibility of the qualitative findings was established by member checks of my interpretations of perceptions and evidence of growth expressed in the focus groups, interviews, and portfolios (Creswell, 2003, 2007). A preliminary draft of the case narrative was presented to each participant in early June and they were asked to review the narrative for accuracy and to provide further clarification and elaboration if needed. In addition, participants were asked to provide any additional information regarding their professional or personal growth as a result of participating in eMSS. The narratives were then edited accordingly. Furthermore, the case narratives were reviewed by colleagues familiar with the eMSS program to assure logical representation and interpretation of the findings. I also remained invisible in the facilitated discussion areas and Our Places in order to minimize bias (Yin, 2003). Samples of the focus group dialogue, interviews, and portfolio artifacts are included in the final case narratives in order to provide the reader with the data on which interpretations were based.

Potential Limitations of the Study

Despite the measures taken to optimize study quality, there are several potential limitations of this study. First of all, this study was confined to gathering data on mathematics teachers' self-reported professional growth through the participant surveys and the case studies. Self-reported data may amplify or understate the actual growth, however it does provide a good indication of the relative magnitude of the growth in one domain compared to another as well as the relative importance of the various aspects of the eMSS program in promoting this growth. Evidence of professional growth in the dialogue was limited to the ten portfolio entries of each case participant. However, each participant read and posted much more than ten times over the course of their participation in eMSS. Therefore, the selection of a limited sample of posts may have restricted the potential understanding that could have come from a more in-depth observation of participants' reading and posting habits. Furthermore, engagement was measured by self reported time spent on eMSS and number of posts. Another measure of engagement may have led to different quantitative findings. Finally, care must be taken in generalizing the results of the study. Because all mentor teachers have volunteered to participate in eMSS, they may have more interest in seeking content-specific professional development than the average mathematics teacher.

Researcher Perspective

In any research study using qualitative methodologies, it is important to explicitly recognize the perspective the researcher brings to the study because the researcher "is the

instrument of the research” (Maxwell, 2005, p. 38). Thus, it is common practice to relay personal information about the researcher when discussing research methodology. My experiences as a mathematics teacher and my work with eMSS provided me with the perspectives that I brought to this study and I have described those experiences here.

I have six years of mathematics teaching experience. My first three years of teaching were in public high schools in and around Philadelphia. During this time, I participated in both effective as well as ineffective mentoring and induction programs as the mentee. These experiences have shaped my view of the importance of prolonged content-based mentoring and induction. In addition, as a mathematics teacher I participated in a variety of professional learning experiences ranging from one day in-house workshops to prolonged coursework. These experiences have also contributed to my perceptions of the components and outcomes of effective professional development.

I have been a graduate student at Montana State University for the past three years and during this time I have been participating in eMSS as the Montana State Coordinator. In the capacity of coordinator, I recruited and paired the Montana participants and throughout the school year I assisted the project with administrative and event planning activities related to the Montana participants. During that time period I also served as a graduate researcher. In this capacity, I read and quantitatively coded over 5,000 posts in order to determine who was participating and what types of conversations were occurring in relation to program goals. This research revealed to me that mentor teachers were contributing to the dialogue much more than mentees. In addition mentor teachers were discussing strategies for their professional improvement. Conversations with Montana

mentors and reading large numbers of posts lead to my interest in pursuing this particular research problem and discovering any benefits for mentor teachers participating in a mentoring and induction program to the mentor teachers.

CHAPTER FOUR

RESULTS OF THIS STUDY

Introduction

This chapter includes the results of the analysis of the data collected in this mixed-methods study. The first section of this chapter presents the results of the quantitative and qualitative survey analysis while the second section presents the results of the case study analysis in the form of six case narratives and a cross-case analysis. Finally, the third section integrates and summarizes the findings from the survey with those from the case studies as they pertain to the research questions.

Participant Surveys

This section communicates the results of the analysis of the eMSS Teacher Growth Survey, which can be found in Appendix A. The survey was designed to assess the ways in which eMSS promotes the professional growth of mentor mathematics teachers and which features of the eMSS program contributed to this growth. In addition, it was hypothesized that more active mentors would perceive greater professional growth as a result of participating in the program than less active mentors. This hypothesis was also tested using survey results. In specific, through survey analysis I sought to answer the following research questions.

How do experienced mathematics teachers perceive their experiences in a content-based online mentor program to have influenced their professional growth?

- a. *In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?*
- b. *What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?*

Is there a relationship between the activity level of the mathematics mentor teacher and his or her perception of professional growth through participation in a content-based online mentoring program?

See Table 8 in Chapter Three for a concordance of the research questions, methods of analysis, and the eMSS Teacher Growth Survey questions. The survey was administered to all of the mathematics mentor teachers participating in eMSS in March 2008. Thirty-four surveys were returned and are included in these analyses. The response rate for this survey was 79 percent (see a detailed description of the response rate in Chapter Three).

Section I

The purpose of Section I of the survey was to gather background information on the participants. This was the first year of participation in eMSS for most of the mentors. However, six mentors have participated in eMSS from two to five years for one of two reasons. These mentors were either mathematics mentors from Montana, a state that piloted the mathematics version of the program in earlier program years, or were science mentors in previous program years and joined the eMSS mathematics program when the opportunity arose because they have experience teaching science and mathematics. Of the 34 teachers, 19 have over 15 years experience in teaching mathematics, while eight have ten to 14 years, five have five to nine years, and only one has less than five years of mathematics teaching experience. With the exception of six teachers, all were active

classroom teachers during the time of the survey. On average, these mentors reported spending 3 hours per week online, with a range of zero to over ten hours, and posted an average of 149 posts, with a range of 11 to 382 posts, during the 2007/2008 program year. Figures 9 and 10 display the frequencies of self-reported time spent on eMSS and of the total number of posts for the 34 surveyed mentors. The majority of the mentors indicated that eMSS was coherent somewhat or to a great extent with their goals for professional development (91.2 percent) along with their state or district standards and assessments (88.3 percent and 79.4 percent respectively). See Table 9 for the percentage and frequencies of mentor responses in these areas.

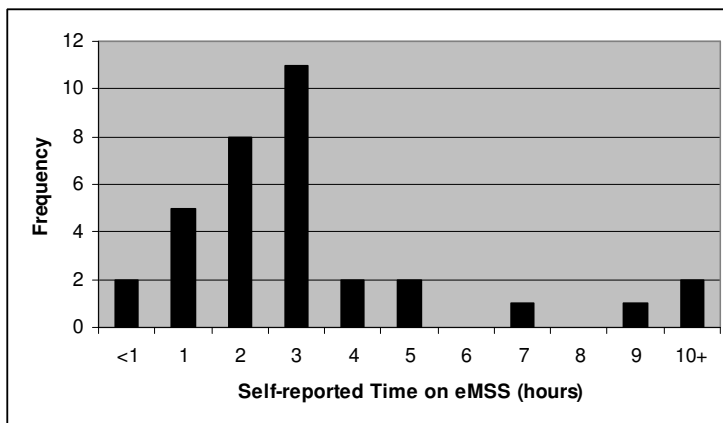


Figure 9. Frequency of Self-reported Time on eMSS.

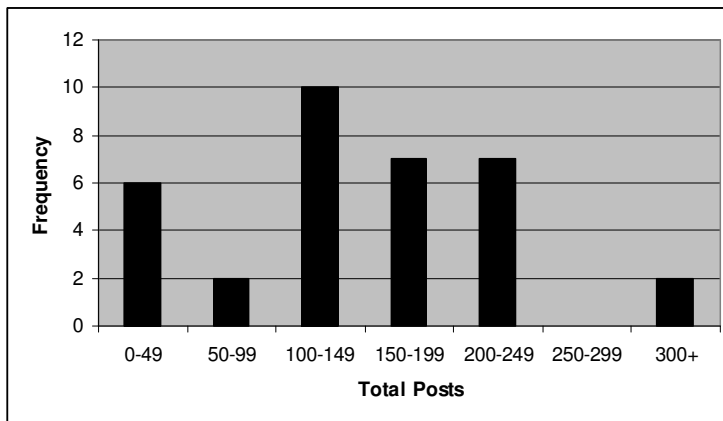


Figure 10. Frequency of Total Number of Posts on eMSS.

Table 9. eMSS Coherence with Professional Development Goals and State or District Standards and Assessments.

	Not at All	Very Little	Somewhat	Great Extent
Align with your own goals for your professional development	2.9% (1)	5.9% (2)	50.0% (17)	41.2% (14)
Support your state or district standards/curriculum frameworks	2.9% (1)	8.8% (3)	55.9% (19)	32.4% (11)
Support your state or district assessments	8.8% (3)	11.8% (4)	58.8% (20)	20.6% (7)

Note. The numbers in parentheses represent the frequency of participant responses.

Section II

One purpose of Section II of the survey was to gather information about mentor teachers' enhancement in knowledge and skills and changes in practice as a result of participation in eMSS. Tables 10 and 11 present the means and standard deviations of the mentor responses for the 11 categories of knowledge and skills (question 1) and the nine categories of changes in practice (question 2), along with the percentage and frequency of the responses, to the questions in Section II. For question 1, enhancement in knowledge and skills was assessed for 11 categories, as listed in Table 10, and the value of Not At All is 1, Very Little is 2, Somewhat is 3, and Great Extent is 4, $N = 34$. For question 2, changes in practices was assessed for nine categories, as listed in Table 11, and the value of No Change is 1, Minor Change is 2, Moderate Change is 3, and Significant Change is 4, $N = 34$ less those reporting Not Currently Teaching. Although the Likert responses are not scale but ordinal data, the magnitude of the means allow for comparison between the assessed areas.

Table 10. Mathematics Mentors' Perception of Enhancement of Knowledge and Skills, (N = 34).

	M	SD	Frequency of Ratings			
			Not at All	Very Little	Somewhat	Great Extent
Curriculum	2.94	.736	5.9% (2)	11.8% (4)	64.7% (22)	17.6% (6)
Instructional methods	3.12	.686	2.9% (1)	8.8% (3)	61.8% (21)	26.5% (9)
Approaches to assessment	2.85	.744	2.9% (1)	26.5% (9)	52.9% (18)	17.6% (6)
Use of technology in instruction	2.91	.712	2.9% (1)	20.6% (7)	58.8% (20)	17.6% (6)
Strategies for teaching diverse student populations	2.68	.638	5.9% (2)	23.5% (8)	67.6% (23)	2.9% (1)
Deepening knowledge of mathematics content	2.88	.946	8.8% (3)	23.5% (8)	38.2% (13)	29.4% (10)
Leadership development	3.24	.781	0.0% (0)	20.6% (7)	35.3% (12)	44.1% (15)
Reflective practices	3.47	.706	0.0% (0)	11.8% (4)	29.4% (10)	58.8% (20)
Adapting teaching to meet state assessments	2.47	.788	8.8% (3)	44.1% (15)	38.2% (13)	8.8% (3)
Adapting teaching to meet state standards/frameworks	2.53	.861	11.8% (4)	35.3% (12)	41.2% (14)	11.8% (4)
Understanding educational policies and practices	2.71	.676	2.9% (1)	32.4% (11)	55.9% (19)	8.8% (3)

Note. The numbers in parentheses represent the frequency of participant responses.

From Table 10, it is evident that at least 50 percent of the mentor teachers reported enhanced knowledge and skills ranging from somewhat to a great extent in every category except adapting teaching to meet state assessment requirements. Using the mean rating values, the highest area of reported growth for the teachers was in reflective

practices followed by leadership development, while the lowest reported levels of growth were in adapting teaching to meet state assessment and standards/curriculum framework requirements. In addition, almost 80 percent or more of the mentors rated their enhancement in knowledge and skills as somewhat or to a great extent for the categories of curriculum, instructional methods, leadership development, and reflective practices.

Table 11. Mathematics Mentors' Perception of Changes in Practice, ($N = 34$).

	M	SD	Frequency of Ratings				
			No Change	Minor Change	Moderate Change	Significant Change	Not Currently Teaching
The mathematics curriculum content	2.13	.885	23.5% (8)	38.2% (13)	23.5% (8)	5.9% (2)	8.8% (3)
The cognitive challenge of classroom activities	2.52	.811	8.8% (3)	35.3% (12)	38.2% (13)	8.8% (3)	8.8% (3)
The instructional methods I employ	2.69	.821	5.9% (2)	32.4% (11)	41.2% (14)	14.7% (5)	5.9% (2)
The types or mix of assessments I use	2.31	.780	11.8% (4)	47.1% (16)	29.4% (10)	5.9% (2)	5.9% (2)
The ways I use technology in instruction	2.38	.833	11.8% (4)	44.1% (15)	29.4% (10)	8.8% (3)	5.9% (2)
The access I have to instructional resources	2.63	.976	11.8% (4)	32.4% (11)	29.4% (10)	20.6% (7)	5.9% (2)
The approaches I take to student diversity	2.13	.763	17.6% (6)	47.1% (16)	23.5% (8)	2.9% (1)	8.8% (3)
My involvement in professional activities	2.63	1.10	17.6% (6)	26.5% (9)	23.5% (8)	26.5% (9)	5.9% (2)
Reflection on my practice	3.25	.803	2.9% (1)	8.8% (3)	47.1% (16)	32.4% (11)	8.8% (3)

Note. The numbers in parentheses represent the frequency of participant responses.

As evident in Table 11, at least 50 percent of the mentor teachers who are currently teaching reported that they had made moderate or significant changes in their practices in the following areas: cognitive challenge, instructional methods, access to instructional resources, involvement in professional activities, and reflection on practice. In fact, 87 percent of active teachers reported a range of moderate to significant changes in reflection on their practice. Using the mean rating values, the greatest area of change reported by mentors was reflection on their practice and they reported making the least of amount of changes in their mathematics curriculum content and approaches to student diversity. Although enhancement and changes in reflective practices was reported as a high level of growth by the mentors, it is interesting that the changes in all other practices were reported on average in the range of minor to moderate. Perhaps this is can be attributed to reflection leading to confirmation of current teaching practices. In addition, it is possible that many mentors may only be comfortable with making small changes in their practice during the current school year.

Using results from this section, four multivariate analyses of variances (MANOVAs) were conducted to assess if there were differences between more active and less active mentors on a linear combination of the 11 measures of enhancement in knowledge and skills and on a linear combination of the nine measures of changes in teaching practices. Although the Likert ratings were ordinal, all assumptions of multivariate normality, homogeneity, and independence were met in this analysis (Tabachnick & Fidell, 2007). Activity level was determined in two ways, by the number of posts and by self-reported time spent working on eMSS. Both measures of activity

level were used in order to try to capture engagement through posting and through reading. Two groups were made for each measure depending on if the activity level was below the group average (low) or at the group average or above (high). Low posting activity was considered less than 149 total posts during the 2007/2008 eMSS year, while at least 149 posts was considered high posting activity. Using this criterion, 16 mentors posted a high amount of posts, while 18 mentors were posted a low amount of posts. A low amount of time on eMSS was considered a self-reported average of zero to two hours per week, while three or more hours per week was considered a high amount of time on eMSS. In this case, 15 mentors spent a high amount of time on eMSS, while 19 mentors spend a low amount of time on eMSS. Posting numbers and self-reported time on eMSS were treated as separate measures of engagement. A non-significant, weak positive correlation between total number of posts and self-reported time online was revealed, $r(34) = .121, p = .494$. This low correlation may be attributed to a variety of factors. For example, it is possible that some mentors may engage primarily through reading, but may not post very often. On the other hand, some mentors may post many frequent short posts in the discussions in which they are involved, but may not spend much time reading or engaging beyond those discussions.

The results for the four MANOVAs can be found in Tables 12 and 13 and in these tables Wilk's Λ , the F ratios, probability of significance (p), and effect sizes (η^2) are reported. Throughout the discussion of the survey results, effect size is reported as eta squared (η^2), which describes the amount of variance attributed to group differences. The results for the two MANOVAs assessing the differences between High and Low Posting

and Time on eMSS groups on ratings of enhancement in knowledge and skills can be found in Table 12. As seen in this table, significant differences were found between people who were Low Posters compared to High Posters as well as between people spent a low amount of time on eMSS to those who spent a high amount of time on eMSS on a linear combination of the 11 measures of enhancement in knowledge and skills. Table 13 includes the results for two MANOVAs assessing the differences between the High and Low Posting and Time on eMSS groups on ratings of changes in practice. In this case, no significant differences were found between either categorizations of activity level on the linear combination of the nine measures of changes in practices.

Table 12. Results for MANOVA: Enhancement in Knowledge and Skills.

	Enhancement in Knowledge and Skills			
	Wilk's Λ	$F(11, 22)$	p	η^2
Posts	.406	2.921	.016	.594
Time on eMSS	.309	4.464	.001	.691

Table 13. Results for MANOVA: Changes in Practice.

	Changes in Practices			
	Wilk's Λ	$F(9, 20)$	p	η^2
Posts	.607	1.441	.237	.393
Time on eMSS	.670	1.094	.410	.330

In regards to enhancement of knowledge and skills for the 11 assessed variables, descriptive statistics reveal that High Posters ($N = 16$) reported the same or greater enhancement in their knowledge and skills in all assessed areas except for adapting teaching to meet state assessments than Low Posters ($N = 18$). Likewise, those who

reported spending a high amount time on eMSS ($N = 19$) reported greater enhancement in all areas of practice except for strategies for teaching diverse student populations than those who reported spending a low amount of time on eMSS ($N = 15$). Follow-up univariate analyses of variance (ANOVAs) were conducted on each dependent variable for both posting activity and self-reported time on eMSS. Because 11 ANOVAs were conducted on the same set of data, a Bonferroni correction was utilized to adjust the alpha level to .005. Table 14 includes the results of these analyses, which indicate that no significant differences exist in enhancement of knowledge and skills between mentors who were High Posters than mentors who were Low Posters. On the other hand, mentors who spent a high amount of time on eMSS reported significantly greater enhancement of their knowledge and skills in curriculum and in understanding educational policies and practices than those who spent a low amount of time on eMSS.

The descriptive statistics related to changes in teaching practices for the nine assessed variables indicate that Low Posters ($N = 16$) actually reported greater changes in five of the nine assessed areas including curriculum content, use of technology in instruction, access to instructional resources, approaches to student diversity, and involvement in professional activities as compared to High Posters ($N = 14$) of the 30 teachers who reported that they were currently in the classroom. In contrast, those who reported spending a high amount of time on eMSS ($N = 17$) reported greater changes in all assessed teaching practices than those who spent a low amount of time on eMSS ($N = 13$). Follow-up ANOVAs were conducted on the measures of changes in teaching practices for both posting activity and self-reported time on eMSS and the results can

Table 14. Results of Follow-up ANOVAs for Questions Assessing Perceptions of Enhancement in Knowledge and Skills.

	Activity by Posts			Activity by Time on eMSS		
	<i>F</i> (1, 32)	<i>p</i>	η^2	<i>F</i> (1, 32)	<i>p</i>	η^2
Curriculum	.001	.979	.000	10.648	.003	.250
Instructional methods	2.553	.120	.074	1.996	.167	.059
Approaches to assessment	2.507	.123	.073	.132	.718	.004
Use of technology in instruction	5.093	.031	.137	1.722	.199	.051
Strategies for teaching diverse student populations	1.389	.247	.042	.208	.651	.006
Deepening knowledge of mathematics content	.460	.503	.014	.659	.423	.020
Leadership development	3.765	.061	.105	1.262	.270	.038
Reflective practices	1.464	.235	.044	2.326	.137	.068
Adapting teaching to meet state assessments	.438	.513	.013	1.845	.184	.055
Adapting teaching to meet state standards/frameworks	.043	.836	.001	.139	.712	.004
Understanding educational policies and practices	.747	.394	.023	10.519	.003	.247

be found in Table 15. Because nine ANOVAs were conducted on this set of data, a Bonferroni correction resulted in an adjusted alpha level of .006. Results indicate that no significant differences exist in changes in teaching practices between mentors who were High Posters than mentors who were Low Posters as well as between mentors who spent a high amount of time on eMSS than those who spent a low amount of time on eMSS. Although not statistically significant, these trends may indicate that those who spend more time reading than posting tend to make more changes in their teaching practices.

Future research could shed more light on the relationships between different forms of online activity and changes in practices.

Table 15. Results of Follow-up ANOVAs for Questions Assessing Perceptions of Changes in Teaching Practices.

	Activity by Posts			Activity by Time on eMSS		
	<i>F</i> (1, 28)	<i>p</i>	η^2	<i>F</i> (1, 28)	<i>p</i>	η^2
The mathematics curriculum content	.724	.402	.025	1.666	.207	.056
The cognitive challenge of classroom activities	.047	.830	.002	.250	.621	.009
The instructional methods I employ	2.672	.113	.087	.520	.477	.018
The types or mix of assessments I use	.341	.564	.012	2.814	.105	.091
The ways I use technology in instruction	.060	.081	.778	2.204	.149	.073
The access I have to instructional resources	1.488	1.533	.226	7.464	.011	.210
The approaches I take to student diversity	1.101	1.883	.181	1.726	.200	.058
My involvement in professional activities	.815	.699	.410	.431	.517	.015
Reflection on my practice	.193	.290	.594	.527	.474	.018

The final questions in Section II were related to student learning and engagement. Of 34 respondents, 23 reported that student learning and engagement had improved in their classes as a result of their participation in eMSS and three themes emerged to explain the reasons behind these changes. The most prevalent theme was gaining new ideas, resources, and strategies for teaching mathematics; incorporating technology into

instruction and using more varied assessments were commonly mentioned. A second theme was reflection on practice. Several mentors expressed that participation in eMSS has stimulated their reflection, which they attributed to ultimately impacting student learning and/or engagement in their mathematics classes. Finally, a couple of mentors expressed feelings of enthusiasm as a result of participation in the program. Table 16 provides some insightful mentor feedback supporting these themes.

Table 16. Insightful Mentor Feedback: Reasons for Improved Student Learning and Engagement.

Insightful Mentor Feedback
I think that any time you can mix things up a bit in your classroom, you are having an effect on student engagement. If they are engaged, there is a better chance that they will learn. So, the tips I have picked up from participants in eMSS have provided me with opportunities to change my classroom approach, thus impacting engagement.
The biggest change in my classroom is my use of technology and with that change I have noticed an increase in student participation.
Mainly in the area of alternative assessment and ongoing (daily) evaluations of learning/understanding.
I teach and assess the students differently now. I use multiple assessment methods such as daily assessment. I use lessons that are more interesting to students. I also reflect on what works and what does not work.
I think the enthusiasm for quality teaching on eMSS has encouraged me to improve my methods and student involvement. With eMSS as a sounding board and in open dialogue with others I reflect on my practices constantly. When I read an idea online then I determine if I can use this in my teaching.
Being involved in such diverse conversations brings teaching and learning once again to the cognitive forefront. It gets me out of my teaching ruts and back to evolution in my classroom practice. I'm encouraged and enthused about birnging new techniques to my lessons and this inspires engagement in the classroom.

Section III

The purpose of Section III of the survey was to determine how the various facilitated discussion forums contributed to participants' perceived growth across the eight domains of potential teacher growth and development. One participant did not

complete all of Section III, therefore only 33 responses were included in the analysis of this section. Table 17 contains the means and standard deviations for the growth ratings in each of the eight potential domains of teacher growth across the four discussion forums, where the value of Not At All is 1, Very Little is 2, Somewhat is 3, and Great Extent is 4, along with the percentage and frequency of people making each rating, $N = 33$. As seen in this table, participants rated their growth based on their participation in Our Place the lowest and in the Content Forums the highest across all eight domains. Additionally, using the total mean ratings, the domains can be ranked in the following order from most to least perceived growth based on participation in the four facilitated discussion areas combined: reflection on practice, content knowledge, pedagogical content knowledge, general pedagogical knowledge, involvement in professional activities and leadership positions, curricular knowledge, knowledge of how to support diverse learners, and knowledge of educational policies, practices, and objectives.

Eight domains of teacher growth and development, listed in the previous paragraph, were assessed in Section III of the survey. Because these eight variables were sufficiently correlated, they were combined and a MANOVA was conducted to determine the effects of four eMSS discussion forums, Our Place, Content Forums, Inquiries, and Dilemmas, on the ratings of these eight domains of potential teacher growth. Although the Likert ratings were ordinal, all assumptions of multivariate normality, homogeneity, and independence were met in this analysis (Tabachnick & Fidell, 2007). Significant differences were found among the four discussion areas on the linear combination of the dependent measures, Wilk's $\Lambda = .697$, $F(24, 352) = 1.938$, $p = .006$, multivariate $\eta^2 = .113$.

Table 17. Descriptive Statistics for Ratings on the Domains of Growth for the eMSS Facilitated Discussion Forums, ($N = 33$).

Domain of Growth	Discussion Forum	M	SD	Percentage and Frequency of Ratings			
				Not at All	Very Little	Some-what	Great Extent
Content knowledge	Our Place	1.91	.843	36.4% (12)	39.4% (13)	21.2% (7)	3.0% (1)
	Content Forums	2.91	.879	9.1% (3)	15.2% (5)	51.5% (17)	24.2% (8)
	Inquiries	2.58	.792	9.1% (3)	33.3% (11)	48.5% (16)	9.1% (3)
	Dilemmas	2.64	.859	9.1% (3)	21.2% (7)	51.5% (17)	12.1% (4)
	Total	10.04					
General pedagogical knowledge	Our Place	1.91	.879	39.4% (13)	33.3% (11)	24.2% (8)	3.0% (1)
	Content Forums	2.61	.966	15.2% (5)	27.3% (9)	39.4% (13)	18.2% (6)
	Inquiries	2.52	.870	15.2% (5)	27.3% (9)	48.5% (16)	9.1% (3)
	Dilemmas	2.61	.899	15.2% (5)	27.3% (9)	42.4% (14)	15.2% (5)
	Total	9.65					
Pedagogical content knowledge	Our Place	1.94	.864	36.4% (12)	36.4% (12)	24.2% (8)	3.0% (1)
	Content Forums	2.79	.820	9.1% (3)	18.2% (6)	57.6% (19)	15.2% (5)
	Inquiries	2.64	.742	9.1% (3)	24.2% (8)	60.6% (20)	6.1% (2)
	Dilemmas	2.41	.895	21.2% (7)	33.3% (11)	36.4% (12)	9.1% (3)
	Total	9.78					

Table 17 Continued.

Domain of Growth	Discussion Forum	M	SD	Percentage and Frequency of Ratings			
				Not at All	Very Little	Some- what	Great Extent
Curricular knowledge	Our Place	1.82	.882	45.5% (15)	30.3% (10)	21.2% (7)	3.0% (1)
	Content Forums	2.61	.827	12.1% (4)	24.2% (8)	54.5% (18)	9.1% (3)
	Inquiries	2.33	.736	9.1% (3)	45.5% (15)	39.4% (13)	3.0% (1)
	Dilemmas	2.30	.810	18.2% (6)	42.4% (14)	33.3% (11)	6.1% (2)
	Total	9.06					
Knowledge of how to support diverse learners	Our Place	1.91	.879	39.4% (13)	33.3% (11)	24.2% (8)	3.0% (1)
	Content Forums	2.30	.637	9.1% (3)	51.5% (17)	39.4% (13)	0.0% (0)
	Inquiries	2.21	.650	12.1% (4)	54.5% (18)	33.3% (11)	0.0% (0)
	Dilemmas	2.21	.781	18.2% (6)	45.5% (15)	33.3% (11)	3.0% (1)
	Total	8.63					
Knowledge of educational policies, practices, and objectives	Our Place	1.67	.816	51.5% (17)	33.3% (11)	12.1% (4)	3.0% (1)
	Content Forums	2.33	1.021	27.3% (9)	24.2% (8)	36.4% (12)	12.1% (4)
	Inquiries	2.00	.866	33.3% (11)	36.4% (12)	27.3% (9)	3.0% (1)
	Dilemmas	2.00	.901	33.3% (11)	39.4% (13)	21.2% (7)	6.1% (2)
	Total	8.00					

Table 17 Continued.

Domain of Growth	Discussion Forum	M	SD	Percentage and Frequency of Ratings			
				Not at All	Very Little	Some- what	Great Extent
Reflection on practice	Our Place	2.45	.938	21.2% (7)	21.2% (7)	48.5% (16)	9.1% (3)
	Content Forums	3.06	.747	6.1% (2)	12.1% (4)	54.5% (18)	27.3% (9)
	Inquiries	2.91	.843	9.1% (3)	18.2% (6)	48.5% (16)	24.2% (8)
	Dilemmas	2.73	.876	12.1% (4)	24.2% (8)	45.5% (15)	18.2% (6)
	Total	11.15					
Involvement in professional activities and leadership positions	Our Place	2.21	1.083	33.3% (11)	27.3% (9)	24.2% (8)	15.2% (5)
	Content Forums	2.61	1.116	21.2% (7)	24.2% (8)	27.3% (9)	27.3% (9)
	Inquiries	2.42	1.062	21.2% (7)	36.4% (12)	21.2% (7)	21.2% (7)
	Dilemmas	2.39	1.029	21.1% (7)	36.4% (12)	24.2% (8)	18.2% (6)
	Total	9.63					

Follow-up ANOVAs were conducted on each of the eight dependent variables.

Using a Bonferroni correction, the alpha level was adjusted to .006 and results of the ANOVAs indicate that the ratings were significantly different across the four discussion forums for four of the eight potential domains of teacher growth including content knowledge, general pedagogical knowledge, pedagogical content knowledge, and curricular knowledge. The F ratios, probability of significance (p), and effect sizes (η^2) are reported in Tables 18 for the ANOVA results.

Table 18. Results of Follow-up ANOVAs for Questions Assessing Teacher Growth.

Domains of Teacher Growth and Development	<i>F</i> (3, 128)	<i>p</i>	η^2
Content knowledge	8.351	.000	.164
General pedagogical knowledge	4.556	.005	.096
Pedagogical content knowledge	6.602	.000	.134
Curricular knowledge	5.330	.002	.111
Knowledge of how to support diverse learners	1.769	.156	.040
Knowledge of educational policies, practices, and objectives	2.989	.034	.065
Reflection on practice	3.075	.030	.067
Involvement in professional activities and leadership positions	.746	.527	.017

In order to determine which discussion forums affected the ratings in the areas of potential teacher growth and development most strongly, the parameter estimates were utilized. Significant growth ratings in the areas of content knowledge ($p=.001$), general pedagogical knowledge ($p = .002$), pedagogical content knowledge ($p = .040$), and curricular knowledge ($p = .017$) were the only dependent variables discriminating between Our Place and the other three discussion areas. For each case, participants rated their participation in Our Place to have contributed significantly less to their growth in these knowledge categories than in the other three discussion areas. In addition, ratings of growth in pedagogical content knowledge contributed significantly to distinguishing between the Content Forums and the other three discussion areas, $p = .040$. In this case, participants rated their participation in the Content Forums to have contributed significantly more to their growth in pedagogical content knowledge than in the other three discussion areas. No variables significantly contributed to distinguishing among

participation in the Inquiries or Dilemmas from the other discussion forums. In addition, knowledge of how to support diverse learners, knowledge of educational policies, practices, and objectives, reflective practices, and involvement in professional activities and leadership positions did not contribute significantly to distinguishing any of the groups.

Accompanying each Likert style question was an open ended question designed to elicit more detailed feedback about which discussion area or other program aspect promoted perceived growth the most for each domain and how this growth occurred. Table 19 presents an overview of the insightful mentor feedback provided by these survey responses. As evidenced in this table, two of the most prevalent avenues of growth for the mentors, aside from participation in the various discussion forums, include learning from others through reading or communicating with participants in both similar and diverse classroom situations as well as reflecting on one's practice, which was closely related to learning about other people's perspectives and practices as well as thinking about the *NCTM Standards*. Another less prevalent theme contributing to the process of mentor growth was program flexibility to meet individual needs and professional goals. It is important to note that acquiring new teaching ideas, resources, and strategies, as opposed to strengthening existing knowledge and skills, was a prevalent area of growth and could be found throughout the knowledge domains.

One interesting finding is related to the domain of content knowledge. In that domain, many of the participants discussed instruction rather than enhancement of their mathematical content knowledge. Perhaps this is because when thinking about content,

Table 19. Influence of eMSS Discussion Areas on the Domains of Potential Teacher Growth and Development.

Domain of Growth	Insightful Mentor Feedback <i>Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your knowledge? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.</i>
Content knowledge	In the math discussion area when someone asks a question about content. I am informed by answers offered as well as challenged to clarify my knowledge in order to share it. The Content Forums. I have really enjoyed learning about what other people who teach the same content area as I are doing in their classroom. Content Forums. I especially like revisiting the NCTM Standards. Those topics have caused me to reflect on how well I am addressing those in the classroom. Content Forums - I read lots of good ideas, activities, new ways of looking at a problem - often from mentees since my education was way back in the 80s! Definitely the Inquiries and Dilemmas. Any time that you have the opportunity to hear what other teachers are doing in their classroom, despite what state curriculum you might be following, you find yourself reflecting on your own practices and then refining them. The number and variety of content forums and the ability to create my own conversation strands makes this area accomodating, useful, and valuable.
General pedagogical knowledge	Dilemmas: They allow me the luxury of figuring out how to respond to a situation without actually having to face it. The dilemmas offer the most opportunities to discuss pedagogical issue like student behavior, classroom management and others. Being able to help a mentee work through an issue for their first time sheds light on what you are currently doing in your classroom and allows you to reflect on specific issues that the moderators post. In the inquiries, I enjoyed learning about the stop-light strategy for students to express their levels of comfort during the learning of new concepts. I can consider adapting this strategy to my math classes when I teach math again. The inquiries do. I like to trouble shoot with my mentee as to what works and does not work. I also like the imput of the other teachers.

Table 19 Continued.

Domain of Growth	Insightful Mentor Feedback
Pedagogical content knowledge	This inquiry on manipulatives has opened ideas for me to try. The ideas on fractions, paper plates, egg cartons, etc. have caused me to revisit how easily I could use these as a warmup to refresh fractions skills. In "High School Questions about Math Teaching/Learning" when someone asks a question about how to teach a particular topic. I am informed by answers offered as well as challenged to reflect on and clarify the way I present it. Content Forums allowed me to ask for input from colleagues about specific topics in my classes in a timely fashion. I could put suggestions to work almost immediately. Again, Content Forums have made the biggest impact as the topics discussed are relevant to what I teach. There have been discussions about how to teach difficult concepts in a way that is understandable to the average middle school student. These are on an equal basis as far as this question is concerned...keep in mind, I have been in the profession for a long time so the "great extent" category would not really apply very well...
Curricular knowledge	The discussions of higher level courses has reminded me of topics which I have never taught and I need to "connect" more efficiently my content to what comes next. I always appreciate input on how to improve my yearly "umbrella" of math content. This has not been a major focus of eMSS, but is, I believe the key to improving math retention. In "High School Questions about Math Teaching/Learning" when someone asks how or when a particular skill is taught, it is important to think about the order in which topics are presented. Different orders work, but they change the way in which we teach concepts. I must think through my reasoning before I can present it to others, and I also gain insight from the responses of others. Content Areas again. While I haven't added a great deal to my curricula knowledge, the discussions give me a better view of what students have learned in the past and where they are going in the future. I have tried for many years to encourage more interaction between the grade levels, but these meeting carry a lot of baggage when discussion seem to go back to "why don't you teach...in the middle grades/elementary grades, etc. In eMSS there is a more supportive discussion. I have been introduced to some new resources that I consider using in my classroom.

Table 19 Continued.

Domain of Growth	Insightful Mentor Feedback
Knowledge of how to support diverse learners	Since Hawaii's ethnical diversity differs from other states, my PM communications and discussions w/mentee has contributed the most. This is a tough one. I guess it would have to be dilemmas. Some of the dilemmas this year have included support of diverse learners; the recommendations provided here have been insightful. The inquiry on diversity - especially the 1st article made me aware of statements I use that do not support equity There were relatively few discussions regarding diverse groups of learners. Had those strands started, I'm sure I would have found valuable ideas in others words and experiences. Our place because my mentee teaches a diverse population. He is always sharing what he has learned.
Knowledge of local, state, and national educational policies, practices, and objectives	The content forums - specifically the topic of the month. I would not tend to focus on NCTM Standards as frequently as I have this year had it not been for this topic. It has contributed to my growth in that I am more aware of the standards and think about how they apply to my own practice more often. The discusssions on standards have been excellent and have caused me to examine how well I am teaching to those standards. The diverse makeup of eMSS members greatly enhance my interest in and knowledge of policies practices, and objectives. Really none of these areas focuses on these issues... Because of my prior involvement with organizations in National educational policies, practices and objectives, I think eMSS just confirmed what I already knew.

Table 19 Continued.

Domain of Growth	Insightful Mentor Feedback
Reflection on practice	I reflect constantly on my practices as I hear creative, outstanding ideas from colleagues. Reflection was encouraged from reading comments and following the thoughts and logic of others in the forums, inquiries and dilemmas. It was further enhanced my desire and need to offer meaningful and nonrepetitive comments of my own. Anytime I am exposed to the point of view of other people, it causes me to reflect on how and where these ideas are similar to or different from my own conceptions and practices. Anytime I truly reflect on what I do or how I do it or how it impacts my students, I change or revise my practices. Once again the inquiry as there are lots of thoughts and ideas for me to use in my classroom – I then am able to reflect on how they work vs past practice. The discussion are of inquiries and Our Place. Both areas allow me to discuss what worked and what has not worked.
Involvement in professional activities or leadership	Honestly, I don't feel that eMSS has had much of an impact in this professional area for me. I am someone who takes on several leadership roles in my school community each year. However, the opportunity to connect with others who do the same in their communities has been rewarding. Participating in the content forums gave me so many more perspectives and ideas to bring to professional group discussions. I became a far more valuable contributor to groups with goals to improve the learning of our students. I am the only math teacher in our small middle school - the opportunity to share comes from teaching "buddies" I have around the country....I doubt this could be looked upon as leadership, but I do share cool things I learn or read about on the emss site.... I have shared comments, methods, classroom management ideas, etc. I have read on eMSS. One thing we are doing now is scheduling for next year. In our input I have encouraged my principal to be bold and make changes (using an example from a teacher on eMSS) in our schedules so we will improve our math education. I had been involved in professional organizations and leadership positions prior to joining eMSS and it has not had any negative effect on my role in this area. I continue to be involved.

many teachers immediately think about how to teach the content to their students. On the other hand, these discrepancies may be due to the design of the instrument. Content knowledge was the first domain assessed by this section of the survey and perhaps the participants were better able to separate the knowledge and skill domains as the survey proceeded.

At the end of the survey, the teachers were asked to consider if and how their involvement in eMSS has contributed to one of the domains of potential growth and development the most. The most frequently cited area of “most growth” was growth in reflective practices (13 participants) followed by professional engagement and leadership (six participants), general pedagogical knowledge (five participants), pedagogical content knowledge (three participants), teaching resources, ideas, and strategies (two participants), content knowledge (one participant) and knowledge of wider educational policies, procedures, and objectives (one participant). Table 20 summarizes some of the insightful mentor feedback, ending with a quote that captures many of the avenues of growth identified throughout Section III of the survey.

Summary of Participant Surveys

The survey results indicate that these mathematics mentors have grown in their knowledge and skills as well as have made some changes in practices as a result of participating in eMSS. These results are not surprising given that over 90 percent of the participants reported that eMSS aligns at least somewhat with their goals for professional development. Throughout the survey, growth in reflective practices was identified as an

Table 20. Insightful Mentor Feedback: Areas of Most Growth through eMSS Participation.

Domain of Potential Growth	Insightful Mentor Feedback
Reflection on practice	Reflection on practice is the area that has been the greatest area of growth for me. I believe that whenever one has an opportunity to discuss with others in a professional and supportive environment any aspect of their pedagogical approach, reflection happens. So any time I have logged on to eMSS and added to a conversation or just read others I have reflected. Reflection is my weakest point. eMSS has worked reflection into the program as a regular practice. That is a good start for me! (G) Reflection upon my practice because this forum has provided a convenient way to reflect on a consistent basis. The opportunity for reflection along with discussion with peers is not available during a normal school day. I like the fact that someone is leading what is being reflected upon and that participants can add their own discussion questions when needed.
Involvement in professional activities or leadership	Because I am currently not teaching in the classroom, I feel eMMS has contributed the most to growth in area h. It has allowed me to enhance my leadership skills in working with classroom teachers by providing me another forum in which to tap ideas for current pd activities which I can use with teachers. h.) it has opened a whole new world of professional development that I did not know existed. It allows me to learn about opportunities that otherwise I would not have known about
General pedagogical knowledge and teaching resources, ideas, and strategies	My general pedagogical knowledge and skill base has grown extensively. The more tools in a teacher's tool chest the more effective one can be with all types of learners and all learning situations. I now have so many more options when dealing with the many aspects of my job. Aside from the growth with technology, I think my general pedagogical knowledge and skills has been enhanced the most. It is interesting to see how mentors/mentees handle similar situations with such diversity. It has really made me rethink several procedural aspects of my classroom. Once again the diverse amount of information shared by others has allowed me to learn new techniques and strategies to incorporate into my classroom
Summary: Multiple Themes	Reflection on my practices would probably rank as the area that has had the most impact on me. Sometimes being a teacher is a very isolating profession. The vast majority of my time and energy is spent with my students, leaving little time to interact and work with other teachers in my discipline . . . Because we are able to read and participate according to our own schedules, It is possible to interact with other professionals on a regular basis. I am able to process and return to discussions when I am ready. While I am often overwhelmed by the many areas in which I could take part...that is exactly why this program meets the very diverse needs of individuals all over the country and at all levels of experience in this profession.

important area of growth for the participants. Results also indicate that knowledge of content and pedagogy, acquisition of new and varied teaching ideas, resources, and strategies, as well as leadership development were key growth domains. In addition, participant activity level appeared to positively, if not significantly, effect participants' perceptions of growth in knowledge and skills and changes in practices. Finally, the overall survey results reveal that the participants attribute their growth to the following: (1) participating in the Content Forums over the other discussion areas, (2) reflecting on their practice, (3) learning from other enthusiastic professionals, and (4) meeting personal needs and goals through program flexibility.

One of the program goals of eMSS is to improve content knowledge of mathematics through facilitated discussions, particularly in the Content Forums. Although participants attributed their growth in content knowledge to participation in the Content Forums over the other discussion areas, there are discrepant findings related to growth in this domain. In Section III of the survey, growth in content knowledge was second only to growth in reflective practices as a result of participating in the facilitated discussion forums. On the other hand, in Section II of the survey enhancement in knowledge of mathematics content was rated on average between very little and somewhat and was ranked sixth of the 11 assessed domains. Furthermore, open ended responses indicate that many participants perceive growth in content knowledge to be synonymous with instructional strategies to teach mathematics. Thus, there is ambiguity about the degree to which participant's content knowledge has been enhanced as a result of participating in eMSS. Further research could specifically focus on growth in content

knowledge of mathematics as a result of participating in a content-based mentoring program using instruments designed to assess this growth.

Case Studies

This section, in the form of case narratives, presents the professional growth of six eMSS mathematics mentor teachers as a result of participating in the program. Each participant was not only an experienced mathematics teacher during the 2007/2008 eMSS program year, but was also an actively engaged mentor. The data in the narratives was obtained from the focus group, surveys, interviews, and portfolios designed to gain insight to the following research questions:

How do experienced mathematics teachers perceive their experiences in a content-based online mentoring program to have influenced their professional growth?

- a. In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?*
- b. What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?*

What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?

Subsequently, the data was analyzed and synthesized across the six cases in order to provide more convincing answers to these research questions.

Each case narrative provides an in-depth description of the case participant's perceptions of his or her professional growth and the avenues toward this growth as a result of participating in eMSS. Categories that emerged within and across cases such as

knowledge, skills, and resources for teaching mathematics and *reflective practices* were used to organize the data. Each case narrative attempted to describe the participant's professional growth by starting with the most predominant and ending with the least predominant areas of growth evident in the data, followed by the important avenues of growth. In order to provide the appropriate context, each participant's teaching, eMSS, and mentoring experiences as well as his or her personal goals for professional development are included in the narratives. Quotes from interviews, focus groups, surveys, and portfolios are included to support the findings, and spelling and grammatical errors were left in the quotes that were typed by the participants. All names of the participants were changed for confidentiality. When posts included in portfolio entries were taken from private communication, I paraphrased the posts to further protect confidentiality. The cross-case analysis depicts the similarities and differences in the mentor teachers' perceived professional growth as well as the experiences that led to this growth, highlighting the effective features of eMSS and the potential benefits of participating in a mentoring program to the mentor teacher.

Three categories of experienced teacher types emerged through the analysis of the case data including the *Professional Classroom Teacher*, the *Teacher Leader*, and the *Late Career Reflective Teacher*. I developed these categories after discovering distinct similarities and differences among the professional experiences, needs, philosophies, and goals of these teachers. It is important to note that there is some overlap between these categories, and teachers who fit best in one category sometimes exhibited behavior or perspectives characteristic of another category. These phrases simply provide a shorthand

method for describing the essence of the mentors' professional focus. The six cases are presented according to the classification of the teacher.

Professional Classroom Teachers are experienced teachers who are still relatively new to the profession but have advanced beyond the novice and apprentice phases of their careers (Steffy, Wolfe, Pasch, & Enz, 2000). Their primary focus is to find ways to improve their classroom instruction. These teachers seek and utilize professional development experiences to meet their instructional needs and focus on gathering ideas and resources to improve their practice and subsequently the learning of their students. Involvement in professional communities provides a venue for reflection on and enhancement of their individual classroom practices. Three of the eMSS case participants, Vanessa, Sara, and Amanda, are considered *Professional Classroom Teachers*.

Teacher Leaders are experienced teachers who are in leadership positions at the school, district, and/or state levels as well as very active in professional organizations. Given their years of experience, these teachers are comfortable and confident enough with their instructional routines that they can concentrate on the needs of other teachers as well as the needs of their department and school. Thus, their focus is on leadership outside of the classroom. Professional development provides an opportunity for these teachers to contribute their expertise to others as well as to reflect on their own practices and the educational system. Bill is the only case participant classified as a *Teacher Leader*.

Finally, *Late Career Reflective Teachers* are experienced teachers well into their careers and are confident in their practices. While they actively reflect on their teaching and how to best meet the needs of their students, they also look beyond their classroom walls and reflect on the wider educational system. Professional development opportunities provide a forum for these teachers to think more generally about the purposes and goals of mathematics education and the needs of students as well as a way to contribute to their profession. Two case participants, Laura and Joy, are considered *Late Career Reflective Teachers*.

Not surprisingly, the three categories of experienced teacher types that emerged were related to the teachers' years of experience in the profession. Vanessa, Sara, and Amanda have each been teaching mathematics for less than 15 years and are still building their instructional repertoire and evolving as teachers. On the other hand, Bill, Laura and Joy have each been teaching mathematics for 20 years or more and are confident in their teaching practices. While all three are reflective and compassionate practitioners, differences exist between Bill, the *Teacher Leader*, and Laura and Joy, the *Late Career Reflective Teachers*. For example, due to his many administrative responsibilities, Bill tends to think about mathematics education from a management perspective, while Laura and Joy tend to reflect on teaching and student learning from a philosophical perspective. These teachers engage and benefit from eMSS in different ways depending on their interests and needs. The six case narratives and the cross-case analysis follow.

Vanessa: A Professional Classroom Teacher

Vanessa started her teaching career as an elementary school teacher. Ten years into her career she began teaching middle school and has been teaching seventh grade mathematics for five years in North Carolina. Teaching mathematics as opposed to an elementary curriculum has allowed Vanessa to “explore and build a firmer foundation of instructional strategies” because she has been able to focus on one discipline. Vanessa, a National Board Certified teacher, loves teaching mathematics and currently works with a student teacher in her classroom.

In addition to mentoring a student teacher, Vanessa works with one mentee on eMSS. This is Vanessa’s first year participating as an eMSS mentor and has had some trouble engaging her mentee. She believes her mentee is extremely overwhelmed with all of her responsibilities at school. Although Vanessa has tried to use her Our Place with her mentee, most of their interactions have been through private messaging. In sum, Vanessa believes that eMSS has served her professionally more than it has her mentee.

I feel [my mentee] would get alot out of being more active with emss but I also understand that there are only so many hours in the day. As for me, it is like an ongoing professional development that I can tailor just for me :-)))

Vanessa tries to log on at least two to three times per week and says that she spends about two hours per week on the site. Although she contributes through posting, she spends most of her time reading and thinking about how she can incorporate teaching ideas into her practice; “I find myself using emss as a resource for me instead of contributing in a way to help others” and “just in reading you have time to just sit and think hey wait, that’s really a good idea. I never thought of it that way.” Vanessa finds

herself staying in the Middle School Math content area and does not “venture out” too much. In this area, she reads a lot and has started threads related to concerns in her mathematics department such as the pros and cons of calculator use, the lack of students’ foundational skills, and the potential links between the two. In reference to the first few posts she made in the Middle School Math content area, she states:

. . . it was kind of an eye opener for me that I can be more active instead of reactive in the situation. If some things come up that I want help with I have a whole group of people that can help me . . . and so I just think its just having that avenue of being able to talk with other educators about questions, concerns, or like I said just being bored with how you’ve always done it and you want something new.

Vanessa has also participated in all of the Inquiries, two with her mentee and one on her own. She has enjoyed taking part in them even if she felt that she did not guide her mentee much through them. On the other hand, she found the Dilemmas to be “kind of hit and miss.” She takes part when they relate to her classroom situation. All in all, Vanessa believes her participation in eMSS has been valuable; “I think that anything that spurs thoughtful dialogue among professionals can only promote growth in some way.”

Knowledge, Skills, and Resources for Teaching Mathematics. Vanessa’s participation in eMSS has contributed to her growth in a variety of ways. For the most part, her repertoire of strategies for teaching mathematics has grown and her motivation is summed up with four simple words, “I love new stuff!” She states that her goals for professional development include “focusing on how can I develop teaching strategies just to be varied in my classroom so that the way you present things are not the same all the time and that you’re kinda updating what you are doing.” According to her, eMSS

somewhat aligns with her goals for professional development and she has been able to learn about and incorporate new ideas into her classroom instruction because of her participation in the program; eMSS gives her the opportunity to “just say hey, I’m kinda bored with how I teach this, does anybody have any ideas?”

In specific, Vanessa has added or made changes to her general pedagogical strategies to help her students become more successful. For example, from eMSS she has incorporated new cooperative learning strategies to help make sure “everybody participates” in her classes. In addition, she found one idea to help keep her students more organized with the use of a structured binder. In fact, she even brought this binder idea to her principal and is working to implement it in all of the classes in her seventh grade hall. Conversations about grading policies also intrigued Vanessa and as a result of these discussions, she has changed her homework policy this year and she now focuses “on the positive side of completing it than on the negative side.” The following portfolio entries reveal some of the ways in which Vanessa’s repertoire of general pedagogical strategies has grown.

Post:

~To add to [facilitator’s] Think-Pair-Share, you can also, Think-Pair-Ink. It is similar to think-pair-share, however after the discussion with each other. The pairs will write down what they just discussed and learned.

We also have discussions in triads, where only one person talks, one listens, and the other person takes notes of what is being discussed. Then the notes are shared with all participants and may be shared in the large group.

If responses are on chart paper, you could do a gallery walk for all participants to see the contributions of others in a timely manner. The groups or pairs would post their writings, and each group has a minute or so with reading the response. Then moving clockwise to the ring of the timer. Students appreciate the light “walk” after thinking so hard.

~This can be a problem getting all students to get involved in the discussion and managing

responses. What I do is utilize a three-cup method in which I draw students' names. If they respond, their sticks are moved to a cup "answered a question", If they do not respond or get a wrong answer, their name is placed in the cup "second chance." I also incorporate pair and group responses. On some occasion, I allow to do group discussion responses, this work sometime, but I find the students sometimes engage in personal conversation as well.

Who's post? Mentor and mentee

Discussion area: Content Area

Area(s) of growth: General Pedagogical Skills

Justification: This post reflects the different ways teacher can incorporate group work and ensure that all students are involved. I have used the names on sticks before but not the three cup method. I also like the extension of Think-Pair-Share. It requires students to be more accountable for their outcomes as well as incorporates all students in a variety of roles. Instead of listening to others read, the gallery walk through is intriguing. Do children really read the charts or just wander around and miss out on learning? I haven't used this method yet but can't wait to try it.

Post:

I love to use cooperative learning structures in my classroom. One of my favorites is Numbered Heads Together. The steps are:

1. Number students off from 1 to 4 within their teams.
2. Call out a question or problem. (Example: Where do plants get their energy?)
3. Students in teams put their heads together to discuss the answer. They must make sure everyone on the team knows the answer.
4. Randomly call a number from 1 to 4 (use a spinner, draw popsicle sticks out of a cup, roll a die, etc.)
5. On each team, the student whose number was called writes the answer on the team response board. **They may not receive any help from their team at this point!** If they didn't pay attention during the discussion, too bad! They place the response board face down when ready.
6. When all teams are ready, have the designated student stand and hold up their response board to show their answer. Check each team's answer for accuracy.
7. Repeat with additional questions as time allows.

This time of year, though, I find that I'm looking for new cooperative learning ideas to help invigorate my classroom. Do you have any cooperative strategies you use to help organize thoughtful interactions between students?

Who's post? Mentor

Discussion area: Content Area

Area(s) of growth: General Pedagogical Skills

Justification: How we teach is just as important as what we teach. The strategies we use to engage students can be used in any content area. This approach to cooperative learning is a new twist that I plan to use for my next test review. What I like about it is it makes each student

accountable for participating with their team. Peer pressure is a strong motivator at times when groups have one student who may be causing that team to lose.

Post:

I completely agree! My students come from an area where athletics is considered very important. I tell my students that math can be a lot like playing sports. Practice makes perfect! If you want to play in the game, you have to put out the time and effort and do the work. Not only is practice used for perfecting your abilities, but practice is also used as a discipline tool. Athletes and mathletes have to discipline their bodies and brains to keep them in proper shape. I feel that one of my jobs as a teacher is to help my students understand the real world, and in the real world we have jobs, and bosses, and sometimes we have to do things that we don't necessarily want to do. Kids have to learn to be held accountable for their actions.

I also think homework teaches organizational skills and time management. Sure, almost all kids can finish an assignment and put it in the right box before leaving class, but how many kids can go home, remember that they had homework (to start with), do the assignment, and make it back to class with it the next day??? I require that my kids have a three ring binder with dividers. They keep track of their assignments, and they file them accordingly (homework, tests, quizzes, warm-ups, and notes). I take a grade on the binders once a month to keep the students up to date. Yes, it may seem rough on seventh graders, but let me tell you, it teaches them a lot. It also holds me accountable...if I have a grade in my gradebook that a student disagrees with, they can go through the binder, find the graded paper, and prove me wrong. Its great!

Who's post? not specified in post

Discussion area: Content Area

Area(s) of growth: General Pedagogical Skills

Justification: Teaching, regardless of the content area, has many different facets from record keeping to classroom management to interacting with colleagues. General Pedagogical Skills covers all the "other tuff" teachers have to do to have a successful career. This post covers setting high expectations, student accountability, organization, and grading rules. Since my move to middle school, I have struggled with students keeping up with materials (notes, homework, etc.) and coming to class prepared. I really like the idea of a binder to keep everything not just notes and homework. The impact of this binder could far reaching. It seems like one of those things that teachers sometimes take for granted like study habits/skills. Students don't know how to organize or understand the importance of it unless someone shows them. Many of my students lack parental support-they are responsible for themselves and often times siblings. The value of a tool like this is priceless in terms of future student success especially in a high school setting where students are expected to be quite a bit more responsible for themselves than in middle school. I plan to take some time to define exactly how I can implement this idea in my class and then present it at the beginning of the school year.

Vanessa has also grown in her knowledge and skills specific to teaching mathematics. Although she does not feel that her content knowledge has been enhanced, she does feel that her knowledge of how to teach the concepts has grown.

I've not read anything where I went wow I didn't know that in terms of math knowledge but it's been about how to get the math knowledge across to the kids that I've said, oh, I've never thought of it that way . . . so I think that's been the biggest growth, not so much in what the math is as how to teach it.

For example, Vanessa has engaged in several discussions about equivalent fractions, decimals, percents, integer operations and number line concepts, as well as graphing. These discussions have given her ideas of how to teach these topics to her students. She has also gathered ideas and resources specific to teaching mathematics which includes websites and web-based applets, interactive games, graphic organizers, and using stories and books to help or motivate students to learn mathematics. In addition, discussions on eMSS have given her ideas about how to create a Pi Day in her school. In fact, before eMSS she had not even heard of Pi Day. Finally, Vanessa has also learned how to better use the SmartBoard in teaching mathematics.

I just felt like there was a lot more that could be done and I just didn't know how. And there was a discussion thread on eMSS about smartboard and one of the mentors actually attached a sample of one that her department had created and I just started private messaging her and she just helped me tremendously. And now that is a huge component. I take each chapter of my math book and instead of doing notes on the overhead or doing notes on the board and stuff like that all of my notes are already presented in smartboard. For each lesson there is some kind of matching game or you know different aspects that the kids can actually come up and interact. I learned how to link websites into a smartboard presentation so that if I found a game online that I really liked all I had to do was link it into that and I would have *never* known how to do any of that if it weren't for this program.

Discussions in the Middle School math content areas, the Inquires, and the Resources area on eMSS have contributed to enhancing her resources for mathematics instruction.

The portfolio entries that follow demonstrate examples of some of the resources Vanessa has accumulated.

Post:

I think that using a smart board to show interactive examples of problems is a great way to increase learning in a math classroom. The students were more engaged and interested when compared to writing the same problems on a whiteboard.

I also like using games to get the students engaged. A jeopardy or millionaire always gets the students excited! I use these as a means to review for tests.

***Attached a download of solving equations w/ Who wants to be a millionaire.

Who's post? (mine, mentor, mentee content specialist): Mentee

Discussion area: Inquiry

Area(s) of growth: General Pedagogical Skills & Curricular Knowledge

Justification: We all know that the more the interesting your lesson presentation the higher the level of student engagement. What is more fun than playing a game. Isn't that how we teach preschoolers and it works!! In addition, the more motivated the students are to learn the less a teacher has to focus on behavior management. How to use these resources effectively is the key. Although, the template provided by the mentee focuses on one step equations, it can easily be manipulated to cover any material.

Post:

Like (eMSS participant), I'm an internet fan. It's amazing what free applets are available. I spent time over the summer googling my major topics and putting together a matrix with some sites. I've attached it below. WARNING: I have not validated these sites lately--so some links may be dead.

I also like the site aaamath.com--it has many topics and the ability to have students print their results!

***Attached the matrix w/ all applets.

Who's post? (mine, mentor, mentee content specialist): Mentee

Discussion area: Inquiry

Area(s) of growth: Curricular Knowledge & Pedagogical Content Knowledge

Justification: Gone are the days of drill and practice. Children are surrounded by so much technology that teaching has to integrate that facet of society to keep students engaged. Many websites offer stimulating games to help students learn concepts. Sometimes they even provide teachers with alternative teaching methods or strategies for solving problems. Internet is as much a learning tool for teachers as students. Many times the explanation given on a website or through a game is much more effective than our textbook. It offers teachers different way to effectively represent and teach subject knowledge to students.

Post:

~Read a math story to the students for an end of year change. **The Math Curse** by Jon Scieszka and Lane Smith was enjoyed by my 6th grade math students. There are questions (*some silly*) to answer aloud in the classroom during the reading which make the kids really listen and think

about to solve.

~Isn't it a great book?! I substitute manes of my team members and the kids love it... I also read **Teacher from the Black Lagoon**, especially when I teach 6th grade. I have several other books at school...will edit this later.

~What a great idea! Right now, my school district is focusing heavily on content area reading strategies. I have a small bundle of short stories that I read with my classes, but I'm wondering if I'm missing any great opportunities. Just yesterday I saw a unit that was posted on line that focused around Paul Bunyan. That made me wonder - What books do others read with their students that they use either to launch a unit or to be the focus of a unit?

Who's post? (mine, mentor, mentee content specialist): 2 mentors and a mentee

Discussion area: Content Area

Area(s) of growth: Pedagogical Content Knowledge

Justification: We all know that children learn differently and by varying our lesson presentation we can reach more students. These posts reminded me of strategies we utilized in elementary school when we taught in integrated units. This concept is not new but it has served as a reminder to utilize a variety of techniques to introduce new concepts.

Post:

We have a math competition with teams from each of the 3 middle schools. The winners get, of course, pie.

There are many ideas on the web:

The official pi day site: <http://www.piday.org/>

Mr. Herte's site has activities: http://www.mathwithmrherte.com/pi_day.htm

There are even pi songs or you could watch the contest to see who can recite the most digits of pi!

Who's post? (mine, mentor, mentee content specialist): Mentee

Discussion area: Content Area

Area(s) of growth: Mathematical Content Knowledge

Justification: Pi-3.14-everybody knows that right but do they know what it is and where it came from?? When this discussion thread started, I tried to think back to high school and determine how my teachers taught me what pi was. For the life of me, I couldn't. Amazingly enough, until this post, I had never heard of pi day (maybe because I spent my first 10 years teaching in elementary school where it is the 100th Day that gets the big celebration). Anyway, I brought it up at our department meeting. Although many of them had heard of pi day only one had actually done some activities with it through a Masters class. We as a department have been tossing around some ideas for a Family Math Night and have added a Pi Day Celebration to our list of department activities for next year. Measurement and geometry with formulas using pi become a big part of our curriculum in middle school in NC and we felt this would have them have a greater understanding of what pi was instead of just saying use 3.14 or 22/7 for pi in the formula.

While eMSS has contributed to Vanessa's growth in teaching strategies, it has not particularly enhanced her ability to support diverse learners.

I have a lot, especially my first period class, a lot of um socio economic low, low socio economic children. I have some that they try, bless their heart, as hard as they can and they just can't get it but they can't get there so I tend to watch for those postings to see if there is anything that might can help them. Um, nothing specific has come out of it but I do like to read them because they kind of make me think differently.

In addition, Vanessa's curricular knowledge has not been affected and she attributes this to the county pacing guide that she must follow closely. She feels that her "hands are tied" when it comes to the curriculum. On the other hand, eMSS also allowed Vanessa to gain a broader perspective of mathematics education.

I'm almost embarrassed to say that I'm one of those teachers that I get lost in my own classroom and pretty much nobody else exists but my class and so eMSS has kind of forced me out of that box and said ok other things are going on besides what's happening in your class and what's happening in North Carolina.

In particular, eMSS has promoted Vanessa to learn more about the *NCTM Standards*.

Professional Engagement and Leadership. Although Vanessa does not believe that eMSS has greatly influenced her professional engagement because she has not become involved in more professional activities and leadership positions in her school since she started the program, it seems that this has in fact been a significant area of growth for her. Vanessa's participation in eMSS has provided her an avenue to contribute more to the professional activities in which she is already involved. As referenced earlier, Vanessa has brought many of the ideas that she has learned about in eMSS back to her school. For example, she has posted issues and questions that have arisen in her mathematics

department meetings, such as calculator use, on eMSS and has subsequently returned to the meetings with fresh ideas. Vanessa sums up her growth in this area as follows:

You know I used to sit in math department meetings and not have a whole lot to say other than what I do in the classroom. And now it's like [excited] well in my online mentoring group . . . you know so its, its made me think more like I said outside of my four walls as well as in my four walls.

Vanessa has also joined another online professional learning community that she learned about on eMSS, the Silicon Valley Education Foundation, designed to help teachers share lesson plans and teaching strategies. Joining this group has further extended her professional involvement; "Like with eMSS, this site allows educational personnel from across the nation to enter into discussions in ways that were not available before." Finally, eMSS has provided Vanessa with a leadership opportunity. She has been asked to be an eMSS facilitator the 2008/2009 eMSS year. She was surprised and honored by the invitation.

. . . I was uh very taken off guard by that because, like I said, I read and sometimes I am overwhelmed at the knowledge and the depth that some of the people post with. I'm like wow, I'm nowhere near that level as far as the fact that I stay in my classroom. I don't venture out. I don't do a lot of conferences and so I was very surprised that I was asked to do that. Um, very honored as well . . .

Communicating with Others and Reflective Practices. One avenue for Vanessa's growth has been through communicating with others in the program. For example, she developed a one-on-one relationship with another mentor that helped her tremendously in improving the use of the SmartBoard in her classroom. In addition, Vanessa feels that the professional learning community in eMSS has been valuable to her growth. The following quote sums up the importance of the group to Vanessa:

I think the beauty of this program is it doesn't limit you to working just with your mentee - it provides you with so many opportunities to interact with such a wide variety of people yet all focused on the same content area. We only have 9 math teachers in my school and that has not allowed for the type of discussions that are taking place here at emss. In addition to the large number of active participants, it gives me the opportunity to interact w/ people all over the US and I have found that to be very beneficial as well.

Vanessa, believes that reading and learning from the professionals in eMSS promotes reflection; “Most importantly, it gives me the opportunity to engage in discussions w/ people who are in a variety of settings with various philosophies. It just makes me take the time to think instead of always being in the go, go, go frame of mind :-)).” In fact, she finds that reading other people’s posts promotes reflection because they make her “think so differently.”

. . . a lot of that stems from so many of us are in a variety of settings. We are across the United States but we’re all facing and teaching the same content. So because of different situations you have different things to think about and so I don’t think I’ve ever gone on and read that I didn’t at least say hmm, that’s something to think about . . . so that's something I tend to do a lot of when I read is I just stop and think. You know, how does this look in my room? Is what I'm doing equal to this, could this be better, or is mine working well enough that I don't need to bother with it? So I think that's been the biggest thing for me . . .

Other Benefits. Participation in eMSS has benefited Vanessa personally. By helping Vanessa improve her classroom instruction, she feels a sense of satisfaction.

Anything that makes my classroom better benefits me personally because it gives me that sense of satisfaction that I've actually done something. I do believe the motto "to teach is to touch a life forever" you know even if it is just one child. And so anytime that happens for me then I'm personally satisfied.

In addition, eMSS and its participants have been invigorating for Vanessa and have stimulated her desire to be an effective mathematics teacher.

. . . the energy of this group is overwhelming from the new people to the veterans. Since I am right in the middle of my career seeing enthusiasm from both ends is a big boost!!! I still relate w/ the eagerness of new teachers and am constantly looking for new ideas which I can get from them but then again it is encouraging to see so many that are close to retirement still have the passion for teaching children. So I guess more than anything eMSS has helped sustain me in my drive to be a better teacher all around not just in terms of mathematics.

Sara: A Professional Classroom Teacher

Sara has been a high school mathematics teacher for her entire teaching career and is currently in her 11th year of teaching. For her first seven years she taught in a new high school where she worked in “an amazing facility with a great team of teachers.” She now works in a rural community in New Hampshire where she serves as the mathematics department chair. Since she has been at this school, she has been mentoring new teachers in her department. Unfortunately, these new mathematics teachers have been uncertified and for one reason or another have not stayed at the school. As a result, Sara has mentored a new teacher each of her four years at this high school.

Although Sara has been a mentor in her building, this is her first year as a mentor with eMSS. She currently works with two mentees from New Hampshire and two from California. Two of her mentees are fairly active whereas the other two are relatively inactive. Although she encourages them to interact in Our Place, Sara communicates with her eMSS mentees primarily through private messages. Sara believes that developing a real relationship with her mentees has been difficult because of the online nature of the program.

I had a little bit harder time getting the mentees to take the time to build the relationship up because they were so overwhelmed with . . . building a relationship with so many people, all the kids at school, and so it's just one more

thing. I kind of felt like writing might have been just a little bit of a struggle for me to figure out how to get them to open up.

Because her mentees are not very active, Sara states “that the postings in emss are more for my professional development.”

Sara logs onto eMSS for an average of three hours a week and tries to log onto the eMSS site at least once a day. She has her email set up so that she is notified when she has received a private message and always checks those immediately. In addition, she looks through all of the recent postings on the eMSS Home page whenever she logs on and reads the topics that are of interest to her. This allows Sara to read topics posted in every discussion area except for the Inquiries and Our Place, which she must visit separately. Although Sara actively reads and posts in a variety of areas, she has found the Content Forums, High School and Middle School, to be most beneficial to her overall growth as a professional. On the other hand, Sara has not found the Inquiries useful in her professional growth. She could not get her mentees to participate in them and her minimal participation was mainly for program requirements. Overall Sara describes her experience in eMSS as follows:

It's kind of like your own self designed professional development. If you want to learn about something you just post it and people will reply back and you will get an answer to something you can actually use in class the next day versus going online. It's like you can actually post it and people who you know have information. It's something right there to reply back to. It's kind of like an immediate way to do research without having to do leg work. It's a little more efficient . . . You can really hear different people's opinions and weigh things out. But you can do it at your own time . . . it's not like sitting in boring meetings . . . you filter through what's useful and what's not useful. You can kind of do it faster than in a meeting or in a conference . . . I just can quickly go into something that would be interesting so that's good.

Knowledge, Skills, and Resources for Teaching Mathematics. Sara's participation in eMSS has enhanced her knowledge, skills, and resources for teaching mathematics as well as impacted her teaching practices in a variety of ways. This probably has occurred because Sara feels that eMSS greatly aligns with her main goals for professional development. As this was Sara's first year of teaching calculus and statistics, one set of professional goals were related to improving her content knowledge of these subjects. She was able to have conversations with other eMSS teachers about teaching calculus and statistics that she found helpful. In fact, when Sara was not able to answer student questions about calculus, she was able to pose these questions to a particular mentor teacher.

Often times it just validated my response but it added confidence to my answer and sometimes gave me a different way to look at the problem. It was nice to know I would not spend hours looking for the answer in a book or reading online and not actually get the answer to my question.

Sara was also able to engage her eMSS colleagues in conversations around content. For example:

There was just like a really deep content question and it was really obvious that the answer wasn't what this student was thinking it was, but I couldn't convince her that it wasn't that. So I was just asking other teachers how would you respond to this question?

Another set of goals were related to "enhancing teaching math with technology;" "So a lot of the resources and exchange of ideas of different ways to use technology and little tricks of the trade" were beneficial. Sara had just started integrating SmartBoard technology into her mathematics instruction and has been able to get ideas and talk frequently about its implementation with another mentor in the program. Using the SmartBoard has changed her classroom instruction.

I mean that's what was huge for me because I think the whole reason I have a SmartBoard in my classroom is because of this program . . . the way I teach math now, the interactive activities that I can do now that I didn't do earlier this year even and the skills I have teaching math with interactive activities like for the SmartBoard. I mean I still did group work and things like that and interactive activities you know learning the math, but as far as being able to touch a screen and drag answers here and there and balance equations with a balance scale when you touch a screen, those types of things I didn't do before. So a lot of it came from, started from this program.

In addition to the SmartBoard, Sara has been able to gain other resources to add to her repertoire of teaching strategies such as online resources or different ways to explain concepts to her students.

I'll tell the kids I belong to this mentoring thing and this other teacher said this response to it so this is the way they would have thought about it and I just kind of talk with the kids about it. I find like one or two minute little anecdotes to tell the kids. Hey, this is the way another teacher would think about this . . . I'll add little pieces to fill in areas where students might have had you know a weakness or something. That might have helped to catch a couple kids.

These resources and teaching strategies have contributed to helping diverse learners in Sara's classroom. Supporting students who struggle in math is Sara's "passion for teaching math" and "that's what drives [her] to find activities and to help [her students] enjoy it." Sara's participation in eMSS has also added content related instructional strategies to her growing teaching tool box, such as how to more effectively teach logarithms and factoring, and these can be identified in the eMSS dialogue. The following portfolio entries exhibit this growth.

Post:

I love logs- my favorite log property comes from my alg II teacher:

$\log C + \log A + \log B + \log I + \log N = \log CABIN$ Not a manipulative but they do remember it!!

Who's post? mentor

Discussion area: Inquiry – effective use of manipulatives

Area(s) of growth: Growth in knowledge of how to support diverse learners.

Justification: I chose this post because it was the culmination of a discussion about logarithms. Initially, I posted my plan to use manipulatives to teach logs. I like this cute little property and I am going to share it with my students. It is these little ideas that enhance my classroom that I would not have unless it were for emSS.

Post:

Sara wrote:

This is my second time teaching Pre-Calculus. I am starting a unit on logarithms. Some students have a really difficult time understanding these concepts. I am going to do some research and find some activities that help students develop a better understanding of the rules. IF anyone has any suggestions, then I would love to hear about them! I hope to develop some puzzles and find activities that students enjoy but still learn the necessary skills.

(another mentor) wrote:

Its not really a "fun game or puzzle" but it helps! You probably already teach it this way, but I found that alot of people dont so I will throw it out there.

To introduce the rules of logarithms, I make the students go back and investigate the rules of exponents using patterns. We always state that a logarithm finds the missing exponent and from this we derive the properties and rules. I think we get better results when they "discover" versus us giving it out to them.

The activity I made up uses logs with base 10 and the students play around with the numbers for a while after we do the example below together.

If $10^2 (10^3) = 10 \ 10 \ 10 \ 10 \ 10 = 10^5$ multiplication means add exponents

They have to understand what a log computes first.

Well $\log 10^2 (10^3) = 5$ because The exponent of $\log 100$ is 2 and the exponent of $\log 1000$ is 3 so Mult Prop says add exponents... Hence $\log ab = \log a + \log b$

Hope this helps a little! If I find any activities, I will post!

Who's post? (mine, mentor, mentee, content specialist): my post, followed by another mentor's post

Discussion area: Inquiry: Effective use of manipulatives Math Spring inquiry

Area(s) of growth: 4. Growth in curricular knowledge.

Justification: This is just one example of the many conversations I had regarding logarithms in this inquiry. I selected this post because I felt that it became a part of my overall presentation of logs to my students. I was really quite pleased with the students understanding (and enjoyment) of logs. The conversations in this inquiry really gave me a focus and additional resources and activities to complement my lesson.

Post:

(facilitator),

I totally know what you mean. I will show you what I try but it does not work for all students. Sometimes I need to grab a highlighter and show the students several times before they truly understand. Here is the build up I use to factor by grouping:

At the beginning of the factoring unit, I provide the students with a flow chart. The first thing on the flow chart to do for all problems "Is there a g.c.f.?" I beat this concept to death before we move on to other types of factoring. Then we do 2 terms, 3 terms. When they have mastered those, I introduce 4 terms.

Here is how I present factor by grouping:

Factor $2a + 10$

$$2a + 2(5)$$

$2(a+5)$ - notice that our g.c.f is just a monomial, what if our g.c.f was a binomial

$$xy - 5y - 2x + 10$$

$$y(x - 5) - 2(x - 5)$$

The g.c.f is $(x-5)$. What remains is $(y-2)$

$$(x-5)(y-2)$$

* on a side note - I am teaching this unit in a few weeks. I have not taught this unit using a smart board - however I see a great opportunity here - I can use infinite cloner to pull out the $x-5$ and I can use the highlight tool to really point out the g.c.f. 💡

Who's post? (mine, mentor, mentee, content specialist): mine

Discussion area: emss Math home

Area(s) of growth: 3. Growth in pedagogical content knowledge needed for the teaching of mathematics.

Justification: I picked this posting for two reasons. One, I feel that it shows growth over my 11 years of teaching. I have pulled from all sorts of different resources to develop this method for teaching a lesson on factoring by grouping. The other reason I selected this was because of the realization I made at the end. I realized I now have a new tool, Smartboard, to help teach this topic. I think the highlighter tool will come in really handy. I look forward to adding this to my lesson.

Because Sara started teaching at a new high school, she was responsible for developing the curriculum with her department. Being the department head, she is also responsible for developing the curriculum in her current position. Compared to her 11 years of teaching experience, eMSS has not contributed to Sara's growth in her curricular knowledge or content knowledge of familiar subject areas. However, participation has allowed Sara to reflect on her growth in these areas throughout her career, to confirm her practices, and "contribute to those conversations" and "answer other people's questions or provide other things" to others who are engaged in curriculum development or teaching courses that Sara has much experience in teaching.

Professional Engagement and Leadership. Participation in eMSS has provided Sara with opportunities for professional engagement and leadership. Sara has felt like a professional mentor within eMSS because though hard work she was able to bring an inactive mentee back on board who had a bad experience with a prior mentor. In addition, Sara has been asked to become a facilitator for the 2008/2009 program year. During facilitator training, Sara felt that her mentoring and communication practices have grown. Sara included the following entries in her portfolio, demonstrating the importance of these events to her professional experience.

Post:

[Paraphrased private message for confidentiality]

This private message was from one of Sara's mentee to Sara expressing gratitude for a welcome message Sara had sent. The mentee introduced herself and expressed that she was going to continue checking into eMSS.

Who's post? (mine, mentor, mentee, content specialist): mentee

Discussion area: Our Place

Area(s) of growth: Increased professional engagement and leadership.

Justification: I chose this post because this was a new mentee I was assigned part way through the year. I had been told that the mentee had a bad experience with a mentor and it might be difficult to get her back involved. I was elated when I saw this posting. I thought we had brought her back into the program. I had done quite a bit to get her involved again, including a phone call and several e-mails.

Post :

Hi (Sara) -

I wanted to tell you again how impressed I've been with your work on eMSS all year long. And, it looks like we've almost secured funding for next year - so I'm planning ahead!

I wanted to find out if you might be interested in becoming a facilitator for eMSS next year. (Facilitator), our current HS facilitator is bowing out (actually she's my mom and she did it this year as a favor for me), and I've been thinking that as long as you pass the training in May, you'd be a great replacement.

In May, I will be doing a training and you would learn the details of the job. It is a paid position as well - I think it's around \$1200-1500 a semester. You can choose whether to continue mentoring as well too.

So, what do you think?

Let me know if you have any questions, concerns, etc.

By the way, if you don't hear back from me.....it's because I'm out of the country for the next week! We're taking the family to Puerto Vallarta this week! :)

Who's post? emSS coordinator

Discussion area: Personal message

Area(s) of growth: increased professional engagement and leadership

Justification: I feel that this personal message really made me feel like I was getting a promotion. It made feel proud and look forward to taking on more responsibility with this program. I felt that this program is a great compliment professional and financially to my current job. I also selected this personal message because I feel like this relationship is another one that started during training. I will also read this persons posts, send personal messages on a regular basis, and feel that I may meet he some day.

Post:

1. What worked for you in this Inquiry?

Mentee Self Reflection Sample: Before being a teacher I worked in high tech and have been associated with computers and software for nearly 30 years. So I am comfortable in using technology, I am not afraid of using it and trying various things, and I think I have a pretty good grasp of where the landmines could be. I think when I try to implement things,

that I can set realistic goals; so I think I was well prepared for this endeavor.

My response: We are lucky to have you in the mathematics profession. You bring an application of mathematics to our classroom. It's great that your previous training has given you a comfort level with technology. What software programs are you planning to use with the students? Where are you going to use the technology in your school - my guess is that your school doesn't have the high tech set up that your previous work place did, so that may produce a whole set of landmines that you did not have to deal with in the past. You will be a great resource for the other teachers in this program that might need help with their technology

Who's post? mentee self reflection, my response

Discussion area: New Facilitator Institute (Post #9, grading a self reflection)

Area(s) of growth:

Increased professional engagement and leadership.

Growth in reflective practices

Justification: I feel like the facilitator training is really helping me to step back and reflect on how to be a mentor. In education, we all run into the teachers that convert over to the profession. This is a great program for these types of teachers. It is a comfortable environment in which the new teachers can develop their "new bag of tricks". This is especially important for those who have had a another job for 30 years...they know what means to have a "bag of tricks" and working in a new job without them can be very stressful. I felt that my reflection was one where I sandwiched the coaching around some a positive point on both sides of the coaching.

Post:

Hi (mentee),

So, the school year is starting to wind down. How did the circles, trig, kite project go? What a great idea!

I had my students build kites and they didn't think they were ever going to work. One of my students had a kite flying up above the school (all the string had been let out). Then a tractor trailer truck drove by and the string got caught in the exhaust pipe of the truck. The truck driver got out and cut the string and the kite fell on top of the school.

I never thought about calculating the height of the kite using trig...cool idea!

So, what's the next topic on your list? Have you started looking at final exams?

Who's post? Mine

Discussion area: Personal Message

Area(s) of growth: Increased professional engagement and leadership.

Justification: This is my response to [my mentee's] post. In the facilitator training we have been talking about making sure that we provide a positive environment, not a university course setting. I think this post reflects the relationship we have developed and I was able to give [her] positive feedback on her unit.

eMSS has also contributed to Sara's professional engagement and leadership in her school. She has been mentoring mathematics teachers in house for four years and has been able to bring her eMSS mentoring skills to her face to face mentoring practice.

. . . as far as the leadership that I can provide and the way I kind of was trained to deal with my mentees online, I was able to apply it to some of the people in my building, math teachers in my building I have been working with . . . how to provide leadership in the school, to be a better mentor.

In addition to her mentoring skills, Sara brought what she had learned about SmartBoard to her school. She shares the SmartBoard teaching ideas with the colleagues in her school and "the ideas spread! It's contagious!" In fact, through communication with others in eMSS, Sara was able to prepare and present a presentation about the SmartBoard to her school board and as a result, she believes the school board is "trying to get as many SmartBoards as possible for our school now." This seemed to be a gratifying accomplishment for Sara and she was able to do this because of her experiences in eMSS.

Communicating with Others. Through participation in eMSS, Sara has engaged in a professional and supportive learning community. She has established many personal relationships that she did not have prior to joining this community. There is one particular mentor that she has been frequently in touch with about her calculus questions and another mentor that she has been communicating regularly with about implementing the SmartBoard in her classroom. In addition, she has established a relationship through private messaging with a mentor from New Hampshire; "I felt like I know her, however I have not met her yet . . . I now feel that I have a contact in the New Hampshire Department

of Education if I have any questions or concerns.” Sara’s comments sum up her relationship development in eMSS:

. . . there's certain people that if you saw that they posted something I'd read it and I feel like I knew them . . . it's kind of allowed relationships to develop that wouldn't have been possible because you're miles and miles apart you know. So we're able to have conversations with teachers in buildings at 8:00 at night. You wouldn't be able to learn from different people . . . if it wasn't for this program . . . and it's the people that I first met in summer training, you know those people that you met in the beginning and you see them post . . . and then there are some people from New Hampshire so you feel that special connection too.

Engagement in eMSS has also allowed Sara to become a member of a supportive professional learning community.

For seven years I taught at a new school that was full of excitement, new ideas, and developing cutting edge methods for education. When I transferred schools my colleagues in my department were different. My new colleagues wanted a book, worksheets, and in my opinion the easy route. After four years, I start to wonder what is wrong with me . . . why are my expectations too high? This program helps to connect me with high energy teachers, new ideas, and other passionate math teachers. It gives me an opportunity to have professional conversations regarding mathematics that I missed so much!

These professional conversations have allowed Sara to “talk math,” something that she has been craving because it is currently lacking in her school. Additionally, Sara has been able to rely on the support of her eMSS community to help her through difficult times with issues that she was having at her school and to affirm her practices and keep her focused on her philosophies of teaching mathematics. For Sara eMSS has created a “professional network that is outside of my school, so that’s great!”

Other Benefits. Sara has gained other benefits from participation in eMSS other than enhancing her knowledge, skills, and resources for teaching mathematics and participating in a professional learning community. Already a reflective practitioner,

eMSS has promoted Sara's reflection on her growth as a teacher. Reading the posts of the mentees reminded Sara of where she started from and answering other people's questions about teaching mathematics revealed to Sara her "growth over [her] 11 years of teaching." In addition, she feels that participation in eMSS has allowed her to contribute the knowledge gained from her experience to other participants and to feel like a valued professional.

You know, I would do it for free, but it just kind of makes it feel like you know it helps other people. But it's worth your time . . . you feel respected because you get a stipend for doing what is a good professional development activity anyway.

She raves about the program to other people and is even recruiting people she knows from her professional circle in New Hampshire to join as mentors next year. Sara is proud of the mathematics profession for being innovative and staying ahead of other subjects by having this online learning support system for teachers.

Amanda: A Professional Classroom Teacher

Amanda started her teaching career at the elementary level and is now teaching seventh grade mathematics and pre-algebra in New Hampshire. This is her seventh year of teaching. Amanda is actively engaged professionally and takes on leadership roles in her school and her state.

. . . I'm one of those people in my building that just is always, I never say no. I think I need no therapy. I'm always like that sounds really great. If it's good for kids I'm on board with it.

She enjoys engaging in professional dialogue and for that reason is involved in programs such as the Critical Friends Groups, a co-mentoring professional development experience for teachers. eMSS serves as another way for Amanda be involved with a larger

professional community and says “the opportunity to connect with others [in eMSS] who do the same in their communities has been rewarding.”

This is Amanda’s first year participating in eMSS as a mentor, but has mentored early career teachers in her district for the past three years. In eMSS Amanda was assigned two mentees from New Hampshire and has been finding it difficult to keep her mentees engaged. One mentee was active in the fall and winter, but her participation has waned in the spring. The other mentee has been fairly inactive throughout. Amanda has tried to keep her mentees involved with eMSS through posting in Our Place but found that sending private emails was more effective.

I'll send out emails . . . you know, just little updates or news letter kind of things. But I haven't really heard from them . . . I just kind of send it anyway. Maybe they're reading it and thinking - getting something somewhere just knowing somebody's thinking about them.

She feels that the conversations in Our Place were “uptight, not real.” In other words, they did not feel authentic.

Although her conversations in Our Place have not been particularly engaging, Amanda has found value in the discussions in other areas of the program. She spends about an hour a week on the site and enjoys participating in the Content Forums, particularly the Middle School Math discussion area, and the Dilemmas; “Those are the two areas that I find myself drawn to the most and I think that’s probably because that’s where I find lots of great ideas and things that I’m excited about.” She also has found the Topic of the Month discussion area that focuses on the *NCTM Standards* to be effective at promoting reflection on more “global ideas” in mathematics education. The Inquiries on the other hand have been less effective for Amanda. She participated in three

Inquiries, the first with her mentee, but found it “awkward and a bit confusing” to post in two areas. Without an active mentee for the second Inquiry, she only lurked and did not feel like she was able to take part in the conversations. She tried the third one as a participant, “kind of self-mentoring.” Although it was better than the second, she did not feel that it was as engaging as she had hoped. In each of these areas, she has participated by starting discussion threads, replying to other people’s posts, and by reading. Amanda likens her conversations in eMSS to “a great big professional development opportunity where you can go . . . and take part and learn what all these other people are doing.”

Knowledge, Skills, and Resources for Teaching Mathematics. Participation in eMSS somewhat aligns with Amanda’s goals for her professional development and one of these goals includes finding ways to be a more effective teacher of seventh grade mathematics. Although she does not believe that her content knowledge of mathematics has been enhanced as a result of participating in the program, eMSS has allowed her to access new ideas to add to her repertoire of teaching resources; “I really love to read about tricks of the trade that teachers use in their classrooms. It’s always fun to change things up a bit with something new!” Mixing things up in the classroom is important to Amanda because she believes this enhances student engagement. In fact, when Amanda reads about new ideas on the eMSS site that she would like to incorporate into her instruction, she inserts the idea into her book to think about when she reaches the concept. For example, she has already integrated an idea in which students walk the number line into her strategies for teaching integers, and has made a reminder to use a “magic pot” idea when teaching integer operations next year.

Amanda has learned about various general and mathematics-specific teaching strategies to add to her tool box of strategies through participating in the facilitated discussion forums. These discussions have caused her to think about and incorporate ideas on how to teach fractions and how to handle homework policies, as well as to spur her to take the extra effort to utilize calculator technology in her instruction. The portfolio entries that follow demonstrate examples of Amanda's growth in her knowledge and resources for teaching mathematics. Even though eMSS has provided Amanda with many teaching ideas, she has found that she can only use some of the ideas. She states, "You have to decide. Which of those things do I actually feel like I could integrate with my own teaching style and make it kind of seamless in a way that's not going to be too much work?"

Post :

(Mentor), I really enjoyed teaching fractions with food. Equivalent fractions, operations, as well as percents were retained better with visual and concrete images. For instance, to explain division of fractions I used oranges and we analyzed why 6 whole oranges divided by $\frac{1}{2}$ is asking, "How many halves are in 6 oranges?" (Relate this to whole number division.) After cutting the 6 oranges in half, they counted the number of halves. Then students decided how we derived 12 as the answer. This led to a discussion on multiplying by the reciprocal. When multiplying it was easy for students to see how to take $\frac{1}{2}$ of a $\frac{1}{2}$ using large candy bars. I had so much fun with it, then to finalize our studies, a local pizza place donated some pizzas and students earned a piece of pizza by solving problems.

Who's post? mentor

Discussion area: Questions About My Classroom

Area(s) of growth: Pedagogical Content Knowledge

Justification: This is one area with which I always struggle. I hear teachers from all grade levels say that students just don't understand fractions, decimals, and percents. In fact, the students say we've never taught them! This recommendation by a mentor was one that struck me as something with which students could really identify. The experience of seeing the oranges and candy bars divided, I believe, was a really powerful experience for these students.

Post :

I agree that it can be frustrating that teachers are held more accountable for a student's success than the student himself.

One thing that I have been doing to help with the homework issue this semester is that I only assign homework 2 or 3 nights a week and I don't assign more than 10-15 problems. I (like you) try to give my students time in class to complete the assignment. Most of my students are able to complete the problems within that time period. Some days we even have time to go over the 'homework' before the end of the class. This helps because students are able to ask questions about the assignment and it doesn't get lost or forgotten when they take it home.

Another thing that we have been doing at my school for the students who do not turn in most assignments is that we keep the student in class until he/she completes the assignment for that day. Even if the bell rings and it is time for the student to go the next class, the student will sit in class and complete the assignment before going to the next class. This has worked for some students because they are eager to leave the class and will complete the assignment so they can leave! Also, we have started to assign students to our Time Out Center (similar to in-school suspension) if they have more than 3 missing assignments for a class. The students really do not like being in the Time Out Center and will complete the assignments so they can leave and get back to their regular classes and socializing with their friends.

Who's post? mentee

Discussion area: Questions About My Classroom

Area(s) of growth: General Pedagogical Skills

Justification: The homework issue – for me it's an ongoing dilemma. Every year, even within a year sometimes, I am rethinking my homework policy. As I was reading some of the posts in this discussion, I found myself thinking, "Tried that. That one, too. Oh, I tried that one!" . Anytime I read a post that causes me to pause, I make myself stop and read it again. This was one of those posts. I believe it was the "ISS" option. I'm not sure if I agree with it or not, but I brought it to my team for discussion and we had an interesting conversation about the possibility of its practice in our school.

Post:

As students enter class, have them write a problem number on the board if they have a question. If another student has the same question, have the student place a slash next to the problem. When a problem has two slashes next to it, it means at least 3 students have a question about it. These problems need to be worked out.

While this is happening, students should be talking to each other about the homework assignment. If they discover no one else really has a question about the problem they are confused on, another student can help them. While this discussion is happening, the problems that have two slashes next to them (at least 3 students with questions), should be put on the board by a student who completed it correctly.

The responsibility is placed on the students to help each other and multiple questions are addressed. Students who work out the problems on the board can then be asked to give a brief explanation once the class starts. Much of this discussion can take place before the bell rings or in the first 10 minutes of class while you are taking attendance and dealing with the normal beginning of class issues.

It might be difficult to start a process like this at the end of a term, as it takes a few weeks for students to get into the routine.

Who's post? Content Specialist

Discussion area: Questions about math teaching/learning

Area(s) of growth: Growth in general pedagogical skills

Justification: Everyone loves a tip and this was a great tip for me. Throughout every year, I reflect on my purposes for assigning homework. The way I structure my classroom, the first five minutes are spent doing a warm up activity. This suggestion was an effective solution to balance finding time to incorporate questions about the homework with helping students get into a mathematical frame of mind.

Post:

Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning

Who's post? mentor

Discussion area: Topic of the Month

Area(s) of growth: Pedagogical Content Knowledge – I think!!

Justification: This post is the topic conversation – it was too difficult for me to choose just one person's post, since it was the overall conversation that helped in my growth. Aside from using calculators, I have not used technological resources in my classroom for a variety of reasons – one of which is a difficulty to sign out these resources for an extended period of time. This discussion helped me to see that it's worth the effort and I was encouraged to find ways to incorporate technology more into my classroom. One of the ideas I am exploring right now is using CBRs with graphing calculators to help students think about coordinate graphing.

Amanda admits that she already has “a really good basket of skills that I can go through and pull out and work with all different kinds of kids,” but she is always looking for ideas “that might help me to help that student that I haven't been able to reach.” Although she has been able to incorporate strategies that help all of her students in general, Amanda explains that eMSS has not particularly enhanced her ability to support diverse learners.

. . . although I mentioned that we were talking about how do you reach that that one kid that might just not get it with all the other ways that you have in your back pocket and you might find something that might work with them. That just

hasn't happened so much for me . . . just with the diversity of learners I haven't really noticed much of a change for me personally.

Discussions in the Topic of the Month area have provided Amanda a venue to reflect on broader educational policies, practices, and objectives, namely the *NCTM Standards*.

This forum has provided me with the opportunity to think about mathematics teaching from a perspective that is different from my focus on the 80 students that I have in my own classroom. The placement of the forum [the first discussion area on the home site] reminds me every time I log on to eMSS to think about a certain aspect of mathematics teaching. I am then reminded to reflect on my practice and either confirm what I am already doing or remind myself to focus on improving.

These discussions are particularly valuable because the *Standards* are not something her school district is currently focusing on. She states that these discussions have been “a way for me to stay connected with things that are happening in the math world.” Amanda has been able to see what is happening nationally and through thinking about the *NCTM Standards* in “bits and pieces” she has been able reflect on how to incorporate the *Principles* and the *Standards* into her practice.

Reflective Practices. As previously demonstrated in her comments about the *NCTM Standards* discussions, one avenue for Amanda’s growth is through reflection on her practice. The various discussions in eMSS have allowed Amanda to think about her classroom practice and she says it “provides me the opportunity to affirm my belief or change.” She reflects frequently on what she reads on the site and asks herself:

Did it work really well for me? What would I have done differently if I could re-do it this year? What would I do differently if I choose to do it next year? Will I even choose to incorporate it next year?

Because eMSS is an asynchronous dialogue driven environment, Amanda can revisit what someone said by rereading; “Being able to really ‘hear’ the conversations helps me to be more connected to [the discussion] and causes me to be more reflective of my reactions and connections to [the discussion].” Reflection has not only been an avenue toward growth, but has also been an outcome of her growth through participation in eMSS. In sum, Amada believes the following:

Reflection on practice is the area that has been the greatest area of growth for me. I believe that whenever one has an opportunity to discuss with others in a professional and supportive environment any aspect of their pedagogical approach, reflection happens. So any time I have logged on to eMSS and added to a conversation or just read others I have reflected.

The following portfolio entries demonstrate Amanda’s reflection on her practice as a result of engaging in eMSS.

Post:

Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.

Research has solidly established the importance of conceptual understanding in becoming proficient in a subject. When students understand mathematics, they are able to use their knowledge flexibly. They combine factual knowledge, procedural facility, and conceptual understanding in powerful ways.

Learning the "basics" is important; however, students who memorize facts or procedures without understanding often are not sure when or how to use what they know. In contrast, conceptual understanding enables students to deal with novel problems and settings. They can solve problems that they have not encountered before.

Learning with understanding also helps students become autonomous learners. Students learn more and better when they take control of their own learning. When challenged with appropriately chosen tasks, students can become confident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas, and willing to persevere when tasks are challenging.

Students of all ages bring to mathematics class a considerable knowledge base on which to build. School experiences should not inhibit students' natural inclination to understand by suggesting that mathematics is a body of knowledge that can be mastered only by a few.

Who's post? content specialist

Discussion area: eMSS Home

Area(s) of growth: Growth in reflective practices or Other

Justification: This is the last NCTM Topic posted for the 2007-2008 year. I believe it applies to me in the area of Growth in reflective practice because it is one of those posts that – when I read it – I said, “Yeah – I completely agree with these statements!” This is how I plan my lessons, run my class investigations and help students to realize that they *can* understand math!

Post:

(Facilitator), I was able to open the article and noted that this refers to undergraduate students. I can see this is more applicable to college students who are better able to use symbolic representations. Without concrete examples, many students would never get the idea. One thing I have noticed is that I no longer assume my students make the connections naturally. We have to draw conclusions, state results, and make the connections verbally then have students individually state what they have connected or learned. If I do not follow this procedure then students sometimes don't make the transfer from concrete to abstract.

Who's post? mentor

Discussion area: Questions about Math Teaching/Learning

Area(s) of growth: Growth in reflective practices

Justification: There was an article that prompted the discussion. “Basically, the article says researchers conducted an experiment (randomized and controlled) and found that using real world examples to teach abstract math concepts actually decreases the understanding of the underlying concepts. The example gets in the way of understanding the concepts.” Any article that causes me to question interests me more. The growth occurred in that I was contemplating my own approach to abstract vs. concrete examples. As I was reading this article my thoughts echoed this particular post.

Communicating with and Learning from Others. eMSS has given Amanda a place to discuss teaching and learning with her online colleagues; “I’ve found that the communication and the discussions that I’ve had online have really given me some ideas and inspiration about what other people who are in the same position that I’m in are doing. What they’ve found that’s worked for them.” Communicating with and learning from others has been an avenue for Amanda’s growth in her teaching strategies. Several examples support this pervasive theme:

I get so much out of the discussions personally, and increasingly have found that when a colleague and/or I have questions or discussions that eMSS provides a forum to expand that discussion and learn from people who are in situations similar to ours.

. . . we don't get a chance as teachers to actually talk about what we're doing in the classroom all the time and so this is kind of like that opportunity for me to get a little bit of what other people are doing and how they are doing it in their classroom. And seeing what bits of those things that they do can I kind of pull and mold them to be my own.

I'm always excited to see what other people are doing it and how they are doing it. I'm one of those people that when the professional development opportunities come up and it is something related to me I'm like "Sign me up, sign me up!" I just want to hear what other people are doing. What's working for them? [and] Is there something I might be able to tweak in what I'm doing that might make me better in my classroom?

In addition to learning about or reflecting on teaching ideas offered by other teachers, Amanda has felt that participation in eMSS has allowed her to be part of a professional community of learners. For example, she states that "It makes me feel like I'm more connected to a larger community of people who are trying to achieve goals similar to my own." The online nature of the program has allowed her to not only connect to other professionals outside of her building but has also provided opportunities for more in-depth conversations about teaching and learning to occur. The following quotes support this finding:

The math department at my middle school is not so big and although some of the teachers are quite energetic, I find that the excitement and innovativeness of the group of people who are a part of eMSS motivate me to improve my teaching and knowledge of teaching to a higher level.

. . . we don't always have the time in the classroom to talk about, in the same way or in the same depth that you are able to in an online conversation because with something like eMSS you can just log on, be part of a conversation that's taking place over the course of days, but you can read it when you have time and contribute as well.

Amanda believes that the format of eMSS does not allow for many “side conversations,” thus focusing the dialogue on important professional topics. It is through participating in these conversations that Amanda feels she has grown.

Bill: A Teacher Leader

Bill has been teaching mathematics for 37 years with experience at the high school and community college levels. He is currently teaching AP calculus, pre-calculus, algebra two, and geometry in a rural Montana town and serves as the mathematics department head. Bill also provides leadership in his school and is actively involved in state mathematics organizations. Teaching mostly the accelerated upper level courses at his school, Bill describes his teaching style as follows:

I'm pretty much a machinist when it comes to teaching kids to do mathematics . . . I mean I have a pretty good idea what the algorithms are, what the mechanics are, and at least most of the kids I have now, since I no longer teach the really low levels like I started out teaching, I can get by doing most things symbolically and justify parts of it . . . So I'm really spoiled now with the classes that I teach.

A self-proclaimed “calculator nerd,” Bill has a strong interest in using technology in his instruction and explains that “computers, CAS’s [Computer Algebra Systems], and graphing calculators have changed my outlook on secondary mathematics to an extremely positive degree.” Bill attributes this change to being able to provide his students with more application and non-contrived problems. Finally, Bill has set classroom policies and procedures and is comfortable with his teaching style.

Bill has been participating in eMSS as a mentor for five years since its inception in 2003. In addition, he has been a part of content-based mentoring programs in Montana

that preceded the eMSS grant. He has had several face to face and online mentees over the years and is currently working with one eMSS mentee who also teaches upper level mathematics courses. They work together in Our Place, through private messaging, and on the Inquiries. Overall, Bill averages about three hours per week online and says

I am pretty much addicted to eMSS. I check things 2, 3 times each day, just to be nosy! I am so impressed with the posts by the mentees and the wisdom of the mentors and specialists is pretty overwhelming at times!

Bill says that he is most interested in pedagogical and content oriented discussions. Thus, he spends most of his time in the High School Math content area, although he also participates in the Middle School Math content area when time permits. He actively reads and posts in these areas and is upset that the distance platform does not have an equation editor to help with his posts, which reveals the importance of participating in content oriented discussions for Bill. He also gets satisfaction from being able to provide fast and useable feedback or ideas to his mentee or others about content, pedagogy, or technology and believes “that’s exactly how the program should work.”

Reflective Practices. Bill believes that his participation in eMSS has most significantly affected his ability to reflect on his practice.

I think that's probably the most impact this whole program's had on me because I've never thought about my teaching much. I just went to work, did what I thought was best, and went back home. There's a lot of conversations and posts that I'll browse through and I'll think about you know how does that compare with what I'm doing and a lot of times it'll change what I'm doing. And to be honest with you a lot of times it's not going to change what I'm doing. But I'm at least thinking about it, you know, is there something I should change here . . . I'm paying closer attention perhaps to what I do and maybe why I do it.

In specific, eMSS has instigated Bill to reflect on his grading policies, the state of mathematics education, and the needs of early career teachers.

Evidenced by his numerous references to reflecting on a grading policy discussion in the High School Math content area, Bill found this discussion to be particularly thought provoking. Bill does not grade homework in his classes “because philosophically if I collect homework and grade it then homework becomes my responsibility.” Rather, his students check their homework in the solution manual and are expected to be ready for a quiz every Friday. Reading about other peoples’ grading schemes has made Bill reflect on his, which affirmed his practices.

Well it really made me think about the way I was doing it and stuff and it turns out, though I haven't changed what I do. I mean I'm still convinced I think that what I'm doing, it works best the way I do it.

In fact, when this conversation about grading occurred, Bill had a couple of parents complain to the administration about the fact that he does not give homework credit. As a result of reflecting on his policies, he was able to write up a defense of the way he grades.

I guess that's why it impacted me so much at that time because at that particular moment I was going through the same issues in my own classroom. So I read every single post I saw that somebody put about ok, this is how I grade, this is what I grade, and stuff. And I always compared that to what I was doing and nothing I read convinced me to change what I was doing. Of course I didn't, because I think I've evolved into this is just the way I'm going to teach.

During this conversation, Bill also researched everything he could about grading on the internet and found nothing that “comes right out and says yeah, it’s really good to grade homework.”

In addition to reflecting on his homework policies, Bill has also reflected on the state of mathematics education. In fact, five of eight entries in his portfolio discuss issues

that concern him in mathematics education. For example, he reflected on the problem of mathematics becoming contrived, students' feelings of entitlement, the problem of having to re-teach concepts every year, and the disconnect between secondary and post-secondary expectations for mathematics students. The following portfolio entries are a few examples that reveal his reflection on the state of mathematics education.

Post:

You ask some really great questions here. "Who's responsible for the daily steps in learning?" is a question that continues through life. Are we trying to teach students to be life-long learners or is it just about the grade? I feel that learning is a social process through which learners make meaning out of new information. Through action, dialogue, and reflection, they are able to make connections to current schema to apply meaning to the new information. I want my students to take ownership of their learning. I want them to "want to learn" more than I want them to learn. While this is very challenging at times, using scenarios that assess student yet reduce anxiety have helped. Encouraging student to work together to accomplish tasks like completing homework has really helped. Having students journal about mathematical concepts in addition to completing homework has provided a way for students to express what they know in addition to homework.

Grade inflation exists at the college level as well. There are the proverbial "easy courses" and "easy teachers". Many students try to take these courses because they think they are guaranteed an "A". For those that feel it is their job to teach students to think critically, challenge their approaches to learning, and ask students to strive for excellence rather than mediocrity shock their students after having the easy road. This misguided concept of extra-credit happens at the college level as well. While I use assessments that allow students to redeem themselves, they are not "easy". The intention is for students to master the material and ensure that they take the time to do so. I think extra-credit implies just that. If you haven't completed all of the required work for the course, then how can a student be eligible for extra-credit? I prefer to use essay revisions, mastery reform (as mentioned in a previous discussion), and other project assessments that may involve revisions rather than additional "Hail Mary" type extra credit.

Failure is an essential part of the learning process. The ability to find and learn from your mistakes are keys to success in all parts of life. Students need to learn to take responsibility for inaction, lack of follow through, and poor choices.

Failure is the opportunity to begin again, more intelligently. ~ Henry Ford

Who's post? content specialist

Discussion area: Math Teaching/Learning Area

Area(s) of growth: General pedagogical

Justification: This post expresses my concern in present day education. As an advanced math teacher and adjunct professor at a community college, I find that students feel entitled to a class in which they can be successful with a small amount of investment on their part. Their

learning/grade is the responsibility of the teacher or system.

Post:

I am currently teaching Algebra II and we are 1/4 of the way through the class and I am still teaching linear functions. My students did not learn ONE thing in Algebra I. NOT AN EXAGGERATION! This is generally how my Algebra II classes go every year at my current school!. I cant reinforce past topics from Algebra I because there is nothing there to reinforce. I literally have to teach those topics. How do I get through my curriculum and make sure they are actually learning? Some people say move on but all Algbera teachers know that the present DEPENDS HEAVILY on the past. HELP! We just finished Chapter 2 Linear Functions and after grading their test I am not happy with their progress. I have several methods for spiraling in past topics, my problem is HOW DO WE GET THEM TO LEARN ALGEBRA I and not just get by so I can reinforce those topics and NOT water down the Algebra II part of it all?

I know I am repeating myself, but when I am bothered my thoughts are all over the place...🤔 **Mentee**

In our state (NC) we have a Course of Study that highlights the topics that need to be stressed. I am dealing with the dilemma of having to teach Algebra I (NOT REVIEW, but TEACH), before I can even touch my Algebra II curriculum. It forces me to water down important topics. The level of comprehension of Algebra I in my school dwindles every year. What can we do? Are putting too much on our kids at one time..is quantity more important than quality. The requirements for graduation and college are becoming harder to reach for this generation. Is this a method for stratification? (I KNOW THIS DOES NOT APPLY TO ALL KIDS)! However, it applies to a good number of the kids I have worked with and this is my 8th year teaching. What happened to "No Child Left BEhind?"

I am only venting. I am sure you have concluded that this was not a good week at work! (SMILE)! Anyone got some encouragement for me? **Mentee**

Who's post? Mentees

Discussion area: Questions About my Classroom

Area(s) of growth: Curricular knowledge and accountability

Justification: This post was one of many expressing the problem with the cumulative nature of math knowledge. So often, a restart is necessary at even the highest levels to get students ready for the next content. I don't think this is anything new but may even be getting worse in view of the lack of rigor expected by NCLB and administration.

Post:

I am currently tutoring a college algebra student. He is taking a for-credit course, and not a "remedial" one. Most of us would label his course work as ultra traditional. Lots of problems solved but very little application in context. I even checked the publication date of his text, thinking the book seemed far outdated for a time when so many changes have been made at the k-12 level to graduate more skillful problem solvers. I am struck by this seeming disconnect between k-12 teaching changes and college curricula, and wonder if it might help explain why an

increasing number of freshmen are required to take pre-credit math courses upon entering post-secondary education. Is it time to ask our colleges and universities to take a look at course content so to tap into these student strengths? **(Mentor)**

I have been irritated by the college community (even when I was a member of same) and their 'placement' exams for lots of years. I believe for these these exams to have any credibility, they should be given while the student is actively studying mathematics, not after most of them have been mathematically brain dead for a summer or longer. I might add that one of the main concerns among my college (AP) colleagues is that the inflated grades (usually HW) given to students, more often then not, don't reflect their true mathematical talents. I wonder if the ACT or SAT do either..... **(My post)**

Who's post? Mentor followed by my post

Discussion area: Math Teaching and Learning (Should Colleges Change?)

Area(s) of growth:

Justification: I conclude with these last two posts because of my experience in our state working on a " Seamless Transition to College Matematics." Even with a transcript loaded with Advanced and Accelerated Math courses, many students still do not test well into the college mathematics sequence. I wonder if this is a flaw in our expectations of students or a flaw in the placement process it self.

Another important benefit of eMSS to Bill is that it has promoted his ability to think about the needs of early career teachers. In discussing his professional growth, Bill frequently brought the conversation back to the mentees, which prompted his reflection on what it was like to be a new teacher. The following quotes and portfolio entry are just some of the numerous instances in which Bill discussed the issues that early career teachers face, revealing an awareness of and perhaps a growth in his sensitivity to the needs of these teachers.

I learned a lot from listening to some of the mentees talk about the problems and the issues they have presenting this material maybe for the first time and perhaps don't have the depth of knowledge perhaps they would like to have you know coming out of the colleges.

. . . it's one thing that I think is probably that this whole program has done for me is it's made me think about issues that are so long ago . . . After reading what these people [mentees] are encountering, I tried to think back to then and they're much the same issues and the arithmetic skills at that time were not even better

then than they are now. But that was kind of fun remembering in a way, yeah I've been there once.

You know I think the main thing I've gained I think I can honestly say DeAnna I have a greater respect for new math teachers. I've kind of forgotten what it was like when you start out. It's totally awesome reading how, some of the posts and stuff, the new teachers coming on are so strong. They sound strong and I think it is really cool . . . it just makes me feel good about the math teaching profession because we just need more of them I guess. The ones we have just seem to be so strong and ready to go with this math teaching stuff and I hope they stay.

Post:

[Paraphrased private messages for confidentiality]

These two private messages were from Bill's mentee to Bill. The first thanked Bill for sending geometry tests and giving feedback on teaching about logarithms. She also asked Bill a content question about trigonometry. In the second message, the mentee asked Bill about his thoughts on the importance of memorizing a particular formula in calculus.

Who's post? mentee

Discussion area: Private Message

Area(s) of growth: Content knowledge and classroom procedures

Justification: This post is an example of what I believe to be a major role of eMSS for mentees and early career teachers. It reminds me of the importance of content knowledge and confidence in that knowledge for new teachers and even older ones with the changing math world.

Knowledge, Skills, and Resources for Teaching Mathematics. Bill's repertoire of resources to support instruction has grown as a result of participating in eMSS. This is likely due to the fact that Bill believes eMSS aligns with his goals for professional development to a great extent. When asked about his goals and how eMSS aligns with these goals, Bill said the following:

Well, I'm really into the standards and standards based education and the one thing that I've found on eMSS is there's a lot of talk about the standards. What should I be teaching and why should I be teaching this and that's had quite a bit of impact . . . And I'm always looking for ways to do things different, perhaps better or try to find different cues to teach the kids to do the same thing . . . Cause some kids pick up on one cue and other kids, it makes no sense to another one. And so I'm always looking for that in the conversations about particularly content more

than anything else I think. And that's kind of really why I'm in the program. Just to kind of ease drop so to speak.

In terms of resources, Bill has accumulated many “super websites.”

. . . the websites that are available for math it's just overwhelming sometimes. There's so many places you can go to find things. I think that's probably what I got most out of it is the various websites. I printed out that whole set of posts that one time everybody was writing in their favorite websites.

In particular, Bill's participation in the technology oriented Inquiry with his mentee has contributed to this growth. In this discussion, he has learned about how others use Excel in instruction. As a result, he has decided to try to teach his students how to do some modeling on Excel or on the hand held calculator cell sheets. One of the resources he has already incorporated into his instruction is a math plotter software, which helped him make some graphs for his calculus class. Each of the resources that Bill discussed learning about is related to technology, aligning with his own interests in using technology in instruction. Bill sums up his interest in this particular inquiry as follows: “I just like to check it every day to see if there is something neat to talk about with computers and calculators [chuckling].”

Although Bill stated that he is particularly interested in the content and pedagogical discussions, he did not report growth in either of these areas. Rather, these discussions have provided him with an opportunity to think about how he would teach lower level concepts, if he had to, as well as provided him a chance to be able to share his content knowledge with others as evidenced in portfolio entries that follow. Participation in eMSS has promoted Bill to reflect on his pedagogical strategies for teaching mathematics to his students.

. . . pedagogically I guess I see things going on between the newer teachers but it really hasn't affected my way of thinking. Now it could be next year when I go back through some of the stuff . . . because some of the stuff is really new and fresh, all kinds of things.

In terms of his general pedagogical knowledge, Bill has reflected deeply on his homework policies, as aforementioned, and has determined that he is happy with his policies.

Post:

I do teach and use many trig identities in applications. Some of the trig identities and formulas are needed for Calculus : the quadratic identity, the reciprocal identities, the double angle for the cosine and sine formulas, and not many more. I notice that many current Calculus texts do not present the trig substitutions as an integration method except at the end of a problem set where word problems used to be. When given a trig equation to solve for the other ratios, I teach the associated right triangle or use the unit circle. I tell my advanced students that one only needs the sine ratio for right triangles- the rest are convenience.

Who's post? My post

Discussion area: Math Teaching/Learning

Area(s) of growth: Pedagogy

Justification: I posted this in regards to a discussion about the need for teaching Trigonometric identities. I expressed my way of using the necessary ones and essentially ignoring most of them

Post:

Hi (eMSS Participant) - More quadratic stuff!

When you say you are solving a quadratic, do you mean $ax^2+bx+c=0$ and then use the quadratic formula? If so, you are finding either x-coordinate of the vertex ($b^2-4ac = 0$) or the two x-intercepts ($b^2-4ac \geq 0$). As Lisa pointed out, if $b^2-4ac < 0$, the parabola has no x-intercepts and opens away from the x-axis. The parabola does not have constant slope so calculus (or formulas) are needed to find the slope at different x values. The y intercept is found by setting $x = 0$. If you need to draw a parabola opening L or R, use parametric mode : $X_{it} = t^2$: $Y_{it} = t$ ($-10 < t < 10$) will work. Hope this helps some. Bill

Who's post? My Post

Discussion area: Math – Questions About my Classroom

Area(s) of growth: Content knowledge and best practices

Justification: I found that discussing some of these topics difficult with mentees trying to be careful not to diminish their background and training. I am fortunate that I can remember many of the content and how students may react to it.

Perhaps not surprisingly for a teacher with 37 years of experience who is also active in state wide mathematics activities, Bill reported several areas in which his knowledge was not enhanced as a result of participating in eMSS. Bill does not feel that his curricular knowledge has been enhanced as a result of participating in the program. He has been involved with reading the standards, aligning his school's mathematics curriculum to the state standards, and developing the school's curriculum from the top down to prepare students for higher level courses. Thus, he has already thought a lot about the curriculum outside of eMSS. He also does not feel that his knowledge of how to support diverse learners has been affected. In fact, he says

. . . I still go with the idea that I will help the student as much as I can, but they still have to work this out because there's no way around. There are certain things where you just have to put the bells and whistles away and learn how to do the stuff. I mean that's my attitude towards teaching a lot of these kids you know . . . and these diverse learners . . . I don't know how all they learn because I never really concerned myself with that and I probably should.

Bill also feels that he already has a strong knowledge of the broader educational policies, practices, and procedures beyond his school and district due to his involvement in professional organizations in Montana and has not gained any new insights as a result of eMSS. However, as evidenced in his portfolio entries reported in the reflective practices section, eMSS has instigated his reflection on the state of mathematics education in general.

Professional Engagement and a Community of Mathematics Educators. Bill is actively engaged in professional activities outside his school in the state of Montana. In Bill's words, "I went to my first math conference of any kind in 1985 and I have been

going to them ever since.” In Montana, he has been involved with curriculum, standards, assessment, and professional development activities. eMSS has not necessarily promoted his professional involvement but rather is simply another professional activity where he can communicate with other Montana mathematics educators, which he finds so important.

I just really enjoy visiting with other math teachers in our state. Because just the collegiality we have. Most math teachers can talk to any of the math teachers in this state about anything they want to and I don't have to worry about any kind of judgment or anything else going on. You know if you have some kind of dumb question, there's so many people in Montana that'll answer that dumb question and not even think a second about who was asking it and why and it's just, that's my favorite part I guess since I've been going to meetings like that and why I get involved with this kind of program is to get a chance just to have you know, people give me ideas and then I can pass on ideas and it is so important I think for all teachers to do that.

In fact, he uses eMSS as a venue to discuss mathematics teaching issues with his Montana colleagues. In terms of passing ideas on, Bill, as the mathematics department chair in his school, has been able to share issues that were discussed on eMSS with other teachers at his school. All in all though, eMSS serves for Bill as a way to engage professionally with mathematics educators in Montana and across the country.

Other Benefits. In addition to becoming a more reflective practitioner, understanding the needs of early career teachers, acquiring new resources, and engaging with other educators, Bill has become a better writer from participating in eMSS because he has been forced to put his thoughts succinctly into writing before posting them online. More importantly, eMSS has rejuvenated Bill; “The energy, concerns, and the inquisitiveness of the mentees renews my energy as well.” Bill sums up his experience in

eMSS as follows, “It’s a great ride! I don’t know how else to describe it. I think it is cool.”

Laura: A Late Career Reflective Teacher

Laura has been teaching for 27 years. She started teaching at the elementary level but has been teaching middle school mathematics, primarily seventh grade, for 20 years. This year she is teaching sixth, seventh, and eighth grade mathematics. She has eight classes of sixth and seventh grade students who did not pass their end of grade test last year. Her job is to both remediate and teach the curriculum to these students. In addition, she is teaching one class of eighth graders for the first time in her career. Laura explains that her strength is working with struggling mathematics students. She says that she has a “child centered classroom” and depends “heavily on using concrete teaching methods using manipulatives.” Laura believes that testing is limiting the ability of teachers to refine teaching to their students’ needs, but because she is teaching remedial courses, she has been given “free reign” to tailor her instructional methods to the needs of her students.

In addition to teaching, Laura is a mentor and a coach in her school system and she works with a group of 13 first year middle school mathematics teachers. A first year mentor with eMSS, Laura also mentors two online mentees. One mentee “has fallen off the radar screen” and does not even answer her emails. The other mentee is relatively active in eMSS and posts in various forums on the site. Laura does not feel, however, that they use their Our Place as it was meant to be used. Rather, her active mentee posts in Our Place and simultaneously posts the idea in a larger forum such as the Inquiries.

Therefore, Laura does not get to give this mentee a lot of feedback in the developmental phase of the Inquiries.

Although Laura feels that Our Place has not served its purpose, she has enjoyed spending time online participating in eMSS. In fact, she spends an average of seven hours per week on eMSS. Overall, Laura gets overwhelmed navigating all of the possibilities on the site and says “I have found that it is impossible to take part in all of the areas and have probably gained more from reading through the information than I have been able to contribute.” To manage, she returns to the same areas each time she logs on. Laura typically checks Our Place and responds to her mentees and then checks into the discussions in the Middle School Math content area. She states that “the topics in these forums have triggered the most thought and change in what I do or try.” On occasion, she also visits the Cyber Lounge and the Resources link. Laura has participated in an Inquiry with one of her mentees, but admits that “if I had chosen the Inquiry it would have been a different one than they chose and you know I’m not going to do one on my own just to be a part of it.” Although she has not had much time to participate in the Dilemmas, she has used them as conversation starters with her coaching group in her school system. Laura enjoys the flexibility of participating in eMSS on her own time and the program has provided her with a venue to learn new ideas and communicate with her colleagues from around the country.

I have also found that geography does not change the attitudes, problems, frustrations of teachers. Often my thoughts have been articulated by others from across the country far better than I could say them!

Reflective Practices. Going through the National Boards portfolio process, Laura has had much practice reflecting on her teaching. However, she says that “in the last few years that enforced reflection often has been pushed to the back burner because of the constraints of time.” Participation in eMSS has pushed Laura to reflect more on her practice. Implementing new ideas, thinking about the perspectives of other participants, encouraging her mentees to reflect, and the act of writing her thoughts have each served as instigators of reflection for Laura. The following quotes illustrate her process of reflection as it is related to eMSS:

Anytime I try new “things” in the classroom, it involves extra planning and reflection on the front end, resulting in a better thought out lesson. After 27 years of teaching, I must admit that frontline planning for some lessons just happens without a lot of preparation and refinement. As I have read and reflected on my practices through eMSS I have taken a second look at my practices in the classroom.

Reflection on my practices would probably rank as the area that has had the most impact on me. Sometimes being a teacher is a very isolating profession. The vast majority of my time and energy is spent with my students, leaving little time to interact and work with other teachers in my discipline. Because of my responsibility to eMSS and the dedication of many of the individuals involved in this program, I have been reminded of the many similarities of our practices and our frustrations. Because we are able to read and participate according to our own schedules, it is possible to interact with other professionals on a regular basis. I am able to process and return to discussions when I am ready.

And when I’m putting it down on paper, I have to think more about what I’m saying before I write it down because I don’t like to write . . . but it’s still the process of having to think it through and get it written down that makes the reflection go deeper in a lot of cases.

Reflecting on her practice has been an important avenue of growth in her knowledge and skills needed for teaching mathematics and communicating with other professionals has stimulated Laura’s reflective practices and contributed to her professional growth. Thus,

the theme of reflection is integrated throughout the narrative as I explore Laura's professional growth.

Also integrated throughout Laura's narrative are her portfolio entries. Laura was very prolific in her portfolio selections, selecting up to five posts in an electronic thread for each example of growth. In order to enhance readability of her narrative, I have selected one or two representative posts from each thread to include in each of her portfolio entries along with her justification for selecting the thread.

Knowledge, Skills, and Resources for Teaching Mathematics. Through participating in eMSS, Laura's repertoire of teaching strategies has grown. This is probably because Laura believes that eMSS aligns with her goals for professional development to a great extent. One of her main goals includes finding a variety of ways to best meet the needs of her students in order to help them learn mathematics.

. . . one of my professional goals was always to be mindful of where my children were coming from and what level they were working at and what their backgrounds were and what they needed. And with the number of kids I teach and everybody teaches that's very difficult to try to meet everybody's individual needs. But I found very quickly that if I taught something one year, even if it was something as simple as, not as simple as because this is hard for the kids, as fractions – just take that for example. And I would try something one year. I was constantly looking for ways to change it, to improve it, to make it more meaningful, to get the kids more involved . . . so that's always been one of my goals.

She believes the teachers in eMSS have the same goals as her, which are to find and utilize teaching ideas that best meet the needs of their students. Because she likes to change the way she teaches and believes that the most important trait of quality teachers is that they “remain flexible and open to new ideas and strategies,” Laura is open to

learning from others. eMSS and its participants have provided her with “a steady stream of new ideas to draw on” and she has incorporated many of these ideas into her practice.

Of the ideas Laura has learned from the program, many have contributed to her knowledge of how to best teach different mathematical concepts to her students. She has found that participation in the Middle School Math content area has particularly contributed her knowledge “about how to teach concepts in a way that is understandable to the average middle school student.” For example, Laura has engaged in discussions about teaching integer and equivalent fraction concepts, common student misconceptions in mathematics, pros and cons of calculator use in helping middle school students learn mathematics, and the value of teaching mathematics using abstract versus concrete teaching methods. Laura’s portfolio entries that follow reveal her growth and reflection on these ideas. This being her first year teaching eighth grade mathematics, Laura occasionally has had to teach concepts she has never taught. Being able to get teaching ideas from other eMSS participants has been valuable to Laura; “There have been several instances where the algebraic topics that I had to teach this year [were new concepts for me] and people said I’ve tried this or this website is really helpful or here’s a place where you can go.”

Post:

FRACTIONS: We spend a lot of time helping students find equivalent fractions.....what are your favorite real world connections, games, and activities?

... my thinking would be this: $x+y=6$ means that the fraction $(x+y)/6$ equals 1. Since we get equivalent fractions multiplying numerator and denominator by the same factor, then $2(x+y)/12$ is the same as $(x+y)/6$ and both are equal 1. Hence the equivalency of the equations. I think it's a beautiful example of "connectedness" across the topics in math that we should as teachers strive to demonstrate to our students. mentee

Who's post? Mentee

Discussion area: Middle School: [Questions about Math Teaching/Learning](#)

Area(s) of growth: Pedagogical content knowledge needed for the teaching of math.

Justification: I had followed, with interest, the discussion about teaching equivalent fractions. It constantly amazes me that our “problem areas” in math are consistent in all parts of the country and across the grade levels. Many mentees replied in this discussion. No matter how many years I have taught middle school math, my best and freshest ideas often are generated from individuals just entering the profession. Although I have years of experience and some degree of proficiency in teaching concepts, fresh approaches and new angles to work from benefit my students and keep my classroom an energizing place to be. Recently, there was an article in our local paper about a government study that concluded that students needed to receive more/better teaching of the basic math processes in order to be more successful in higher math courses and to be better prepared for college. Well “duh!” math teachers have known that for years, but the government keeps pushing us to accomplish more, earlier every year!

Post:

Using calculators in the classroom:

How can using instructional technology affect mathematics reasoning and problem solving?
...let's think about how mathematical reasoning is empowered (or endangered) by technology.

Technology opens some doors and closes some windows. If kids worked on number sense and the basics in elementary schools and were coming to middle school with some solid mathematical understandings our lives would possibly be a bit easier. I guess we have to decide a balance for our students between number crunchers and critical thinkers. Technology can assist both.

Who's post? Mentor

Discussion area: Middle School/Questions About Math Teaching & Learning

Area(s) of growth: Growth in reflective practices. Growth in pedagogical content knowledge needed for the teaching of math.

Justification: This perennial discussion will probably never be resolved. Certainly, there is a time and a place for calculators in the math classroom. I believe that more emphasis should be placed on the development of basic math concepts in the early grades and calculators should be introduced and used as students mature and emerge as problem solvers at a higher level of thinking. If a seventh grade student has been unable to master the multiplication tables, that should not hold him/her back when confronted with a problem solving situation. Ideally, confidence with mental computation strategies is a part of the middle school “bag of tricks”. The ability to estimate logical answers is another necessary tool. If we truly believe that no child should be left behind, we must use all available tools, including calculators, to help open the doors to math understanding. I must always be aware of the needs of individual students and the primary objective of a lesson when making the decision of calculator vs. no calculator.

Post:

What are some common misconceptions that your middle school students may have? How did you clarify that misconception?

I think it would be a good idea to ask a probing question about why the size of the product - this may uncover the misconception that multiplication always results in larger numbers. **(Mentor)**

... many middle school students may believe (from simple elementary math), that multiplication always results in more - a higher number. **(Mentor)**

Who's post? Mentors

Discussion area: Middle School: Questions about Math Teaching & Learning

Area(s) of growth: Growth in knowledge of how to support diverse learners

Justification: As I plan and assess the learning of my students, I must analyze the errors that are made and the reasons for them. Often basic misconceptions must be recognized and fixed before moving on the "the next step". Networking with other teachers helps me understand the possible reasons for student errors. When I reflect on the ideas of others, I am better prepared to see parallels in my own classroom and thereby find the best way to modify instruction to accommodate the weaknesses in my students' achievement. (It is also comforting to compare notes with others that are experiencing similar situations.)

Post:

RealLifeApplicationsDistract

This comes from the NY Times. Basically, the article says researchers conducted an experiment (randomized and controlled) and found that using real world examples to teach abstract math concepts actually decreases the understanding of the underlying concepts. The example gets in the way of understanding the concepts.

If we look at this developmentally, concrete most certainly comes before abstract levels. Isn't that why students are taught addition using pictures in preschool/early elementary instead of trying to count in their head. When they leave that, don't they go to using their fingers-the one manipulative that you always have with you :-)) Like one of the professors stated in the article, "One size doesn't fit all". That is where we as educators have to determine what a student's needs based on what they bring to our class. Many students have the aha moment when using concrete examples and some don't need it. Not to mention that concrete examples vary by style and level of difficulty. The problem given in the article has a lot to focus on where a simple pizza problem may not. It takes all kinds of instruction because we have all kinds of learners.

Who's post? Mentor

Discussion area: Questions About Math Teaching/Learning

Area(s) of growth: Growth in pedagogical content knowledge needed for the teaching of mathematics.

Justification: Discussions about pedagogical skills among educators can be very diverse and often heated. Homework vs. no homework; calculator use vs. stick to basic computational skill drill; and now algorithms vs. real life connections. Regardless of the stand you take, the common denominator is the desire to improve student achievement and create life long learners. As in any debate, there are good points on each side of the issue. Articles such as this one, published by the NY Times, open the discussion and keep educators involved in looking at their practices, making teaching concepts and the delivery to students relevant to their needs and learning styles. As

effective educators, we must always be willing to hear diverse points of view, adopting the best and casting aside the rest.

Laura's general pedagogical knowledge has also been affirmed and enhanced as a result of participating in eMSS. From communicating with her mentees and other participants across the site she has picked up ideas on using graphic organizers in the classroom and has reflected on her homework policies as seen in the portfolio entry that follows. Overall though, Laura says that eMSS has "just been a reinforcement of the stuff I've always done anyway" in terms of general pedagogy; "I can't say that I came up with a whole a lot of brand new aha moments, I mean I've taught school for 27 years, everything comes around again." On the other hand, Laura has learned more about using technology in the classroom from reading in the Cyber Lounge discussion area. For example, Laura learned how to use the cell sheet on the TI graphing calculator as a means of handheld record keeping as she walks around her classroom.

. . . I had **NO** idea how useful it could be as I moved around my classroom working with individual students. I am still not proficient, but now I am learning to use this tool. I had thought that APPS were just for the high school level courses. This brought back my grandmother's advice to me many years ago...if you still wake up in the morning, there is still something more you can learn!

Post:

So, what is the purpose of homework in today's educational system??

*...speaking just about my kind of student, a student in an alternative school, yes, homework has lost its place in a *home*, since there is little or no motivation and/or help at home. (**mentee**)

*Speaking about mainstream student, I think the place of homework in a *home*, in my opinion depends really on an attitude to homework within the school culture. In my student days homework was a big deal, with grades going in the gradebook along with classwork and test grades. It really mattered. (?)

*Perhaps calling "homework" what it really is---"independent practice" would clarify the issue? I'm not particular, I just want my students to practice the concepts. If they practice at home, great! If they practice at school, also great! I just feel strongly that without practice, most people will not master

math (or any other subject). (mentee)

Who's post? Mentees

Discussion area:

Area(s) of growth: knowledge of educational policies, practices, and objectives.

Justification: As policies and guidelines are discussed in our professional community each year, the area of homework is always approached from divergent points of view. This was also evident in the above selections from the eMSS discussion. My own feelings concerning homework have remained fairly stable over my career...math is a skill that needs to be practiced...students need a chance to process new material in their own style...but quality of practice is more important than quantity. It is important to recognize the changes in the family structure today as it impacts the amount of help available to my different students. As I followed this discussion, it caused me to reflect on my own beliefs about HW and its impact on my students. I need to pay careful attention to the assignments so they challenge my higher level students, but do not frustrate the less able, especially if they have no support at home.

Although Laura's tool box of teaching strategies has grown, she does not feel that her knowledge of how to support diverse learners has been particularly enhanced. It is not an area that she thinks has been discussed much on eMSS. In the same regard, Laura does not feel that her understanding of state and local policies and practices has been enhanced, again citing the lack of discussion. On the other hand, Laura has gained a broader educational perspective on the national level. In particular, she has learned about the similarity of curriculums across the country.

. . . it's surprising to see how closely aligned the curriculums are from state to state in terms of our pacing during the year. So whatever discussions come up in the middle school area they're almost always the same thing I'm teaching at this time of year. Very parallel.

Teaching in North Carolina, her curriculum is set by pacing guide and as a result she states that "while I haven't added a great deal to my curricular knowledge, the discussions give me a better view of what students have learned in the past and where

they are going in the future.” She believes that in “eMSS there is a more supportive discussion” to facilitate talking and thinking about the curriculum across the grade levels.

Professional Engagement and Leadership. Laura is actively involved in a variety of professional activities beyond her regular classroom duties. In addition to eMSS, she has been mentoring for 14 years and coaching for 10 years, tutors, has written a curriculum for her school’s remediation program, and has contributed to the district pacing guide and the state test question development. In the realm of mentoring and coaching in her school system, Laura’s experiences in eMSS have enhanced the ways in which she works with these mathematics teachers. She explains that that “I have been able to use many of the ideas and topics covered in [eMSS] as launches for discussions with them.” For example, she has started to use the dilemmas as discussion starters in her coaching group.

In the past I have found that these sessions can vary from me doing all the talking because no one wants to look like they are having problems and they don't want to feel vulnerable . . . to everyone wanting to "one up" the others with their gripes, horror stories and experiences at school. I have used the dilemma strategy to lay the groundwork for each of our meetings. A week or so before our meetings I email a scenario to each member of the group. I ask them to think about the situation and come prepared to brainstorm and trouble shoot for the teacher in the situation. We have had some good discussions starting with someone else's problem. I know that some of the areas that these newbies bring up are much more personal than they will admit...but the ideas generated in this safe mode have great value. My participation has really helped me grow as a mentor and a coach.

Laura also believes that her mentoring skills overall have improved because of her participation in eMSS, both with her online mentee and her face to face mentees.

. . . just having some experience has made me more confident in how I approach my mentee . . . the more you do something it kind of cements your idea that yeah,

I can listen to you and I can reflect on what you're saying and I can offer advice in a way that's non-judgmental.

Laura attributes her growth in her mentoring skills to the eMSS summer training that helped her develop her language and questioning techniques she uses with her mentees. Finally, discussions with other eMSS mentors have caused Laura to reflect on the qualities of effective mentors as evidence by the following portfolio entry, which in turn has caused her to think about how to improve the eMSS program.

Post:

What Makes an effective mentor? What professional development is needed?

... I find the most important skill is the willingness to help, which is of course present in anyone interested in the program. The second skill, which can be developed through the summer training, is comfort and ability to work in the online environment. **Mentor**

...effective mentors need to possess good listening skills and a great amount of patience. ...You work to establish a strong relationship built on trust and understanding. You observe and listen to your mentee to determine what they need most from you, their mentor, and then find a way to provide it. **Mentor**

Who's post? Mentors

Discussion area: Professional Development (Mentor Discussion Area)

Area(s) of growth: Increased professional engagement and leadership

Justification: With the growing need to attract and retain the highest quality professionals in education, programs such as eMSS which offer support to novice teachers are desirable. Not everyone is equipped to offer quality support. The discussion among eMSS mentors should be encouraged and broadened. The need for patience, a willingness to help, and being a good listener are the most obvious traits of an effective mentor, but only scratch the surface of the desirable qualities. An understanding of curriculum and knowledge of pedagogy; experience working with diverse learners and experience with reflective practice are also needed.

The second part of this discussion involved the summer institute and professional development. Again, any program that is going to grow and become stronger must have input from the participants as to their needs to make a positive contribution to the program. Again, I think that there needs to be a wider participation from the participants as the program undergoes change. Due to the nature of the interactive program, I think a lot could be gained by having an open discussion in addition to the general evaluation of the program.

Professional Community of Learners. Involvement in the eMSS professional learning community has served an important role in Laura's attitude toward the profession. She has come to realize that "geography does not change the attitudes, problems, frustrations of teachers" and praises eMSS for "giving us a place to share and learn with other professionals who are not willing to just get by in the same ways we have done things in the past!" Laura feels like she has truly come to know many of the eMSS participants personally even though she has not met them face to face; "In the areas that I go to it's almost like I feel like I know some of these people because you know, well, oh, there's [facilitator]. I feel like I know them. I see their names so often." The portfolio entries that follow demonstrate the value Laura finds in participating in a supportive community. Overall, working with other professionals dedicated to teaching has been encouraging for Laura and says that "It is exciting to be associated with such a diverse, energetic and professional group of people!" She sums up her attitudes toward working with other professionals in the following way:

It just gives you a forum for seeing what other professionals are doing. It also has kind of kept me um more energized - maybe that's the word . . . because when I'm in my school I get such a jaded picture because like in any school you've got certain people who are just there you know in the door, go through the motions, out the door, and what else do you want from me. And then there are those people who seem to wind up doing all the all the work because they are willing to try new things and they are not so worried about well it's 2:45, I'm out of here, I'm off the clock. It's not a clock job. And so it's been nice with this program to see how many people all over the country really go beyond what is expected of them for you know their salary and you know that's, that's been a good thing professionally to realize that there really are people out there that care about the profession as a profession and not just a job you do.

Post:

I just passed the state mathematics exam for teachers. I have been waived to teach up until this point. I had my NYS certifications in biology and chemistry years ago, but let them lapse... I decided to take a math position because it was open, and I thought hey how hard can the test be?

Well, hard is the answer. I hadn't done math in 20 years...no less calculus...ugh! I didn't pass the first time I took it, I failed by 1 point...and was DEVASTATED...so after much studying of calculus, because I honestly didn't remember any of it...I took the test and failed again...by a point...oh my....last chance to take it was in March....I took it again and thought I failed for sure...and guess what...I didn't....I am so excited...coming back into teaching after 20 years, and switching subjects wasn't easy...but I am sure happy today!!! Thanks for sharing in my joy!!! [Mentee]....now a fully certified, not waived...math teacher! phew!!!

Who's post? mentee

Discussion area: Cyber Lounge

Area(s) of growth: Increased professional engagement and leadership

Justification: Over the course of the last ten months, a feeling of trust, friendship, and a strong network of professionals has grown in the eMSS community. Excerpts such as the one above are evidence that this forum provides a place for us, as professionals, to celebrate our accomplishments with a caring, supportive community. On good days, and bad, it is a bonus to having folks who truly care about our profession and the members of it.

Post:

From Middle School Questions About Math Teaching/Learning

Questions About My Classroom: Burn Out

While I have been lucky enough to work with several good administrators, the people who have taught me how to deal with "burnout" are my fellow teachers! It seems the better teachers get the "problem" kids because those teachers can "handle" the biggest problems and help the kids make more growth. **Mentor**

Talk to other teachers about ways to "work smarter". Lend an ear to a fellow teacher and when they say thanks, just ask if they'll listen when you are the one with the bad day. Remember we (Kids as well as adults) all need love the most when we deserve it the least. Separate the behavior from the kid.. Remember, every day is a fresh start! **Mentor**

Who's post? Mentors

Discussion area: Middle School Questions About Math Teaching/Learning

Area(s) of growth: Growth in reflective practice

Justification: As a mentor, I always warn my novice teachers about taking care of themselves; preserving family time; getting away from work and having fun; and pursuing personal interests. I am sure this is true of most, if not all mentors.

We know the traps. Law may be a jealous mistress (according to my lawyer husband), but so is education. Teachers assume many roles as professionals, most are not truly in their official job descriptions...we mother, coach, guide, advise, nurse, entertain as well as teach. The needs of our "kids" are many. As caregivers, we give and give while putting our own needs on a back burner. While participation in this program is yet another commitment, it is a supportive network for professionals who understand what is it really like "on the front line". Perhaps this is a way to keep ourselves grounded.

Joy: A Late Career Reflective Teacher

Joy has been teaching for 29 years and started her teaching career in the elementary school. She switched to the junior high level and has “never regretted specializing in math.” She is currently teaching mathematics to eighth graders in North Carolina. The school she teaches in is an Impact School, which means it has received grant money to integrate technology into instruction. As a result, Joy has been trained and is working with a variety of technologies in her classroom this year; “This has been a dream come true . . . We are hoping to see increased understanding among our students over a period of time.”

In addition to her interests in technology, Joy is interested in mentoring early career teachers. Joy is nearing retirement and believes that eMSS is an avenue for fulfilling this professional goal.

. . . I really want to be in a position that I can offer a listening ear as well as things I have discovered about the profession that will enhance the teachers’, not only excellence in the classroom but also longevity. I’m really concerned about this nation and the fact that we don’t have enough math teachers as it is. And where are we going to find math teachers in the future? . . . that’s my main goal is how can I in the next 2 or 3 years prepare and be in a position to, to offer some council and some experience and hopefully wisdom to those teachers who are starting and who have been there for a while and who are really burning out. So this has been perfect because I mean I feel like we have not only touched base with new teachers but we’ve touched base within our professional experience realm also.

Joy believes that online communication is a valuable tool to reach all of these teachers. She believes that “we get a lot more done with that extra online help” and that working with mentees online “would keep me in touch with them and mathematics teaching and how it’s changing.”

This is Joy's first year mentoring online with eMSS and she has two mentees from North Carolina. One of her mentees "faded out of the picture" halfway through the year and the other is still active. Joy also mentors a new eighth grade mathematics teacher in her school. Joy has been able to share teaching strategies and other ideas she has learned or talked about on eMSS with this mentee. For example:

I talk with my inhouse mentee about grading policies, school departmental focus, and NCTM standards sharing ideas discussed on eMSS. Neither of us has been using the Mimio (smartboard adaptor), but I have told her about the enthusiasm I have seen on eMSS concerning its use in math. We are committed to expanding on this next year. This year my inhouse mentee has become an open book of questions and concerns about our low achievement in the school, and again I have shared thoughts from eMSS.

Joy enjoys participating in eMSS and has "appreciated input from dynamic and enthusiastic mentors." Other than trying to engage and encourage her mentees, Joy spends most of her time participating in the Middle School Math content area discussions, the Inquiries, and the NCTM *Standards* discussions. The Dilemmas, on the other hand, "have been ok, but I guess I haven't found as much meat there as the other two areas." She spends about three hours per week on eMSS and sometimes checks in as frequently as nightly. Joy feels that eMSS is an efficient way to communicate about mathematics teaching; "When I sit down with eMSS I say oh wow, now I can really respond to something and get something said."

Reflective Practices. Joy is a reflective teacher and her engagement in eMSS seems to occur predominantly through reflecting on her practice. The following excerpts represent just a few of Joy's frequent references to reflection on her practice:

[eMSS] has provided a specific time to think about this profession and listen online to other's thoughts about a particular topic. I like to go back and reread responses at times and find I often agree with others comments on the topic.

I think the enthusiasm for quality teaching on eMSS has encouraged me to improve my methods and student involvement. With eMSS as a sounding board and in open dialogue with others I reflect on my practices constantly. When I read an idea online I determine if I can use this in my teaching.

And I'm so glad that eMSS brought [the NCTM *Standards*] back to us and made us question and reflect on them and just see where we were lacking. I've done a lot of introspection with those and that's been good.

It seems that Joy's professional growth has not always been a direct result of knowledge or ideas she has learned or picked up through participation in eMSS; the program frequently stimulated reflection on her practices, which also lead to her growth. As I explore Joy's professional growth in various areas, the theme of reflection is integrated throughout.

Knowledge, Skills, and Resources for Teaching Mathematics. Joy believes that the "wealth of eMSS is the immediate ideas coming forth. And when people ask for help . . . there's an immediate response from someone who has a good idea." Although she has been teaching for 29 years, Joy states "I'm constantly looking for new ideas . . . I don't think you ever get all completely finished. I mean you just always need a new idea." Two of the main resources that she has taken from the program are ideas for using manipulatives in mathematics instruction and useful websites. Joy participated in an Inquiry about using manipulatives in mathematics instruction and believes it was "excellent because that is how the students learn and retain and I have just picked up several ideas . . . how to teach effectively with manipulatives has just been a wealth of

knowledge.” As a result of this Inquiry, she plans on using different manipulative ideas when teaching fractions to her students and is looking into attending a training about the manipulative program “Hands on Equations.” Joy has also added many websites to her toolbox of resources.

I think that’s been a wealth . . . I search websites and I see lists of websites, but when someone else has used it and sees it as a valid tool, then we’re more likely to go to it. I am at least.

In addition to acquiring teaching resources, Joy has reflected on her strategies for supporting diverse learners. For example, eMSS conversations have spurred Joy to rethink how she is using inquiry and investigation with her low achieving students.

The methods I use have been successful for most but not for all. I am analyzing how to modify some expectations for the number of unmotivated students I have this year. These students could also be described as low achievers and are so behind in basics. So many topics are difficult for them so I am having to "connect the dots" whereas other years students have been able to generate rules, draw conclusions, and analyze with greater success.

Conversations with her mentee have particularly spurred her thinking on how to support low achieving students in her classroom. In addition, conversations with the eMSS community have instigated her thinking of how school policies can better support struggling students. The following portfolio entries exhibit Joy’s reflection on how to reach these students.

Post:

[Paraphrased private message for confidentiality]

This private message was from one of Joy’s mentees to Joy. The mentee was concerned about getting a new, low achieving student in one of her already full courses. She believed that the student did not belong in that particular class and the principal agreed. She was also upset that the counselors at her school did not notify her of the new student, nor at the time of the message had they notified the student that she was going to be removed from this class.

Who’s post? mentee

Discussion area: Our Place

Area(s) of growth: Classroom diversity in socioeconomic backgrounds

Justification: This post from my mentee brought me to a point, "How do I really help here?" My mentee needed an outing, a flower, something I could not give online; however, I did encourage her that a new day would dawn tomorrow and things would look better. My mentee is an outstanding teacher with compassion for her students, but she has been overloaded with a classroom of extremely low students who are lacking in self-discipline and self-worth. I knew she would not give up because she cares so much. This took me immediately to my students who are passive and I realized she has one classroom full. At least my thirty are spread within three classes. I really reflected on this and became more determined to find ways to reach about 10 of these students who are still performing below my expectations. I began looking at my technology tools and designed three products on the computer art programs in our lab. One was on exponential growth (nonlinear functions in grade 8), another was on scenarios and graphs of linear functions, and a third on indirect measure. The results are phenomenal. Students are still finishing some or parts of these and they are terrific. I am giving test grades for the first project and lab grades for the other two. I saw students who hate math blossom with these productions and they have been FUN!!!!

Post:

I too agree with the comments made...strong teams make for less stress and less burn-out. I am dealing with this issue now as I have had the advanced 7th graders for the past 5 years. It is wrong of me to be bored with the advanced students. I enjoy teaching to them and feel that I have less teaching and more facilitating to do during their class, but I don't get the kick that I do from my low level students, the at-risk, so to speak. The activities that I do with these students are great and they love the class and they complain constantly about having to think, but I don't enjoy that class near as much as the class with below grade level students. I worked in an alternative school for the first 5 years of my career. These were some hard-nosed kids, I tell you. But the reward of seeing these kids succeed was so much more than what I get now when these advanced students are knocking out the 99th percentile on state tests and taking the SAT and ACT.

For the past two years, I have proposed to my administration the idea of rotating the high level students among the teachers in each grade level instead of it being always one teacher who gets them. The response that I get shocks me..."what would the parents think if an OK teacher got their kids and not the best teacher on the hall? It's these parents that make the most noise, it's these parents that are the most involved with the school (boosters, PTO-PTA). It's these parents that we have to make happy". I agree that the "best" teachers often get the "best" or "worst" kids, but what is "best" for the students?

Who's post? Mentor

Discussion area: Questions about my Classroom

Area(s) of growth: Supporting Diverse Learners and Understanding Professional Practices

Justification: This mentor spoke up for the equity needed in teaching assignments and I applaud him. Through an inhouse committee I saw change in our middle school philosophy of giving the lowest achievers to one team or to the same teacher. We did, as a committee, influence our principal to spread students among the teams, recognizing their needs as low achievers may be

different from those who are in the middle and high ranges of achievement. We also influenced change so that our academically gifted students were spread equally among the three teams. This gave every teacher a sense of worth so “burn out” lessened.

One statement I appreciated in the mentor’s statements was that the rewards are great with students who are not academically succeeding. I agree. That has been my experience. The one thing I do add to this entry is that the advanced students need challenging. I have to be very specific in planning and develop high expectations for the advanced classes, such as algebra in grade eight. Because algebra is difficult for many eighth graders I think I give more time and energy into my curriculum planning and analysis than I do with my Math 8 classes which are heterogenous. When I did teach ninth grade competency classes the concepts being taught were easier because it was basic math; however, now that all students are tested in our state, I must expect higher level thinking from all of my students.

This year I am in a situation where I constantly battle with how to help students who lack retention skills. Many new ideas have emerged as I have reflected on this year, but it has been exhausting. I still love helping low achievers and seeing their confidence soar and their successes are so great. Next year I want to modify some methods I have used in the past and try a few new things, such as more visuals posted in the room. Also I want to use more frequent reviews and cumulative testing.

Going beyond reaching the low achieving students, Joy has reflected on the content and pedagogical knowledge and skills needed to effectively teach concepts to all of her eighth graders; “I am constantly analyzing how students best learn a concept and changing my approaches in the classroom.” Conversations in various areas of eMSS have spurred Joy to analyze issues such as the effectiveness of technology in inquiry based mathematics instruction, using “tricks” to help students learn, employing manipulatives to facilitate concept development, and teaching difficult concepts in smaller units. She has particularly appreciated the conversations about the NCTM *Standards* such as the discussion about the Connection Standard.

. . . I've been going back and thinking, now how much have I connected these topics? Right now I'm crunched for time with state testing to get everything finished up and time for review and I'm thinking am I specifically connecting like, we're doing formulas right now, am I connecting those and analyzing exactly where they come from or am I just pushing the formula at them. . . But if I make

the connections, then the chance for retention is greater and so I constantly go back and say am I using this, am I being effective with this?

Although Joy has reflected on finding ways to better teach her students, she admits that conversations in eMSS have not necessarily focused on pedagogical content knowledge in the context of student learning.

. . . the latest on brain research is showing us more about the pedagogy we need to develop because everybody's brain is a little different. But the one thing I do try to analyze constantly is how a student learns it and retains it. And it's not just learning that day, but retaining it in a few weeks or a few months or the next year. That's what I focus on . . . I don't feel like we've covered a lot of that . . . but I do constantly examine that myself, but I am just not sure I've grown in that direction through eMSS.

Her reflection on content and pedagogical knowledge for teaching mathematics is exhibited in the following portfolio entries.

Post:

For instance, my pet peeve (and I'm sorry to whomever I'm offending that uses this) this time a year starts when I'm teaching systems of inequalities. Students try to apply some sort of alligator mouth trick they learned - and now it doesn't work. You can't have $y > 2x + 1$ eating something else like an alligator.

Who's post? content specialist

Discussion area: eMSS Math Home Middle School questions

Area(s) of growth: Growth in Mathematical Content Knowledge

Justification: Wow, this one hit close to home as I often feel the mnemonic devices or little tricks are not teaching understanding. Yet, I, too, use them when all else fails. Now I ask myself how can I improve on this and not accept these tricks and rhymes as learning.

A colleague has been involved in a California based program, "Power Teaching", and is now sharing techniques with other schools in NC. He is quite good at it and he uses hand motions and movement to learn concepts. One student had trouble with positive and negative slopes in the fall, so she developed a hand signal and I would see her using it on a test. She placed her right hand at approximately a 45 degree angle leaning in a positive slope with her left hand in the negative slope at the left side of her head, same approximate angle. She equated her head to zero on the number line with positive numbers to the right and negative numbers on the left of zero. Now she recognizes positive and negative slopes. Clever!!! I began thinking of musical memory devices with hand and body signals to teach mathematical concepts. This will be easier if I involve my students after state testing to help me figure these out. It is also a lot of fun....(tee-hee). Of course I am reading Marcia Tate's materials on using music and hand signals also. Just purchased a second book of hers. She is on target with how students learn.

Post:

My plan is to use Paperplates in helping the students to understand equivalent fractions. I will then use Egg Crates to help the students understand finding common denominators in order to add and subtract fractions.

Who's post? mentee

Discussion area: Spring Inquiry Manipulatives

Area(s) of growth: Pedagogical Content Knowledge

Justification: I was reminded of how desperately my students need mental math skills in fractions. Their understanding has not been developed. I remembered a time when I used manipulatives to teach fractions and their operations. As I look at the last few weeks of school I can not devote several days, but I may do just a couple of days revisiting fractions. My students really need it and when this mentee shared that he uses manipulatives to help adults understand fractions. I think it will be worth the time to try some of these ideas. In the past I have always used manipulatives to teach fractions but often run short of time in the year to cover reviews on fractions.

Post:

[Paraphrased private message for confidentiality]

This private message was from one of Joy's mentees to Joy. The mentee explained that he or she was teaching solving standard form linear equations for y . The mentee expressed frustration with trying to get the students to understand the procedure and explained how he or she motivated the students to progress with their learning.

Who's post? mentee

Discussion area: Our Place

Area(s) of growth: Content and curricular knowledge

Justification: Wow, this is exactly what I am struggling to complete. One area which I examine and re-examine continuously is breaking content into parts. There is no way students learn in large units with many new and difficult concepts taught all at once. Even though I have figured out some of this through experience, I still am redefining how to teach linear conversions in parts. This motivated me to do more color coding in class and I encouraged my student teacher to also look at more color coding. I also returned to basic two step equations and now am convinced that next year I will have students "create" equations to unwrap, or solve, them later in the classroom. My mind stays in high gear constantly with, "How can I do this with the technology I use?" This is on my list of "to do's" this summer, with my moving at a gradual pace. I need the summer to refresh and be with family, but this is one area I want to have ready in the fall, revisit in the winter, and master in the spring.

Most of her reflection on strategies for improving student learning has occurred in the Inquiries and Middle School Math discussion areas as well as the NCTM *Standards* thread. The Dilemmas, on the other hand, have provided Joy with a just couple of ideas

about general pedagogy and classroom management strategies. For example, she picked up an idea for using a timeout chair to deal with classroom disruptions. From the content area she also found a new way to check for questions about homework as seen in portfolio entry that follows. For the most part though, Joy says “I sort of know what works for me . . . I just sort of have that in place and I’m pleased with what I am doing . . . So I haven’t really hit anything that’s strongly impressed me.”

Post: As students enter class, have them write a problem number on the board if they have a question. If another student has the same question, have the student place a slash next to the problem. When a problem has two slashes next to it, it means at least 3 students have a question about it. These problems need to be worked out.

While this is happening, students should be talking to each other about the homework assignment. If they discover no one else really has a question about the problem they are confused on, another student can help them. While this discussion is happening, the problems that have two slashes next to them (at least 3 students with questions), should be put on the board by a student who completed it correctly.

Who’s post? Content Specialist

Discussion area: Questions about Math Teaching/ Learning

Area(s) of growth: Other, Evaluation Techniques

Justification: This is quick and efficient for getting through homework checks and being certain that student questions are answered. My only concern is that some students do not feel comfortable writing on the board or acknowledging they need help. I know that the same students who are outspoken ask for help or state the problems which need reviewing. I’m thinking of trying this in the fall to see if it opens up with most students participating.

Joy also stated that she has grown very little in her curricular knowledge as a result of participating in eMSS. However, one of her goals for her professional development is to further explore how to best organize the curriculum to support learning.

. . . one thing that I think we've missed is in eMSS is that there is a part of our teaching that involves how to organize our curriculum so that it is effective in helping students retain math concepts and knowledge. And I don't know that

we've touched on that much. This is something that I'd like to see improved in eMSS. I'm not sure how to do that but I guess in my experience, teaching the text isn't working anymore. Teaching the curriculum goal by goal isn't working. We've got to find other ways that are more effective and I think eMSS has the potential to do that.

Although Joy does not feel that eMSS has adequately addressed this issue, it seems through seeking out curriculum related posts, Joy has indeed been reflective about curricular issues. Through reflection in eMSS, she has expressed the need to “re-arrange our curriculum, look at our curriculum and say what is really toughest, what is really hard for these students, what is going to take the longest time to absorb, [and provide] more opportunities for the student to see this concept” as opposed to teaching by the book. The portfolio entry that follows reveals an example of dialogue, which has spurred Joy’s reflection on the mathematics curriculum. What Joy has learned directly from her engagement in eMSS is related to the content that is taught at the high school level. This knowledge has allowed her to revisit her curriculum to ensure that she is effectively connecting it to the high school curriculum; “I try to give them a peek’ into the future and help them understand how all of this is connected from year to year to year.”

Post:

I am currently teaching Algebra II and we are 1/4 of the way through the class and I am still teaching linear functions. My students did not learn ONE thing in Algebra 1. NOT AN EXAGGERATION! This is generally how my Algebra II classes go every year at my current school!. I cant reinforce past topics from Algebra I because there is nothing there to reinforce. I literally have to teach those topics.

Who’s post? mentor

Discussion area: eMSS Home Middle School

Area(s) of growth: Pedagogical and Content Knowledge

Justification: This causes me to reflect on what I have grown to understand about our math curriculum. There are topics which are very difficult for students and as we examine those topics we must set up our pacing guides accordingly. I did have an opportunity through a county committee to express concern that the difficult and more abstract concepts are being taught at the end of the year. Two eighth grade teachers agreed they would split parts of the algebra strand

into sections and teach part of this at the beginning of the year. This year the pacing guide changed. They told me they had never thought of breaking it into parts; they just followed the text and taught the tough stuff at the end of the year so students would not forget it prior to testing.

This has been an observation since my sons were in elementary school. The oldest is now 36 years of age. Much of the elementary school math was organized via the text and the first three months of the school year was spent on reviewing and redoing previous topics. August-October is Prime Time for teaching. The fractions and decimals as well as percents were taught in the spring prior to the test....a philosophy I began to see in middle school as well. Teachers were saving the hardest materials to teach until right before the test. What does this accomplish? There is no time for mastery and mastering curriculum goals is a necessity in each grade level. I think this is a major reason remediation is growing each year. Now I will get off my soap box and tell you that this post and another post about the need for remediation in college freshmen increasing has prompted my speaking up. A little change occurred this year and I had to share with my supervisor and lead teacher that I can not follow their pacing guides. Students are not mastering material this way. So far I am allowed to follow my plans because I am experienced and I am confident that what I do works most of the time with most students. I must admit that last year and this year I have worked harder than ever before. These are years 28 and 29 in my teaching career. The students needing remediation have been overwhelming.

Professional Engagement and Leadership. Already active in professional engagement and leadership, Joy's experiences in eMSS have allowed her to bring new ideas back to her school and other committees that she is involved in. The following quote summarizes the ways in which Joy has offered ideas from eMSS to her colleagues:

I am new to the school so I am not in key leadership positions but because I am a veteran some teachers do want to converse and hear my ideas. But the one thing I've done is gone to um, I have spoken up at the school improvement committee . . . And I've shared a couple of ideas that have come out of eMSS. One about organizing the curriculum a little better and another was about organizing and structuring our classes, which I mentioned before, for next year. And those have been heard and acted upon and that's where I'm just sort of a quiet leader on the side right now and I don't really care to be anything else because I've done all the you know committee leadership, team leadership things in my past and right now I'm just new on campus and I just quietly offer ideas. So that has been helpful and like I said I've communicated with my own mentee within the building some ideas from eMSS and my principal also. He's very receptive.

In fact, from reading about what is happening in other eMSS participants' schools, Joy has been able to encourage her principal "to be bold and make changes . . . in our schedules so we will improve our math education" to better support diverse learners. Through her reflection about the curriculum, she also "had to share with [her] supervisor and lead teacher that [she] can not follow their pacing guides." The portfolio entry that follows demonstrates Joy's reflection on student retention of mathematics and how she can become involved in improving the curriculum and helping teachers to enhance student learning. Supporting teachers, in addition to making changes to the curriculum, is also one of Joy's goals for professional development. Through engaging in eMSS, she has been able to start meeting this goal. Working online has been a positive experience for Joy and she is also looking to possibly teach in a virtual school after retirement.

Post:

Fractions to me are just an extension of number sense, something that we often fail to address early on in education. In middle school algebra the need for fractions in a visual sense isn't huge, but the need to understand how the numbers relate to one another. Finding equivalent fractions is essentially number sense - the ability to factor and see immediately what numbers are divisible by others. When we come to trinomials it is so evident that the number sense is missing! I would love to hear any suggestions teachers have about how to solidify the concept of number sense before the students reach middle school.

Whose post? mentor

Discussion area: Math Discussion Area for Middle School

Area(s) of growth: Growth in curricular knowledge; reflection

Justification: I think this mentor has expressed a concern which is universal and a question which needs addressed. How do we "solidify ...number sense" before middle school. As I reflect on 29 years of teaching, I have seen student retention from year to year decrease, as the need for remediation increases. One of our content specialists in emss expressed the need for math remediation on the college level has increased. How can are our students who are successful in secondary mathematics still not be efficient with fractions?

The answer is one which I would like to see NCTM tackle. I am sure it has been addressed many times, but how do we bring it to the individual classes throughout our nation? My concern is that if we do not find a solution nationally, then our math students will become more deficient in number sense in another decade. With the help of NCTM we now have a national curriculum

and most states are on board. I wonder if we need to reexamine how to resolve this issue and place a higher priority on mental math and number sense. Are the students today just not able to handle fractions or are teachers not well trained to teach mathematics in earlier years.

I am excited about helping teachers with our revised state curriculum in the next year. In July I will be in state training to help middle school teachers adapt to the rigor of the new curriculum which will be in place in 2010. I also enjoy mentoring and learning from mentees as well as sharing ideas which have worked for me. Through these opportunities I hope to learn more about how to help elementary teachers also.

Communicating with Others and Other Benefits. Joy has gained other benefits from participation in eMSS. She has developed a personal relationship with a science teacher in her school who is a mentor in the eMSS Science program and they “have been able to communicate goals in sci/math integration.” In addition, Joy enjoys engaging in a professional community of learners and feels encouraged by the enthusiasm she finds from the people online.

Hearing from teachers throughout the nation has been encouraging as I see many educators through emss who have high expectations of both themselves and their students. This enthusiasm and passion for our profession has been successfully communicated through dialogue on emss. I have learned from my mentee as I see how determined she is to develop strong math students. She has a compassion for her students which I also find encouraging. One perception is that there are many dynamic, flexible math educators in this program and I am grateful for the opportunity to learn from [them].

Because of her communication with these professionals or just reading their posts, eMSS has also “been a therapy of sorts” for Joy. In fact, she gets to enjoy participating in eMSS from the comfort of her own home.

It's fun. Let me tell you, I go to the computer some evenings. Under our technology grant we've been granted a laptop this year, we've been given a laptop to use. So I take it home and I have leaned back in my lounge chair, turn on the news and I go to eMSS . . . It's kind of like a release. It's kind of like here, well now I've met the rigors of the day, now I can talk about something you know.

She feels that anyone would grow if they participated in the program; “I don't think you can help but grow on it.”

Cross-Case Analysis

Analysis and synthesis across the six cases not only generated categories of experienced teacher types, but also resulted in several themes. The first set of themes reveals the ways in which the teachers grew professionally from participation in the program. The second set of themes depicts the experiences that lead to this growth. Finally, because eMSS is a dialogue, text-driven learning environment, it was hypothesized that teacher growth could be found in the posts and commentary selected by the case participants. Portfolio entries were analyzed across cases to determine if growth was evidenced in the dialogue. A detailed description of each set of themes follows along with the research questions that the description attempts to answer.

Domains of Experienced Teacher Growth. *In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?* The findings suggest that eMSS mentor teachers do in fact grow professionally as a result of their participation in the program and this growth occurs over a variety of domains. Table 21 lists each of the pre-identified domains of professional growth used to develop the study instruments along with any domains that emerged from the research. It also summarizes which participants reported growth in which domains. Definitions for the pre-identified domains can be found in Chapter Two.

Table 21. Domains of Growth and Participants who Reported Growth in these Domains.

Domain of Growth	Participants who Grew
Knowledge, skills, and resources needed for teaching mathematics	
teaching ideas and resources (<i>emergent</i>)	All participants
general pedagogical knowledge	Vanessa, Bill, Amanda, Laura, Joy
content knowledge	Sara, Laura
pedagogical content knowledge	Vanessa, Sara, Amanda, Laura, Joy
curricular knowledge	Laura, Joy
knowledge of how to support diverse learners	Sara, Joy
knowledge of local, state, and national educational policies, practices, and objectives	Vanessa, Joy, Amanda, Laura, Bill
Reflective practices	Vanessa, Bill, Amanda, Laura, Joy
Professional engagement and leadership	Vanessa, Sara, Bill, Laura, Joy

Teaching Ideas and Resources. As evidenced in the table, one domain emerged that was important for all of the participants. Every case participant expressed value in acquiring more resources and teaching ideas to enhance their classroom instruction. It is clear that this area of growth was important for all of the participants because none of the participants were probed in this area and yet each participant discussed a variety of ideas that they learned and incorporated into their practice from the program. It is important to note that these teachers took different ideas from the program. For example, learning how to implement SmartBoard technology was very important for Sara and Vanessa,

enhancing her use of manipulatives was a key learning for Joy, Amanda has incorporated new teaching “tricks” into her instruction, Laura has learned about using cell sheets in the classroom, and Bill has acquired many new websites. These are just a few of the different ideas and resources that these participants have taken back to their classrooms to aid in their instruction.

General Pedagogical Knowledge. Learning about general pedagogical strategies was important for some of the participants while not as important for others. Vanessa seemed to have particularly benefited from adding ideas to her repertoire of general pedagogical strategies, evidenced by her frequent references to learning about strategies for organizing students’ work and group learning. Participating in discussions about homework policies instigated reflection on their own policies for Bill, Laura, and Amanda. For Bill and Laura it strengthened their philosophies while for Amanda it allowed her to bring fresh ideas back to her school. Finally, Joy and Laura admitted to learning a few ideas about general pedagogy, but this was not a particularly important area of growth for either of them.

Content Knowledge. Although eMSS is a content-based mentoring program designed to help participants think more deeply about mathematics content and pedagogy, very little growth was reported in this area for the participants. Most participants felt confident in their knowledge of content, perhaps because they had taught the same concepts many times before. On the other hand, Sara and Laura both were teaching new subject areas, calculus and statistics for Sara and eight grade mathematics

for Laura, and as a result have grown a little in this area. Because of their new courses, they were seeking assistance in teaching the content and/or answering student questions.

Pedagogical Content Knowledge. Other than Bill, the remaining participants reported growth in their pedagogical content knowledge. Vanessa, Sara, Amanda, Laura and Joy discussed and reflected on various strategies for how to best teach certain concepts to students. In addition, Joy and Laura reflected on student thinking and learning. For example, eMSS conversations have caused Joy to analyze the effectiveness of teaching difficult concepts in smaller units for comprehension and have spurred Laura to think about possible reasons for student errors and how to address common misconceptions in mathematics. That data suggests that the *Professional Classroom Teachers*, Sara, Vanessa, and Amanda, thought about and incorporated teaching strategies that they could immediately use in their classrooms whereas the *Late Career Reflective Teachers*, Laura and Joy, went beyond thinking about strategies for their classroom and reflected on student learning of mathematics in general.

Curricular Knowledge. Laura and Joy were the only teachers that reported growth in their curricular knowledge. Although both are teachers in North Carolina, a state that uses a mandated pacing guide, participation in eMSS allowed these two teachers to learn about the curriculum across grade levels. Joy, concerned about the mathematics curriculum in general, reflected greatly on how to best organize the curriculum to support student learning of mathematics. She expressed the desire that eMSS focus more on developing the curricular knowledge of its participants. Sara and Bill acknowledged that

they have spent a great deal of time thinking about the curriculum in their teaching positions and organizational involvement respectively, and could not attribute their growth to their participation in eMSS.

Knowledge of How to Support Diverse Learners. Most participants did not feel that eMSS had contributed to their knowledge of how to support diverse learners. However, Sara and Joy provided evidence for their growth in this domain. Evidenced by several of her portfolio entries being self labeled as growth in supporting diverse learners, Sara felt that the some of the teaching ideas that she had learned about helped her to reach these students. Joy was the only teacher that explicitly discussed her growth in this area. She was seeking new strategies to support diverse learners because she was in a new school and teaching more low achieving students than she had in the past. In addition, her mentee was struggling with these same types of students and they were able to discuss strategies together.

Knowledge of Local, State, and National Educational Policies, Practices, and Objectives. Several of the case participants grew in their knowledge of the wider educational system, but in different ways. Vanessa felt that she was the type of teacher that tended to focus only on her classroom. eMSS allowed her to see “out of her box” by listening to the experiences of others. Learning that difficult concepts for student learning and curriculum pacing are relatively the same all over the country was eye-opening for Laura and provided her with a wider perspective. The Topic of the Month forum that focused on the *NCTM Standards* provided Vanessa and Amanda a venue for thinking about mathematics education

different from their own day to day experiences. Finally, participation in eMSS provided food for thought for both Joy and Bill, instigating reflection on broader education issues.

Reflective Practices. Several teachers grew in the frequency of their reflection, but most did not grow in their disposition toward or skills in reflection as a direct result of participation in the program. Other than Bill, all of the other teachers perceived themselves as already reflective in nature. Amanda, Vanessa, Laura, and Joy explicitly expressed that eMSS instigated further reflection by giving them a time and a place to reflect and topics to reflect on. As a result, they felt they have likely reflected more than they would have without eMSS. Laura also explained that the act of writing to communicate her thoughts promoted her reflective practices. Sara expressed that she is always reflecting on her practice and did not attribute eMSS to enhancing the frequency of reflection or her reflective abilities. It seems that eMSS simply provided another venue for her reflection. Bill, on the other hand, felt that he did not reflect much on his teaching prior to participating in eMSS. Thus, eMSS stimulated his reflective practices and in fact, Bill felt that this was his largest area of growth.

Professional Engagement and Leadership. Case data revealed enhanced professional engagement for most of the participants. The most common type of professional engagement for the participants was bringing ideas learned in eMSS back to their schools and in some cases instigating change in their buildings. Vanessa, Sara, Bill, Laura, and Joy all shared eMSS experiences with their face to face colleagues and/or in-house mentees. Vanessa also joined another professional activity that she learned about

through eMSS. Finally, Sara and Laura felt that they had grown as professional mentors through improving their mentoring skills. In terms of leadership, both Vanessa and Sara were asked to be facilitators for the 2008/2009 eMSS year and were proud to be chosen as eMSS leaders. Because her goal is to work more actively with early career teachers after retirement, Joy believes that eMSS has given her a venue to increase both her professional engagement and leadership in mathematics education.

Other Benefits. Case participants expressed other professional and personal benefits of participating in the mentoring program. For example, eMSS forced Bill to become a better writer and allowed Sara to reflect on her professional growth in her career. Vanessa felt satisfied every time eMSS allowed her to better her classroom instruction and Sara felt respected because she was able to give back to her profession through mentoring. Joy felt that eMSS acted as a therapy session at the end of a school day. Finally, Vanessa, Joy, Bill, and Laura all felt rejuvenated, citing the enthusiasm of the other participants as invigorating.

Interpreting the Domains. The surveys, portfolios, and interviews were based on the framework for potential teacher growth and development. Although each participant was given definitions for each of these domains in their portfolios and asked to think about their growth in each of these domains on the survey and in the interview, the teachers frequently brought their responses back to their classroom instruction or muddled the lines between the following domains: general pedagogical knowledge, content knowledge, pedagogical content knowledge, curricular knowledge, and

knowledge of how to support diverse learners. For example, a couple of Sara's portfolio entries were self-labeled "growth of how to support diverse learners." These entries show ideas for teaching mathematical content to students but do not discuss how the strategies helped her to reach or think about diverse learners. When Joy was asked about her content knowledge, she discussed challenging concepts for her students to learn and how the curriculum should be reorganized to support student learning. In responding to a prompt about growth in her curricular knowledge, Amanda proceeded to discuss learning about ideas that other teachers have tried that worked. The evidence reveals that for these participants, the domains of knowledge needed for teaching mathematics are not clearly distinct. Perhaps this is because teachers themselves do not think about their knowledge needed for teaching in categories because they must integrate this knowledge when teaching.

Avenues of Experienced Teacher Growth: *What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?* The data reveals similarities and differences in the ways in which the participants engaged in the program and utilized the various discussion areas. Furthermore, two prevalent themes emerged, communicating with others and reflection on practice, as important avenues for the participants' professional growth.

eMSS Participation. Although the case participants engaged in the program differently to meet their professional needs, all of the participants expressed that participation in the Content Forums greatly impacted their growth. This may be attributed

to the fact that the Content Forums provide teachers with the largest variety of discussion topics and an area to post their own questions. Although each case participant had at least one active mentee and each participant checked Our Place each time they logged on to eMSS, only Joy reported that Our Place contributed to her growth. This is likely due to the fact that both Joy and her mentee were struggling to meet the needs of low achieving students in their classrooms. The impact of the Inquiries and Dilemmas on the other hand varied greatly for the participants' growth. Vanessa, Bill, and Joy found value in the Inquiries for promoting their growth in teaching resources and strategies. Amanda and Laura found that participation in the Dilemmas promoted their growth, providing Amanda with teaching ideas and Laura with dilemmas to bring back to her district coaching group. The Topic of the Month forum related to the *NCTM Standards* provided Amanda with a venue for thinking about "more global" issues in mathematics education and instigated Joy's reflection on ways to improve student learning. As Laura explained, the variety of ways to engage in eMSS is overwhelming; clearly teachers pick and choose the areas that are of most value to them.

Communicating with Others. Participating in dialogue and developing relationships with other dedicated professionals was an important avenue for growth for all of the case participants. Being a member of a professional learning community of enthusiastic teachers allowed the participants to discuss issues related to mathematics education and get fresh ideas and think about different approaches. Vanessa, Sara, Amanda, and Laura also expressed that they could not have these kinds of discussions with the colleagues in their schools, thus eMSS was a much needed forum to work with

dedicated professionals with similar goals. In addition, Bill mentioned that eMSS allowed him to work closely with his Montana colleagues that he works with both inside and outside of the mentoring program. Vanessa, Sara, and Joy also developed important one-on-one relationships with other mentors who helped them in particular aspects of their practice.

Reflection on Practice. Another important vehicle for professional growth for many of these mentors was their reflection on their practice. Growth in many of the aforementioned domains could not have occurred with the absence of reflection. The case data for Vanessa, Amanda, Laura, Joy, and Bill revealed the importance of reflection on their growth. Through hearing and reflecting on the ideas of others, these teachers were able to affirm, change, or incorporate new ideas into their repertoire of teaching strategies and think more deeply about their objectives and philosophies. Joy's case highlights the value of reflection in promoting growth; most of her growth occurred not as a direct result of acquiring new ideas and strategies, but rather through reflecting on her practice.

Evidence of Teacher Growth in the Dialogue: *What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?* Because eMSS is a dialogue driven environment, engagement in the program occurs through reading and writing. Thus, it is presumed that evidence of professional growth could be found in the written dialogue. Portfolio posts and justifications supported growth in each of the domains and avenues of growth discussed previously. Interestingly, the case participants chose dialogue for their

portfolios from other eMSS participants' posts more frequently than their own. Their justifications indicated that these posts caused them to gain new ideas, reflect on their practice, or build new relationships. Thus, it seems that much learning takes place "behind the scenes" on eMSS and is never truly reported back.

Summary of Case Studies

These case studies reveal that the mentor mathematics teachers did in fact grow professionally as a result of participating in eMSS. However, the participants engaged in the program differently and followed different avenues toward their growth. In general, the *Professional Classroom Teachers* tended to focus more on their immediate classroom needs while the *Late Career Reflective Teachers* tended to reflect on broader realms of mathematics education in addition to their own practices. The *Teacher Leader* engaged predominantly by contributing his knowledge to others while also reflecting on his practices, the educational system, and the needs of early career teachers. The data indicates that mentor professional growth is individualized. Their patterns of engagement and professional growth complement their teaching styles and their current classroom/school situations as well as reflect their personal goals for professional development. Thus, eMSS has the potential to meet mentor teachers' immediate classroom needs and provide opportunities for reflection on broader professional issues through interacting with a supporting community of learners and professionals.

Summary of Findings

This concurrent mixed-methods research study explored the professional growth of mentor mathematics teachers as a result of participating in eMSS. Data was collected through surveys and six case studies. Results from the various analyses provided answers to the following overarching research question:

How do experienced mathematics teachers perceive their experiences in a content-based online mentor program to have influenced their professional growth?

Quantitative and qualitative analysis of participant surveys provided insight into the experiences of most of the mathematics mentor teachers who participated in eMSS during 2007/2008. Survey results indicate that mentor teachers perceived they had grown professionally as a result of engaging in the program. In particular, growth in reflective practices, professional engagement and leadership development, knowledge of pedagogy and content, and access to new instructional ideas, resources, and strategies were reported as more important areas of growth than the other assessed areas. Overall, participation in the Content Forums contributed more to the mentors' growth than other facilitated discussion areas. Other aspects of the program that were cited as playing an important factor in the growth process were reflecting on practice, learning from other enthusiastic professionals, and meeting personal needs and goals through program flexibility.

While the survey data established that mentor growth was indeed a program phenomenon, the in-depth case studies provided more insight into intricacies of the growth. Findings from the case studies complement the survey findings; case study mentors emphasized their growth in the same domains highlighted by the survey data and

expressed that participation in the Content Forums was particularly meaningful. Although content knowledge was reported as an important area of growth, survey data indicated and case study data confirmed that when teachers were asked about their growth in content knowledge, many described growth in strategies and skills for teaching the content. The case studies also provided more insight into the process of mentor growth. Similar to the survey results, case studies indicate that mentors grew through reflecting on their practice and engaging with a community of professional learners.

In the surveys, program flexibility was mentioned as an important reason why eMSS served as a venue for professional development for the mentor teachers. This is important because the case studies highlighted that mentor growth is individualized. Because mentors are in different phases of their careers, as well as in different classroom and school settings, mentors have different instructional needs and professional goals. Program flexibility and a variety of quality experiences allow mentors to engage in ways that are most valuable to their professional growth.

In conclusion, the findings from this study reveal that purposefully designing a flexible content-based mentoring program has the potential to meet the professional development needs of experienced mathematics teachers.

CHAPTER FIVE

CONCLUSIONS

Introduction

The eMSS program was designed to support and help develop the professional needs of early career teachers of mathematics and science with the goals of greater teacher retention, improved practice, and ultimately enhanced student achievement. The online nature of the program allows beginning teachers to be matched with an experienced teacher by content area and grade level regardless of geographic proximity, thus providing many early career mathematics teachers with a trained content-based mentor when they otherwise may not have had access to one. In addition to communicating in a private discussion area, both mentees and mentors can participate in a variety of public discussion forums, which allow participants to engage professionally with a supportive community of mathematics educators. The structured facilitated discussion forums offer professional learning experiences for all of the eMSS participants and are intended to foster collaboration and reflection in order to enhance professional growth, particularly in content and pedagogical knowledge of mathematics.

eMSS, designed with the needs of early career mathematics teachers in mind, was based upon the research supporting best practices in professional development (Jaffe et al., 2006). Therefore, it seemed possible that the experienced mathematics teachers would benefit from the program as well. Thus, one purpose of this study was to explore the professional growth of the mentor mathematics teachers. Although literature exists

describing the benefits of engaging in effective content-based mentoring and induction programs (Britton et al., 2000; Lopez et al., 2004; Luft et al., 2007; Luft & Patterson, 2002; Luft et al., 2003; Ralph, 2002) and professional development (Banilower et al., 2006; Cohen & Hill, 2000; Garet et al., 2001; Hill & Ball, 2004), very little research exists documenting the benefits of participating in a mentoring program for the mentor teachers. Therefore, this study also attempted to add to this limited research base.

Specifically, this mixed-methods study, utilizing survey and case study data, sought to answer the following research questions:

How do experienced mathematics teachers perceive their experiences in a content-based online mentor program to have influenced their professional growth?

In what ways do experienced mathematics teachers grow professionally as a result of participating in a content-based online mentoring program?

What aspects of the content-based online mentoring program contribute to experienced mathematics teachers' professional growth?

What evidence of professional growth can be identified in the online dialogue and commentary provided for analysis by the mathematics mentor teachers?

Is there a relationship between the activity level of the mathematics mentor teacher and his or her perception of professional growth through participation in a content-based online mentoring program?

Chapter Four presents the findings of this study in detail and relates those findings to these research questions. In summary, the results indicate that experienced mentor teachers of mathematics do indeed grow in a variety of ways as a result of participating in an online, content-based mentoring program. This professional growth occurred despite the fact that the eMSS program was not purposefully designed with the professional development needs of experienced mathematics teachers in mind, other than their need to

learn online mentoring skills. Although mentor professional growth is individualized, most mentors cite reflecting on their practice and engaging with a professional community of mathematics educators as important avenues toward this growth. In fact, these avenues of growth went hand-in-hand for the mentors; the mentors frequently credited their engagement in reflective practices to interacting with many enthusiastic and dedicated mentors, mentees, and program facilitators. Most of their reflection occurred outside of their communications in Our Place and was a result of their participation in the larger mentoring community. In addition, the evidence suggests that the activity level of the participant influences his or her perceived growth, with more active participants perceiving more growth than less active participants. Finally, portfolio data reveals that much growth occurs “behind the scenes” and may not be directly evident in the online dialogue.

The purpose of this chapter is to discuss the implications of the findings for educators and how the findings may be used to purposefully design mentoring programs to assist in the professional development of mentor teachers of mathematics, as well as recommendations for further research.

Implications for Educators

The findings from this study reveal that an effective content-based mentoring program can positively impact the professional development of the mentor mathematics teachers. In order to capitalize on these findings, content-based mentoring programs should be purposefully designed to include experiences that best meet the needs of both

the early career and the experienced teacher of mathematics. In order to do so, several areas of research must be considered. First of all, the components of successful mentoring and professional development identified in the literature should be used to inform the design of such programs. Understanding teacher knowledge needed to teach mathematics and the various potential domains of growth is also important for creating an effective program. Furthermore, if the program is to occur asynchronously in the online environment, features of effective online learning environments should be considered as well. In the following paragraphs, I have combined recommendations from the literature and findings from this study in order to offer recommendations for program designers interested in purposefully crafting mentoring programs to meet the professional growth needs of mentor teachers.

Effective Program Components in Facilitating Mentor Professional Growth

The mentoring and professional development literatures reveal that many of the components of effective mentoring are the same as the components of successful professional development. According to the professional development literature, effective professional development provides opportunities for active learning and collaboration, reflection, and leadership development and is coherent with teachers' daily lives (Cohen & Hill, 2000; Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Loucks-Horsley et al., 2003). Furthermore, it engages participants in sustained, content related learning opportunities supported by trained professionals with knowledge

of the content (Banilower et al., 2006; Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Hill & Ball, 2004; Loucks-Horsley et al., 2003).

eMSS was designed with these components of successful professional development in mind, and this study confirmed that these features are indeed important in facilitating mentor growth. In fact, both the case study data and participant surveys indicated that communicating and collaborating with other mathematics professionals and reflecting on practice were important avenues of growth for the mentor teachers. Communicating with other dedicated professionals is particularly important for those mathematics teachers who either do not have other mathematics teachers in their schools or are unable to engage in collaborative discussions due to the environment of their departments. In addition, many busy educators put reflection on the “back burner” and can benefit from having a specific time and place to reflect. Because of the importance of these experiences in promoting growth, designers of mentoring and professional development in mathematics must provide opportunities for teachers to engage in reflective dialogue with their colleagues as well as for independent reflection.

This study also revealed that program flexibility promotes coherence with teachers’ professional goals and teaching situations, which subsequently impacts teacher participation and growth. Although the vast majority of participants found that eMSS was at least somewhat consistent with their personal goals for professional development, the case studies revealed that these goals varied for the participants. The case study findings suggest that there are different categories of experienced mathematics mentor teachers and three categories emerged in this study. In general, the *Professional Classroom*

Teachers gravitated toward experiences that helped them to improve their immediate classroom situations, the *Teacher Leader* sought out opportunities to contribute his mathematics teaching expertise to others and engaged in dialogue that promoted reflection on his practice and wider issues in mathematics education, and the *Late Career Reflective Teachers* used the program both to meet their classroom needs and to think more deeply about mathematics education beyond their classrooms.

A quality professional development experience is flexible and should differentiate instruction to meet the individualized needs of mathematics teachers. For example, while all teachers are interested in their personal classroom needs, *Professional Classroom Teachers* should be encouraged to become more involved in professional activities and leadership positions beyond the regular expectations of their classroom duties. One way to encourage this is to invite these teachers to be leaders within the professional development program. On the other hand, *Teacher Leaders* are already actively engaged in administrative and professional activities and much of their attention is given to their leadership roles. Professional development experiences should provide opportunities for these teachers to reflect on their mathematics classroom practices. Finally, given that they have already been dedicated to the mathematics profession for many years, *Late Career Reflective Teachers* and *Teacher Leaders* may be nearing retirement and subsequently may be entering the emeritus phase of their profession (Steffy et al., 2000). Opportunities for these teachers to give back to the profession are important if these teachers are to stay involved in mathematics education. Mentoring programs provide an important

opportunity for these experienced teachers of mathematics to stay connected to the profession through mentoring and their efforts should be recognized and encouraged.

With regard to the eMSS program, flexibility is built into the curriculum. In addition to Our Place, there are three main structured discussion forums including Content Forums, Inquiries, and Dilemmas. Participants can choose the discussions they want to join in the Content Forums, as well as in the Inquiries and Dilemmas, that suit their interests. Survey analysis revealed that participants rated the influence of their participation in the Content Forums on their growth in all assessed domains more highly than their participation in Our Place. Perhaps this is because the Content Forums, including Middle School, High School, and Topic of the Month, allow for the largest amount of choice in discussions in which to engage. In addition, these areas encourage participants to start discussions of interest. In all cases, Our Place was rated least beneficial in promoting mentor growth. Perhaps this is because Our Place is dependent on the needs of the mentees, which tend to be immediate needs and problems that mentor teachers have much experience with. Also, many mentors complained of inactive mentees, which limited their engagement in Our Place. There were mixed findings on the value of Inquiries and Dilemmas on mentor growth. It seems that these areas are “hit or miss” depending on the topics. These findings suggest that mentoring program designers should build in learning opportunities that are not solely dependent on engaging with mentees if mentor growth is a goal, and these opportunities should also be diverse and flexible. On the other hand, it has been documented that mentees overwhelmingly post in Our Place as compared to the other discussion areas (Pasley & Madden, 2007). Program

designers cannot assume that the areas of greatest value to early career teachers and experienced teachers will be the same.

Domains of Teacher Professional Growth

Effective professional development not only incorporates the “best practices” identified in the literature, but also aims to enhance teacher knowledge and skills. However, Fennema and Franke first noted in 1992 that there is no agreement about what knowledge a teacher needs in order to effectively teach mathematics, and this is still true today. In order to make sense of teacher knowledge and skills and study the ways in which eMSS mathematics mentors grew professionally, I created a framework for potential teacher growth and development based upon the teacher knowledge literature with a focus on the knowledge needed to teach mathematics. This framework can be found in Chapter Two. The results of the study indicate that teachers grew professionally in all of the areas identified in the framework, including content knowledge of mathematics, pedagogical content knowledge, general pedagogical knowledge, curricular knowledge, knowledge of how to support diverse learners, knowledge of wider educational policies, practices, and objectives, professional engagement and leadership, and reflective practices. A detailed discussion of this growth can be found in Chapter Four. In the following paragraphs, I discuss the implications of the findings for educators and program designers related to the domains of professional growth.

Two domains of potential growth and development can be identified in the eMSS program goals. Program goals include meeting the immediate needs of early career teachers of mathematics while also improving their content and pedagogical knowledge

through reflection and collaboration. Thus, it was expected that the experienced mathematics teachers would grow in these areas as well. Because eMSS mentor teachers no longer have to primarily focus on their immediate needs, professional development experiences that extend and deepen content and pedagogical knowledge of mathematics are particularly important for these experienced teachers (Feiman-Nemser, 2001; Mundry et al., 1999).

With regards to program goals, the study revealed that teachers' immediate needs were met through acquiring resources, ideas, and strategies to enhance their instruction. Pedagogical content knowledge and general pedagogical knowledge were also cited as important domains of growth. Although growth in mathematical content knowledge was reported, evidence indicated that for many participants this was really a perceived growth in strategies and skills needed for teaching the content. Actual growth in knowledge of mathematics content was not evidenced for many because they claimed they already had a solid grasp of the content that they were teaching. Professional development programs that intend to broaden and deepen participant content knowledge of mathematics must realize that teachers may think about their content knowledge only in terms of the content they teach their students. In order to promote growth in this area, program designers may want to create ways to engage participants in activities that are explicitly content oriented. Such learning activities should facilitate deeper understanding of the mathematics their students are learning as well as challenge teachers to learn about content beyond or different from the content they teach their students. For example, teachers could choose from learning modules for graduate credit that would allow them

to learn about interesting and unifying topics in mathematics. Through a facilitated curriculum, teachers could be challenged to make connections among important mathematical topics and to delve deeply into foundational ideas in mathematics.

On the other hand, the mathematics mentors did not feel that they grew much in the domains of supporting diverse learners, curricular knowledge, and knowledge of wider educational policies, practices and procedures. Several case study participants revealed that their growth did not occur in these domains because there was not a lot of discussion about these ideas in the program. However, those that did report growth attributed it to personal need or interest. Thus, they may have participated in Inquiries or Dilemmas that focused on supporting diverse learners, sought out curriculum oriented discussions in the Content Forums, or engaged in the Topic of the Month threads related to the *NCTM Standards* to broaden their knowledge of mathematics education. This evidence also supports the necessity and importance of program flexibility in meeting the individualized needs of participants. Furthermore, if programs want to promote growth in these areas, the curriculum should be purposefully designed to stimulate discussion and reflection on these topics.

Two other important areas of growth identified by the mentor teachers included growth in their reflective practices and growth in their professional engagement and leadership. eMSS, a voluntary experience, seems to attract teachers who are already actively engaged professionals and leaders who tend to reflect on their practice. Therefore, eMSS offers yet another venue for supporting professional engagement, leadership, and reflective practices. Program designers of professional development

experiences should be cognizant of the ability to stimulate growth in these areas and purposefully create opportunities to encourage teachers' natural reflective tendencies and foster professional dialogue and leadership. For example, the findings indicate that the act of writing posts spurred reflection for some participants. Designers of professional development programs can capitalize on this finding by incorporating writing into the professional dialogue.

Engagement and Learning in the Online Environment

The professional development literature reports that active engagement is important if professional development is to be successful. The findings from this study provided some evidence to support this claim. Because eMSS is an online program, engagement was measured utilizing participant activity level in two ways: (1) by number of posts and (2) self-reported time spent on eMSS. The average number of posts for mentors during the 2007/2008 program year was 149 posts and the average self-reported time online was three hours per week. Survey responses indicate that for both measures of activity level, those who participated at the average level or above reported more enhancement in knowledge and skills and changes in practices in most assessed categories than those who participated below the average group level. However, many of the differences between groups on measures of enhancement in knowledge and skills and changes in practice were not statistically significant. In addition, the number of posts and self-reported time online were only weakly positively correlated. Perhaps this is because engagement is a complex variable that cannot simply be defined by posting behavior or time spent working on the program. Some participants may be active posters, but do not

create quality posts while others may post less frequently, but their messages may be thoughtful and engaging. Likewise, time spent on eMSS may be related to other variables such as comfort with working in the online environment. Some participants may spend a great deal of time simply learning to navigate the platform. Program designers of online mentoring and professional development should carefully consider appropriate measures and expectations of engagement and should monitor participant activity to learn more about typical and productive engagement in their program.

Regardless of how engagement is defined, interactions and subsequent professional growth in eMSS must occur through reading, writing, and reflection due to the online nature of the program. Therefore, this study sought to determine if teacher growth could be identified in the written dialogue through analysis of participant portfolios. Although participants gave reasons for why certain posts promoted their growth, the posts in and of themselves did not reveal participant growth. In fact, on most occasions, participants did not even choose their own posts to include in the portfolio. The portfolio data suggest that eMSS mentor mathematics teachers may learn primarily through reflecting on other people's posts. It is important for program designers and facilitators to realize the power of reading and reflecting and not to assume that learning is only occurring if participants are actively posting.

eMSS is a unique mentoring and professional development program because it is delivered completely online. Like face to face learning environments, the best practices in online learning environments are often connected to constructivist based learning theories (Bender, 2003; Garrison, 2003; Garrison et al., 2000; Granger & Bowman, 2003;

Hannafin et al., 2003). In particular, the literature indicates that designers of online learning environments should be aware of learners' individual needs and personal goals, build instruction upon students' prior knowledge, and promote flexible, self-directed learning. Furthermore, social construction of knowledge and community building can be facilitated through climate setting. Findings from this study are consistent with the "best practices" identified in the online learning literature and suggest that the eMSS program design promotes both individual and social knowledge construction. As previously mentioned, program flexibility was frequently cited by participants as an important aspect of the eMSS program which promotes individual knowledge construction. Facilitation practices that encourage collaboration among participants and communicating with other professionals were cited as another important avenue toward participant growth. In light of these findings, it is recommended that online mentoring and professional development programs implement and facilitate a curriculum that not only considers the diverse individual professional needs of the participants, but also welcomes collaboration and community building.

Recommendations for Further Research

Moving Beyond Self-Reported Data

Several unanswered questions and recommendations for further research resulted from this study. First of all, this study was limited to self-reported data. It is possible that there are impacts that cannot be captured through the participants' perspectives because the participants are not themselves aware of them. In fact, this phenomenon became

apparent in the case studies. For example, one participant did not report growth in professional engagement, but case evidence revealed that she had indeed become more engaged professionally in her school as a result of participating in eMSS. Further research using observation data could build from the findings of this exploratory study using more objective measures of growth in knowledge and skills and changes in practice.

Measuring Teacher Practice and Student Achievement

Effective mentoring and professional development programs in mathematics aim to enhance teacher knowledge, improve practice, and subsequently impact student achievement. Measures of growth in knowledge (e.g., through rigorously designed instruments), observations of changes in practice (e.g., through a detailed observation protocol), and measures of changes in student achievement (e.g., through utilizing standardized test scores) went beyond the scope of this study. However, establishing the effectiveness of eMSS through measures like these would add to understanding the impacts of participating in a mentoring program to both the teacher and his or her students.

Understanding Teacher Knowledge

Eight categories of potential teacher growth and development in mathematics were used to frame this study. An interesting finding is that teachers tended to overlap the categories of content knowledge, pedagogical content knowledge, general pedagogical knowledge, curricular knowledge, and knowledge of how to support diverse learners.

Understandably, teachers must draw on and integrate several categories of knowledge when teaching. Teacher knowledge is messy and difficult to break down into categories for study. However, researchers are careful to try to distinguish between and clearly define the components of each category. This finding begs the question: Is it important for teachers to distinguish between these types of knowledge? If so, how can professional development give teachers the tools to think about the categories separately? Perhaps professional development in mathematics could ask participants to view videos of lessons and discuss the mathematical content knowledge, pedagogical knowledge, including knowledge of student thinking, and curricular knowledge needed to teach or improve upon a particular lesson. Activities like this would provide teachers the opportunity to critically tease apart the components of knowledge needed to teach mathematics.

Understanding the Effects of Enhanced Teacher Knowledge

This study determined that mentor mathematics teachers did grow across a variety of knowledge domains; however, it did not study the effects of this growth on teacher practice and student learning. In the field of mathematics education, limited research does exist connecting teacher knowledge in mathematics with effective instruction and student achievement (Hill, Rowan et al., 2004; MSP, 2007). Hill, Rowan, and Ball (2004), have done groundbreaking work in this regard, working primarily with elementary school teachers. Through their research, they were able to claim that teachers' content knowledge of mathematics is a significant predictor of student achievement gains. Furthermore, the Math and Science Partnership (MSP, 2007) conducted a comprehensive review of the empirical research literature related to teacher knowledge in mathematics.

Consistent findings indicate that teachers' mathematical content knowledge impacts the instructional resources they use, how they engage students, and student learning. Further research exploring the connections between teacher knowledge, teacher practice, and student learning can contribute to this important research base.

Understanding the Reflection and Changes in Teaching Practices

Although participants reported growth and changes in their reflective practices, they indicated relatively low amounts of changes in all of the teaching practices assessed on the survey. The question remains: How can professional development designers provide experiences that facilitate transitions from reflection on teaching practices to enhancement in teaching practices? In eMSS, there are several occasions when reflection is formally built into the curriculum, such as at the conclusion of an Inquiry. One idea to bridge the gap between reflection and changes in practice is to ask the mathematics teachers to include short action plans at the end of their formal reflections. In addition, findings suggested that participants who were active readers reported making more changes in their teaching practices than those who were active posters. These findings were not conclusive and should be explored in more detail. Further research could shed light on the relationships between mentor activity level and changes in teaching practices.

Developing Teacher Categories

In this study, three categories of teacher types emerged from the case studies and recommendations for professional development experiences were made based on these categories. Analysis of the experiences of a greater number of mentors may result in

several more types of experienced teachers. This knowledge would be particularly useful in designing mentoring programs with the needs of experienced mathematics teachers in mind. With this knowledge, the structured curriculum could purposefully incorporate learning experiences to meet the needs of a wide range of experienced teacher types. In addition, the three categories that emerged in this study seem to have been influenced by the teacher's level of experience. Thus, looking at mathematics mentors along a teaching experience continuum may also be useful in designing effective professional development for mathematics teachers in various stages of their careers.

Establishing Measures of Engagement

In addition to exploring the professional growth of mentor teachers, this study also investigated the relationship between mentor activity level and mentors' perception of growth in knowledge and skills and changes in practice. Mentors' activity levels were measured by the number of post and by time spend on eMSS, and these two measures were explored separately. However, I am not convinced that these measures adequately capture participant engagement. It seems that participants engage in different ways and "active engagement" may have many definitions. I am left wondering what justifies "active engagement" in an online, collaborative learning environment. Other research studies utilizing different measures of engagement may shed additional light on this question. For example, researchers could ask participants to log the amount of time spent actively reading, posting, or thinking about program activities, separate from spending time navigating the program platform, and use this as a measure of engagement.

Understanding Learning in Text-based Environments

This study also attempted to determine if mentor growth could be identified in the online dialogue via analysis of participant portfolios. Evidence indicates that much learning takes place out of view of program designers and facilitators. Professional development experiences offered through online environments are relatively new, and further research is needed to determine how teachers engage and learn in these environments.

Summary

This study sheds light on how mentor mathematics teachers grow professionally from participating in a content-based mentoring and induction program. It is clear that active engagement, measured by posting or time spent online, in such a program designed with professional development opportunities accessible to the mentor mathematics teachers does promote professional growth. However, this growth seems to be individualized based on the participants' personal needs. Additionally, the aspects of the program that contribute to professional growth are different for different teachers. Thus, professional development experiences should be flexible to better meet the varied needs of mathematics teachers. Due to the large investment of money and time needed to develop mentoring programs for early career mathematics teachers, it would be wise to purposefully design professional development experiences for the mentor teachers as well. Mentoring and induction programs that promote the professional learning of both the early career and experienced mathematics teacher have the potential to improve teacher practice and subsequently student learning across the phases of a teacher's career.

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APPENDICES

APPENDIX A

EMSS TEACHER GROWTH SURVEY: MATHEMATICS

eMSS Teacher Growth Survey: Mathematics

1. Section I: Background Information

The purpose of this survey is to determine how eMSS has contributed to mentor teachers' professional growth and development.

I want to thank you in advance for taking the time to complete this survey.

- * 1. Please type your name below. Your personal information will not be disclosed in any reports affiliated with this research project and this survey will not be used to evaluate your participation eMSS.**

- * 2. Including this year, how many years have you been participating in the eMSS program as a mentor?**

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

- * 3. Including this year, how many years have you been teaching?**

☐ 0-4 ☐ 5-9 ☐ 10-14 ☐ 15+

- * 4. Including this year, how many years have you been teaching math?**

☐ 0-4 ☐ 5-9 ☐ 10-14 ☐ 15+

- * 5. Are you currently a classroom teacher?**

☐ Yes

☐ No

- 6. If you answered "no" to question 5, why are you out of the classroom this year?**

- * 7. How much time do you spend on average each week working on eMSS?**

Time hours

- * 8. To what extent does eMSS:**

	Not at All	Very Little	Somewhat	Great Extent
Align with your own goals for your professional development	☐	☐	☐	☐
Support your state or district standards/curriculum frameworks	☐	☐	☐	☐
Support your state or district assessments	☐	☐	☐	☐

eMSS Teacher Growth Survey: Mathematics

2. Section II: Enhancement and Change in Practice, Skills, and Knowledge

*** 1. To what extent do you feel that your knowledge and skills have been enhanced in each of the following areas as a result of your participation in eMSS?**

	Not at All	Very Little	Somewhat	Great Extent
Curriculum (e.g. lessons, units, texts)	☐	☐	☐	☐
Instructional methods	☐	☐	☐	☐
Approaches to assessment	☐	☐	☐	☐
Use of technology in instruction (e.g. computers, graphing calculators)	☐	☐	☐	☐
Strategies for teaching diverse student populations (e.g. students with disabilities, from underrepresented populations, economically disadvantaged, range of abilities)	☐	☐	☐	☐
Deepening knowledge of mathematics content	☐	☐	☐	☐
Leadership development	☐	☐	☐	☐
Reflective practices	☐	☐	☐	☐
Adapting teaching to meet state assessment requirements	☐	☐	☐	☐
Adapting teaching to meet state standards or curriculum framework requirements	☐	☐	☐	☐
Understanding educational policies and practices	☐	☐	☐	☐
Other (please specify)				

*** 2. To what extent have you made changes in each of the following teaching practices as a result of participation in eMSS:**

	No Change	Minor Change	Moderate Change	Significant Change	Not Currently Teaching
The mathematics curriculum content	☐	☐	☐	☐	☐
The cognitive challenge of math classroom activities	☐	☐	☐	☐	☐
The instructional methods I employ	☐	☐	☐	☐	☐
The types or mix of assessments I use to evaluate students	☐	☐	☐	☐	☐
The ways I use technology in instruction	☐	☐	☐	☐	☐
The access I have to instructional resources	☐	☐	☐	☐	☐
The approaches I take to student diversity	☐	☐	☐	☐	☐
My involvement in professional activities	☐	☐	☐	☐	☐
Reflection on my practice	☐	☐	☐	☐	☐
Other (please specify)					

*** 3. Have student learning and engagement improved as a result of changes you introduced in your classes based on participation in eMSS?**

☐ Yes

☐ No

4. If you answered "yes" to question 3, please explain why you believe student learning and/or engagement has improved as a result of these changes.

eMSS Teacher Growth Survey: Mathematics

3. Section III: Effect of eMSS Discussion Areas on Teacher Growth

*** 1. To what extent do you feel that your mathematics content knowledge has been enhanced as a result of participation in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

2. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your mathematics content knowledge? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 3. To what extent do you feel that your general pedagogical knowledge such as classroom management and procedures has been enhanced as a result of participating in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

4. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your general pedagogical knowledge? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 5. Pedagogical content knowledge is defined as content knowledge for teaching that embodies understanding how to effectively represent and teach the subject knowledge to students, as well as understanding what makes the learning of topics challenging or easy for students (Shulman, 1986).**

To what extent do you feel that your pedagogical content knowledge needed for teaching mathematics has been enhanced as a result of participating in the following discussion areas?

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

eMSS Teacher Growth Survey: Mathematics

6. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your pedagogical content knowledge for teaching mathematics? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 7. Curricular knowledge is defined as the knowledge of how to use resources and arrange topics over time to organize the study of a discipline (Shulman, 1986).**

To what extent do you feel that your curricular knowledge of mathematics has been enhanced as a result of participating in the following discussion areas?

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

8. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your curricular knowledge of mathematics? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 9. To what extent do you feel that your knowledge of how to support diverse learners has been enhanced as a result of participating in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

10. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your knowledge of how to support diverse learners? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

eMSS Teacher Growth Survey: Mathematics

*** 11. To what extent do you feel that your knowledge of local, state, and national educational policies, practices, and objectives has been enhanced as a result of participating in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

12. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your knowledge of local, state, and national policies, practices, and objectives? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 13. To what extent do you feel that your reflection on your practice has been enhanced as a result of participating in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

14. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your reflection on your practice? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 15. To what extent do you feel that your involvement in professional activities or leadership positions beyond the regular expectations of classroom teaching has been enhanced as a result of participating in the following discussion areas?**

	Not at All	Very Little	Somewhat	Great Extent
Our Place	☐	☐	☐	☐
Content Forums	☐	☐	☐	☐
Inquiries	☐	☐	☐	☐
Dilemmas	☐	☐	☐	☐

eMSS Teacher Growth Survey: Mathematics

16. Which discussion area or other aspect of eMSS do you feel has contributed most to enhancing your professional involvement or leadership positions beyond the regular expectations of classroom teaching? Please specify in what ways this discussion area or aspect of eMSS has contributed to your growth.

*** 17. Consider the areas of potential growth and development identified in questions 1-16, including:**

- a) mathematics content knowledge**
- b) general pedagogical knowledge and skills**
- c) pedagogical content knowledge**
- d) curricular knowledge**
- e) knowledge of how to support diverse learners**
- f) knowledge of local, state, and national educational policies, practices, and objectives**
- g) reflection on your practice**
- h) involvement in professional activities or leadership positions beyond the regular expectations of classroom teaching**

Do you feel that your involvement in eMSS has contributed to your growth in one of these areas the most? Please specify in what ways your participation in eMSS has contributed to your growth.

APPENDIX B

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

Informed Consent for Participation in Research

Project Title: *Professional Growth through Mentoring: A Study of Experienced Mathematics Teachers Participating in an Online Mentoring and Induction Program*

Researcher: DeAnna McAleer, Montana State University
Phone Number: (406) 697-2655

You are being asked to participate in a study exploring the professional growth of mathematics mentor teachers as a result of participating in e-Mentoring for Student Success (eMSS). In order to document teacher growth, data will be collected through surveys, interviews, and portfolios.

If you agree to participate, you will be asked to collect samples of eMSS dialogue that have contributed to your professional growth, participate in a series of online or audio-taped interviews, and complete an online survey. The purpose and specific nature of your involvement will be explained in detail for each of these data collection processes. For your efforts, you will receive a stipend of \$300.

This consent form serves to cover all of the data collected in this study, which will take place in the winter and spring of 2008. Your participation is voluntary and at any time you may refuse to participate. In all study efforts, your confidentiality will be maintained. No names or specific identifiers will be reported in this study. Results will be shared with my dissertation committee members at Montana State University and possibly with others via reports, presentations, and publications. The risks for participating in this study are minimal. I foresee no physical risks associated with your participation. All information you share will remain confidential, minimizing any social risks associated with your participation.

Please feel free to phone me if you have any questions or concerns about this research study, and please retain a copy of this letter for your records. Thank you for assisting me with my research.

Sincerely,
DeAnna McAleer
CLTW Fellow, Montana State University

Participation is voluntary. You may decide to refuse participation or withdraw from the study at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Office of Sponsored Programs, Montana State University, P.O. Box 172470, 309 Montana Hall, Bozeman, MT 59717; (406) 994-2381.

Participant's Signature

Date

Researcher's Signature

Date

APPENDIX C

EMSS TEACHER GROWTH FOCUS GROUP QUESTIONS

eMSS Teacher Growth Focus Group

Week 1: Introductions

I am conducting a study exploring the professional growth of mentor mathematics teachers as a result of participating in eMSS. The purpose of this focus group is to learn more about your experiences in eMSS and how they may have contributed to your professional growth. I think it would be useful if the members of this focus group spent this first week getting to know one another. To do so, please answer the following prompts.

- 1) Let's take some time to get to know one another as math teachers. Tell us a little bit about your experience as a math teacher.
- 2) Let's take some time to get to know one another as eMSS mentors. To do this, please describe your mentoring experiences in a typical week.

Week 2-3 (I will extend this if the conversation is still occurring after week 3): Professional Growth

Now that we have gotten to know each other, I would like to start a discussion about your professional growth as a result of participating in eMSS. Please answer each of the following discussion prompts and respond to other participants' posts. Your insight is appreciated and valuable.

- 1) How do you think your knowledge used to teach mathematics have changed as a result of participating in eMSS?
- 2) How do you think your teaching practices have changed as a result of your participation in eMSS?
- 3) eMSS is a dialogue driven learning environment. How has reading, writing, and interacting through dialogue contributed to your professional growth?
- 4) What aspects of the eMSS program have contributed to your professional growth?
- 5) Have your perceptions of mathematics teaching changed as a result of participating in eMSS? If so, how?

APPENDIX D

EMSS TEACHER GROWTH PORTFOLIO

eMSS Teacher Growth Portfolio

The eMSS mentoring and professional development curriculum aims to extend teachers' understanding of mathematics content and improve teachers' discipline-specific pedagogy through online collaborative activities. It is our hope that both the beginning and experienced teachers benefit from participation in eMSS.

One component of evidence for this study is the teacher growth portfolio. This portfolio is a document created by you, the experienced mathematics teacher and mentor, which will reveal and describe your professional growth as a result of participating in eMSS. Your portfolio will contribute to our understanding of the benefits of participating in a mentoring program for experienced mentor teachers.

Possible Areas of Professional Growth and Development

1. Growth in mathematical content knowledge.

Attributes: Extending and deepening of knowledge of mathematical facts and concepts, how these facts and concepts are generated and organized, and/or why these facts and concepts are true.

2. Growth in general pedagogical skills.

Attributes: Extending and deepening of non-content-based teaching knowledge such as general teaching strategies, management of student behavior, classroom procedures, etc.

3. Growth in pedagogical content knowledge needed for the teaching of mathematics.

Attributes: Extending and deepening of content knowledge for teaching. This includes understanding how to effectively represent and teach the subject knowledge to students, as well as understanding what makes the learning of topics challenging or easy for students.

4. Growth in curricular knowledge.

Attributes: Extending and deepening knowledge of how to use resources and arrange topics over time to organize the study of a discipline.

5. Growth in knowledge of how to support diverse learners.

Attributes: Extending and deepening of knowledge of students' individual differences and unique learning needs. This includes knowledge of students' interests, abilities, skills, knowledge, family circumstances, peer relationships, and racial, ethnic, cultural, and socioeconomic backgrounds as well as knowledge of how to support students' unique learning needs based on these differences.

6. Growth in knowledge of educational policies, practices, and objectives.

Attributes: Extending and deepening of knowledge of educational policies, practices, and objectives at the local, state, and national levels, which allows the teacher to access resources and engage collaboratively with various members of the educational system.

7. Increased professional engagement and leadership.

Attributes: Enhanced involvement in professional activities or leadership positions beyond the classroom and school duties expected of a teacher.

8. Growth in reflective practices

Attributes: Enhanced skills in and/or increased frequency of thoughtful or purposeful contemplation of one's knowledge and skills or practices needed to teach mathematics.

9. Other

Directions for Evidence Collection

Please use this template to chronicle your professional growth as a result of participating in eMSS. In order to demonstrate your supporting evidence, I encourage you to try and use a variety of places on the eMSS website—such as Our Place, Inquiry Discussion Groups, Content Areas, Dilemmas, Personal Messages etc.

Personal Information

Your name:

Your grade level and subject area:

Evidence of growth

1. From the list of possible areas of teacher growth and development, choose 10 examples of thoughtful or reflective dialogue that have contributed to your professional growth. Feel free to choose examples of your own posts OR posts by others. You do not need to choose a post from every category.
2. Cut and paste this example into the template below. Please include other posts in the thread in order to provide context if necessary.
3. Label the post as yours or other participants' post.
4. Label the area(s) of teacher growth and development promoted/exhibited by this post. If you choose an example that does not fit into the first 8 categories, please label it as "other."
5. In two or three sentences, briefly justify your selection. For example: How does this post evidence this aspect of professional growth? What did you learn as a result of reading/writing this post?

Example Post 1 (paste below)

I struggle with getting higher order thinking in my classroom. I spend alot of time on basic skills--add, subtract, multiply, divide--without those skills, can you achieve higher order thinking? Or will my students get more frustrated. Don't you need a baseline of skills to apply to higher order problems?

Who's post? (mine, mentor, mentee, content specialist): mentee

Discussion area: Content forum

Area(s) of growth: pedagogical content knowledge

Justification: This post caused me to reflect on my experiences with students who do not have the basic skills down. It is my belief that students can achieve higher order thinking even if they do not have the basic skills down, but I had to really think about how to answer this question. I wanted to give this mentee concrete examples of how higher order thinking could be achieved without these basic skills. I was able to come up with examples from my classroom, but this interaction caused me to think about how to infuse more higher order thinking into my curriculum, even in the lower level classes.

Example Post 2 (paste below)

As is true in all mathematics, I think it important that our vocabulary be clearly defined here. Reading through these posts regarding geometric constructions and proofs, I get the sense that we may be discussing slightly different understandings or working definitions of "proof." Proof to me is simply a clearly stated and supported argument. I rarely accept an answer or solution from a student without a follow-up "why?" The answer to that question is a proof, I think. The steps involved in a geometric construction require students to answer yet more follow-up questions that lead to further discovery and conclusion. To me, this process is a proof. I frequently mirror students' logic during problem-solving using a two-column format. Long before we formally study proofs written as such, they are used to this particular tool. I hesitate to allow students to draw conclusions based on the few examples they might create in a classroom situation. By asking for support at each step of a process, I hope to get them to think more deeply about the possibilities. In this way, my most important job as a math educator is to discipline the minds of my students. I'd be very interested to hear from those of you who have mentioned not teaching proofs any longer...what do you consider a proof in the context of this discussion?

Who's post? (mine, mentor, mentee, content specialist): other mentor

Discussion area: Content forum

Area(s) of growth: mathematical content knowledge and pedagogical content knowledge

Justification: I chose this post because it caused me to reflect on my definition of proof and the role of proof in my math classes. I decided that there are formal and informal proofs and students should understand the importance of formal proofs in the field of mathematics by completing some relatively simple formal proofs. However, I believe it is even more important to engage students in writing informal proofs because it is this thinking and justification process that will allow students to understand the math in more depth. I like how this mentor also mentioned that the process allows them to see other possibilities. I had not thought about it this way before, but that is another advantage to informal proof.

Post 1 (paste below)

Who's post? (mine, mentor, mentee, content specialist):

Discussion area:

Area(s) of growth:

Justification:

...

Post 10 (paste below)

Who's post? (mine, mentor, mentee, content specialist):

Discussion area:

Area(s) of growth:

Justification:

APPENDIX E

EMSS TEACHER GROWTH INTERVIEW PROTOCOL

Teacher Growth Interview Protocol

As you know, I am conducting a study exploring mentor teachers' professional growth and development as a result of participating in eMSS. To explore mentor growth in more detail, I would like to speak with you about your experiences in eMSS.

Professional Growth through Mentoring

1. Can you tell me what your own goals for your professional development are?
On the survey, you said that eMSS aligns with your goals _____. In what ways?
2. From the focus group, your portfolio, and the survey, it seems that you have benefitted from eMSS most by _____.
Can you give me some examples?
How did participating in eMSS contribute to this learning?
3. How do you feel that your topics addressed below has grown as a result of participating in eMSS?
Can you give me some examples?
How did participating in eMSS contribute to this learning?

Possible Areas of Growth	Addressed
a. Mathematics content knowledge	
b. General pedagogical knowledge and skills	
c. Repertoire of ideas/resources for teaching	
d. Pedagogy and content needed for teaching mathematics (i.e. content knowledge for teaching that embodies understanding how to effectively represent and teach the subject knowledge to students, as well as understanding what makes the learning of topics challenging or easy for students)	
e. Curricular knowledge (i.e. how to use resources and arrange topics over time to organize the study of mathematics)	
f. Knowledge of how to support diverse learners	
g. Knowledge of local, state, and national educational policies, practices and objectives	
h. Ability to reflect on your practice	
i. Involvement in professional activities or leadership positions beyond the regular expectations of classroom teaching	

4. How do you feel you have benefited personally as a result of participating in eMSS?
Which aspects of eMSS have been most beneficial in your personal growth?
5. What are your views on the importance of dialogue in the eMSS program?
How has reading, writing, and interacting through dialogue contributed to your personal and professional growth?
6. Is there anything else you would like to tell me about your experience in eMSS?
What should I have asked that I have not?