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Understanding Teachers' Change Towards a Reform-Oriented Mathematics Classroom

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ABSTRACT

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Within the current mathematics teacher population there are teachers that want to change from traditional teaching styles to become more reform-oriented (i.e. focusing on student understanding rather than procedures). Many of these teachers do not know how to begin this change. This research looks into the tools that are most valuable for teachers as they change from traditional teaching practices to include more reform-oriented teaching practices. Through this phenomenological study, six successful reform-oriented teachers were interviewed to understand what tools they found to be most valuable in their process of change. The interviews uncovered a common guiding principle that facilitates successful change towards reform teaching—focusing on the students' mathematics. This guiding principle led all the teachers to implementing task-based lessons and improving their questioning towards their students. The two tools found to be of most value, reflection and collaboration, are identified and explored. The implications of a reform curriculum are also discussed. Limitations of the study are identified and areas of future research are explored.

Keywords: mathematics education, phenomenology, reform, collaboration, reflection, reform curriculum, questioning

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INTRODUCTION

Within the mathematics teaching population there is a group of teachers that are seeking to align their classrooms with the reform ideals that many of the reform initiatives are calling for (e.g., National Commission on Mathematics and Science Teaching for the 21st Century, 2000; National Council of Teachers of Mathematics, 2000; National Research Council, 2001). This relatively small subgroup of teachers sees value in reforming their classrooms. They desire students "who (1) value mathematics, (2) are confident in their own abilities, (3) are problem solvers, (4) can communicate mathematically, and (5) can reason mathematically" (Confrey, 1993, p. 300).

Within the small section of teachers that see the need for reform in their classrooms is a smaller subset that includes teachers who are successful in implementing reform in their classroom. These teachers have found the tools they need to create classrooms that are in accordance with new reform measures.

For many that desire reform, their classrooms have remain unchanged. In my own teaching experience, I have been in the classroom with a traditional curriculum and wondered how to employ ideals of the reform movement. I have also had more experienced colleagues come to me as a new teacher hoping to find access to new ideas. In a discussion that Armstrong, Sowder, and Philipp (1994) had with teachers, the teachers expressed frustration at not knowing how to reform their classrooms. The teachers in the study expressed concern that professional development did not help them create the change they desired. The professional development experiences were "too brief, and focused on such topics as how to use manipulatives in classrooms rather than on helping the teachers develop a deeper mathematical understanding," (p. 56) which the

teachers felt was vital to creating change in their classrooms. These instances speak to the broader problem of the lack of teacher knowledge towards the process of change.

The purpose of this study is to understand how successful reform teachers are able create reform-oriented change in their teaching practice. I study the experiences of teachers who have been successful in making reform-oriented changes with a focus on the means through which these teachers create change. I refer to these means as tools. Tools are the vehicles that have allowed the teacher to create reform-oriented changes in their practice. For example, one tool might be a *professional development experience* that provides a teacher access to reform-oriented principles that they are then able to implement into their classroom. Another tool might be *collaboration with other teachers* where they are able to talk about how to help students come to understand the ideas they are trying to present.

By looking at multiple teachers' experiences, a generalized portrait of the experiences teachers have as they work through the process of reform-oriented change is created. This portrait provides an understanding of what tools these teachers have used to reform their teaching practices and provides insight into the tools that are most likely to enable others to make similar changes.

My research fills a void in mathematics education. Researchers have seen a need for research that describes how teachers have been able to create change in the classrooms. By looking into how teachers create change, I am adding to an area where Heid (2006), Shulman (1987), and Ferrini-Mundy and Graham (1997) observed a lack of research. I connect the research community with the community of practice, especially in ways that study the process and nature of change. I also am doing as Boyer (1990)

suggested—conducting research to create “a good description of practice that moves in the direction of reform” (p. 563).

THEORETICAL FRAMEWORK

My research looks into the tools that facilitate the process that teachers go through as they change from traditional to reform-oriented teaching. Here I describe a framework that allows me to identify and interpret the changes teachers go through. I also define traditional and reform teaching.

Change

Part of my research involves looking at change in teachers. To look at change I have adapted ideas from Linda Ackerman (1986), one of the leaders in organizational change. The framework for change has been clarified by the United Kingdom's Joint Information Systems Committee (2008). The framework for change is specific to creating change in business organizations that is implemented from the top down. I have modified the ideas to fit change within a single classroom and by a single teacher.

The Joint Information Systems Committee (JISC) described the different types of changes that can occur. Each of these types of change has a different implication for classroom change. According to JISC change can be *planned* or *emergent*, *continuous* or *episodic*, *internal* or *external*. Planned change is change that is deliberate, a product of conscious reasoning and actions. Emergent change occurs in an apparently spontaneous and unplanned way. Continuous change is ongoing, evolving, cumulative, and is characterized by people constantly adapting and editing ideas they acquire from different sources. Episodic change, in contrast, is infrequent and discontinuous. Internal change is change created by one's own decision whereas external change occurs because of the decision of an outside influence.

Planned vs. Emergent Change in the Classroom

Planned change in the classroom means that the teacher makes a purposeful decision to do something different. Purposeful classroom change is an active change that can come in many forms. It might be a teacher who takes a job in a new school that uses a reform curriculum, sees the value in the new way of teaching, and begins to search out other ways to improve their teaching. Or purposeful change might occur when a teacher notices a conflict in how they teach and what they want their students to learn (Breyfogle & VanZoest, 1998; Wood, Cobb, & Yackel, 1991) and so they begin to search out ways to change.

Continuous vs. Episodic Change in the Classroom

The change from a traditional to a reform classroom is a continuous effort. I did not expect to find teachers who felt they had "completed" the change to reform since, like Ferrini-Mundy and Graham (1997), I do not believe change towards reform teaching is ever complete. Rather I consider teachers from all different stages of change. Some teachers may just be beginning the process of reform in their classroom while other teachers may have been making changes for many years. But no matter how long the teacher has been making changes, reform-oriented teachers are continually seeking new ways to improve their teaching.

Internal vs. External Change in the Classroom

Change that is motivated internally has more effect on the teacher; whereas change that is motivated by external forces tends to be superficial and does not become integrated into the classroom (Breyfogle & VanZoest, 1998; Cohen & Ball, 1990). When a teacher is motivated by external forces (e.g., an administrator requiring change) the

reform principles tend to be integrated superficially or the teacher may adapt the new ideas to fit into their traditional style of teaching.

This framework for change was initially used to ensure the methodology enabled the identification of various types of change. For example, after I had written the protocols, I realized that I did not have any questions or activities that allowed me to explore explicitly whether change was internal or external. To remedy this missing change, the tool "administration" was added to allow teachers to discuss if external forces played a part in their change. Also, after each description was written (see methodology section), this framework influenced the analysis that occurred. As I read through the individual descriptions and analyzed for themes I kept the framework in mind as I attempted to understand the change that each teacher underwent. When the descriptions were analyzed to compare similarities and differences for the participants, I used the framework to analyze how their change was similar and different from each other.

Traditional versus Reform Teaching

To be able to understand mathematics classroom change from traditional to reform, we must have a definition for each. Traditional teaching is characterized by teacher-centered classrooms; much of the authority comes from what the teacher says (Hiebert, 1999; National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Stigler & Hiebert, 1999).

> The approach used for the lessons [are] numbingly predictable: (1) a review of previous material and homework,(2) a problem illustration by the teacher,(3) drill on low-level procedures that imitate those demonstrated by the teacher, (4) supervised seat work by students, often in isolation, (5) checking of seatwork problems, and (6) assignment of homework. (National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 20)

In traditional classrooms, most of the classroom time is focused on practicing skills "to prepare students to produce correct responses to narrowly defined problems" (Tate & Rousseau, 2007, p. 1223). In contrast, reform teaching is characterized by a student-centered classroom, where discussion occurs frequently as students work together to discover the principles behind the mathematics.

The expectations of what is learned are different in traditional and reform-oriented classrooms. In a traditional classroom students are expected to mimic the procedures put forth by the teacher. The problems are often multiple "practice" problems that drill the same application of the procedure. In general, the assignments end with one or two superficial application problems. In a reform-oriented classroom the students spend time building an understanding of how the mathematics works and the focus is on the process, not only the answer. The assignments the students are given may have only a few problems that require the students to apply their knowledge to new situations. There is little need to drill the procedure since students are typically not expected to follow any given procedure and are encouraged to use multiple strategies to solve problems.

Definition of Reform Teaching

There are many ideas of what reform teaching looks like (Ferrini-Mundy & Graham, 1997; Sherin, 2002) but for the purpose of this study I used ideas put forth in *Mathematics Teaching Today* (National Council of Teachers of Mathematics, 2007) as my framework for reform. Mathematics Teaching Today (MTT) states six major objectives for reform teachers to implement in their classrooms:

- Communities that offer an equal opportunity to learn to all students
- A balanced focus on conceptual understanding as well as procedural fluency
- Active student engagement in problem solving, reasoning, communicating, making connections and using multiple representations

- Technologically well-equipped learning centers in which technology is used to enhance understanding
- Incorporation of multiple assessments that are aligned with instructional goals and practices
- Mathematical authority that lies within the power of sound reasoning and mathematical integrity. (National Council of Teachers of Mathematics, 2007, p. 7)

This definition of reform was chosen because it is more specific than many available definitions. *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000) was written to be general and to create a vision that could be adopted by all teachers. Because the descriptions in the *Principles and Standards* are so general, there are many teachers that have looked at their classroom practices and have concluded that they already are in line with the reform ideals laid out by NCTM. But, upon closer look by researchers, many of the teachers have been identified as pseudo-reformers, teachers with only a superficial implementation of the *Principle and Standards* (National Council of Teachers of Mathematics, 2000). The more specific definition by MTT has implications for what occurs in a reform-oriented classroom. (See Appendix A for a list of attributes.) For this thesis I focus on the following critical aspects of reform from MTT:

- The teacher uses meaningful math tasks.
- The teacher and the book are not the sole mathematical authorities.
- The teacher focuses on student understanding more that student computations.
- The teacher requires the students to justify their thinking.
- Lessons are discussion based and focus on problem solving.

Some implications are more critical than others since there are many aspects of reform that can be present in non-reform classrooms. Pair work and group work are common in reform classrooms, but facilitating group work that is primarily focused on learning mathematical procedures by rote does not constitute a reform mathematics classroom. Although technology or a reform curriculum may be present in the classroom,

their presence does not imply that the classroom can be defined as reform. There is a correlation between these tools and reform classrooms, but not necessarily causation. Similarly, a classroom may have respect for all students and all students may be engaged, but if the focus of class is not on understanding the mathematics, that classroom cannot be considered reform. These other aspects, in combination with critical aspects, guided me in choosing reform classrooms for this study. By using a more specific definition of reform teaching, I focused on classes that have more meaningful implementations.

The second reason for using this definition of reform is that the definition encompasses the ideals that other researchers place on reform teaching. Sherin (2002) defined reform as making changes in instructional materials, employing an adaptive style of teaching, and a focusing on classroom discourse. In the *Curriculum and Evaluation Standards* (National Council of Teachers of Mathematics, 1989) reform classrooms are defined as involving problem solving, communicating, reasoning, drawing connections, and using multiple representations. In 2000 NCTM came out with their revised edition of the *Standards* (National Council of Teachers of Mathematics, 2000). Here reform was defined as meeting their six standards: equity, curriculum, teaching, learning, assessment and technology. The standards are addressed in a more direct manner in the definition from MTT (National Council of Teachers of Mathematics, 2007).

For the purpose of this study, I have chosen to focus on change in teacher practice with an emphasis on the tools that have allowed teachers to change. By studying teachers in the process of change towards more reform teaching I explored answers to these research questions: (1) What tools have secondary mathematics teachers used successfully to make reform-oriented changes in their classrooms? 2) How have

secondary mathematics teachers who have been successful in making reform-oriented changes found access to the tools that facilitate those changes?

LITERATURE REVIEW

It is important to understand what other research has been done regarding mathematics teachers' change towards implementing reform ideals in their classroom and how my research fits into that context. Because of recent changes in the United States there is a great need for change in mathematics classrooms (Lester, 2007). Trends from national testing have shown that there is a need for mathematics education to improve among ethnic and lower socio-economic students. Because of the trends, there have been calls by government agencies and others, with No Child Left Behind, and national and state standards, to improve mathematics education. Calls for reform have caused many researchers to study teacher change, resulting in a wide selection of related research.

The research surrounding teacher change discusses three major ideas: critical factors for change, effects of a specific tool, and identifying sites of reform. The following sections discuss the literature surrounding these topics and how it relates to my research.

Critical Factors for Change

Research has described some critical factors that allow change to occur. One factor is disposition of teachers. Teacher change must be in line with teachers' beliefs (Richardson, 1990; Senger, 1999) and teachers must be open to the changes that are occurring (Ferrini-Mundy & Johnson, 1997). If the change that is being requested is not in line with their belief system, the change is often not significant or worthwhile. Weissglass (1994) added that although "new information is important, furnishing it is not sufficient to overcome personal resistance to change, the tenacity of the existing culture, and the working conditions of educators" (p. 75).

A second critical factor is the environment in which change is taking place. For change to be effective there must be support from the administration, from the school community, and from a leader or specialist (Ferrini-Mundy & Johnson, 1997; Lester, 2007). Without support, teachers tend to revert back to their original ways of teaching and abandon their attempts to make difficult but desired changes.

Fennema and Nelson (1997) described a third critical factor: encountering conflicts between what is being taught and what is being learned. The authors also described how teacher knowledge must change to include knowledge about problem solving and conceptual ideas of mathematics.

The research about critical factors for change describes what needs to be in place for teachers to begin making changes. The critical factors of disposition, environment, and encountering conflict have been adapted into the tools that I expected some teachers to describe as helpful in their process of change. My research is not interested in a teacher who does not have the disposition for change because I do not feel effective reform change can be pushed upon somebody. Some teachers are fortunate to be in an environment that has cultivated reform, but others have been able to create reform in spite of their environment. Encountering conflict can help a teacher see a need for change, but such teachers may feel unsure of how to reform. Exploring a variety of tools allows for a more broad understanding of how change occurs and can provide valuable insight and tools to teachers desiring change.

Effects of a Specific Tool

The most prevalent research in teacher change focuses on answering questions similar to "What effect does _____ have on in-service teachers?" Researchers are

curious about the impact of one specific tool and so they tend to implement that tool into classrooms and study how teachers use the tool and the impact it has on the classroom. The following sections describe four common tools that are discussed in research. The sections describe the value in the tools that the researchers found in their studies and how the tools are of benefit to in-service teachers. My research differs from these studies by looking at teachers who are *not* part of research studies. From there I attempt to understand if the teachers sought out the tools and what value they were to the teachers. These tools have been adopted into my protocols to see which tools were of use to teachers who were not part of studies exploring specific tools.

Case Studies

Armstrong, Sowder, and Phillip (1994) were interested in how teachers could use case studies to help improve their teaching. The researchers gave teachers a set of case studies that focused on reform classrooms and then discussed together the implications these case studies could have on their teaching. The authors found that case studies could be an effective tool for teachers to use in their classroom. The teachers felt that the case study dialogues between teachers and students were applicable to their teaching. They also used the case studies as a discussion base for their weaknesses and their successes. The teachers were able to discuss attempts they had made toward reform and whether or not they had been a success or a pseudo-reform success. They found that for the case studies to be helpful they must contain a respect for the teaching task, empathy for the person who engages in the task, and anonymity.

Barnett and Friedmann (1997) also describe how case studies can be used as a tool for teacher change. In their project *Mathematics Case Methods Project* they use case

studies that describe “an instructional sequence in which the teacher is surprised or perplexed by students’ responses or by the results of an assessment task. All cases include descriptions or samples of student work or dialogue” (p. 382). The teachers would meet with facilitators (teachers with case study experience) and discuss questions or issues that were raised by the case studies. The authors found that by discussing the case studies, the beliefs and teaching practice of the participating teachers were challenged and the teachers were forced to question their ideas against the ideas presented in the case studies.

Davenport (1994) was also interested in how teachers used case studies, along with other material resources, to change their teaching practices. She looked at teachers who had access to the resources through the Teachers’ Resources Network and examined how often each resource was used. The material resources that Davenport looked at included curriculum, articles, books, and guides. She found that the resources that the teachers turned to the most “contained stories from classrooms that conveyed images of how teachers and students work together or included numerous examples of students’ mathematical thinking” (Davenport, 1994, p. 194). The teachers were interested in resources that could be immediately applied to their classrooms.

Reflection

Brown (1996) looked into how teachers use reflection and writing to guide their classroom practices. The study was conducted with teachers who were entering their third year of their Masters coursework. As part of their course work they were required to compile their writings and reflections that they had made throughout the first two years of the program. Brown emphasized that writing should be an integral part of teaching and

that is an important way for teachers to monitor their changes in teaching. By writing, the teacher is able to capture the past and reflect on how it can affect their future. Brown claimed that writing can be used to monitor change. By reflecting on lessons and experiences the teachers were able to reflect back on their experiences. Reflections allowed the teacher to explore how it could have been done better which allowed for improvement towards the teachers' goals.

Knowledge of Student Thinking

Another tool that has been studied in creating change is the tool of teachers' knowledge of student thinking. Research has shown that when teachers take the time to thank about how their students are thinking about the mathematics they realize that their current way of teaching is not as effective as it should be (Franke, Fennema, & Carpenter, 1997; Lubinski & Jaberg, 1997). Franke, Fennema and Carpenter (1997) discuss how their professional development program, Cognitively Guided Instruction (CGI) engages teachers in changing their beliefs about how students learn mathematics. The authors noticed that when teachers focused inquiry on children's mathematical thinking it led them to think about how the student will understand the mathematics which led them to think about what pedagogical instruments would be best suited to help teach the topic. This type of inquiry led to a positive change towards reform in the teachers' classes. Lubinski and Jaberg (1997) noticed similar changes in teachers at a rural Illinois elementary. The researchers noted that although all the teachers had implemented varying degrees of change, they noticed that every teacher had modified the amount of time them spent explaining procedures and focused more on how their students solved problems.

These changes came because of the faculties' focus on how students' were thinking about the mathematics.

Support Networks

Many authors have discussed the role of support networks in teacher change (Feikes, 1998; Jones, 1997; Lubinski & Jaberg, 1997; Secada & Adajian, 1997; Stein & Brown, 1997). Jones (1997) discussed that when studying teacher change it is important to look at the context of teaching and one valuable aspect of the context is the support that the teachers have. He argues that in order for change to be studied the research must take into account that change in teaching, epistemology or mathematics will be effected by the support that teachers have from their networks. By looking at support networks, Stein and Brown (1997) were able understand why teachers at one school (Riverside) were able to create change while teachers at a second school (Norton) were not. Both of the schools had been sites where the QUASAR program had been implemented. At Riverside the QUASAR project had taken hold and had been strongly implemented by the teachers, while at Norton, the implementation had been weak. By looking at the sociocultural framework of support networks, the authors realized that Riverside had well developed support networks for the teachers to rely on as they made change in their practice and at Norton the support networks did not exist. As they studied Norton they were able to track the changes that occurred as support networks were put in place and developed and how they networks allowed the reform community to develop.

Secada and Adajian (1997) discussed how the support networks at Krome Elementary School created the community necessary for change. The authors described their support networks as those with (1) a shared sense of purpose, (2) a coordinated

effort to improve students learning, (3) collaborative professional learning, and (4) collective control over important decisions. The authors observed and interviewed the teachers to understand what ways the school had supported or impeded individual efforts to change. The authors found that the teachers had formed tightly knit professional communities that focused on the students' learning. The authors discuss that through these learning communities the teachers are able to create long-term change in their teaching and in their school.

Feikes (1998) discussed the roles that formal and informal support networks play when teachers attempt to create change in their classrooms. He discovered that as Mary, the teacher being studied, attempted to create change in her classroom, her network of support played a vital role in her learning. Mary relied on the support network of other teachers who participated in a common professional development, the project staff member and Feikes as the researcher. The support was vital as Mary attempted to create the change she desired and encountered opposition for other people. Raymond (1995) showed that collaboration with university personnel is an effective way to create change in a classroom. As the author collaborated with Brad, a seventh-grade mathematics teacher, Brad was able to incorporate problem solving activities and change his teaching to be more in line with the *Standards* (National Council of Teachers of Mathematics, 2000). Lubinski and Jaberg (1997) showed how one teacher took the initiative to create an environment for change. The teacher, Ms K., described her role as

> (a) encouraging collaboration between the university and her school staff, (b) providing information to parents about the change process, (c) finding funds for materials for her staff, (d) encouraging collaboration among her teachers, and (e) recognizing faculty and student achievements (p. 248).

Through Ms K.'s efforts in creating support networks between the teachers, administrators and parents, all the teachers are the school were able to create change in their classroom.

Summary

Across these articles, there is similarity in the teachers that participated. The teachers that were chosen were typically teachers that were committed to improving their classrooms and their beliefs were in line with the reform ideas that were presented. Many of the teachers (Armstrong, et al., 1994; Davenport, 1994; Feikes, 1998; Lubinski & Jaberg, 1997; Raymond, 1995; Stein & Brown, 1997) were also already connected to the researcher, either by involvement in a study or a professional development that the research was connected to. These studies show how specific tools can be used to create reform changes in classrooms. Each article demonstrated that when given the access to certain tools, teachers are able to use them to create reform-oriented changes. Although the articles also highlight the vastness of the tools that can be used by teacher, they do not allow us to see what tools are accessible to teachers and what tools are most useful in creating change. My research, instead of focusing on a tool and extending towards teachers, will focus on the teacher and move in the direction of the tools that were valuable.

Identifying Sites of Reform

A large study on teacher change (Ferrini-Mundy & Schram, 1997) looked for school sites that had effectively implemented reform ideals. This section describes the *Recognizing and Recording Reform in Mathematics Education Project* and describes how their study relates to my study.

In the *Recognizing and Recording Reform in Mathematics Education Project*, Ferrini-Mundy and Schram (1997) identified "sites of reform" and discusses how they are influenced by, what they know about, and how they interpret the *Standards (National Council of Teachers of Mathematics, 2000)*. They looked at the sites and "identify two or three things that stood out about each site's efforts towards bringing about reform" (Ferrini-Mundy, 1996, p. 2). The case studies that were presented illustrate the context in which reform occurs. The implications of their study are outlined in Figure 1.

Implications for instructional practice	**Implications for administrators and policy makers**	**Implications for further research**	**Implications for the future of mathematics Standards and for looking at Standards-based reform**
• Change of teachers' beliefs is highly individualized. • Collaboration and reflecting with others is critical.	• The shift to reform can be supported by administrators by supplying resources. • View the mathematics teacher as the expert and value their input in decision making.	• Extend the study to K-8 grades. • What is the role of support mechanisms? • How does reformist interventions relate to student learning? • Studies of different aspects of change. • How do teachers view change? • How do teachers' beliefs change over time?	• Both grassroots and systematic development can lead to change in classrooms. • Studying the *Standards* is difficult because they are too broad and underdetermined. • The standards can be interpreted in many meaningful ways.

Figure 1 Implications from recognizing and recording reform in mathematics education (Ferrini-Mundy, 1996)

The findings of Ferrini-Mundy and Schram (1997) have many applications towards the research presented here. In their implications for instructional practice they describe that the process of change is highly individualized. This proposed study is designed to look at the individualized processes of teachers and come to understand the similarities across multiple experiences. The authors also describe the importance of collaboration, reflecting with others, and support of administration. These implications

have been included in the research as tools that can be used to facilitate change in the mathematics classrooms. The authors also describe implications for further research that relate to the proposed study. My proposed study will be looking into the different aspects of change that were most valuable from the teachers' perspective.

Ferrini-Mundy and Schram's (1997) look into how reform was facilitated was secondary in the research project and therefore, the researchers were not able to come to a conclusive understanding of what aspects that allowed change were common in all the sites. The research also did not look into what allowed the "sites" to begin their change towards reform. This research project is important to show that there are places that are successful in creating reform, but I will build on their research by looking into what has allowed this reform to happen.

The methodology of Ferrini-Mundy and Schrams (1997) is also very different from my methodology. Their research focused on presenting case studies of teachers who have been successful in making changes. They present snapshots from a moment in that teacher's history. The methodology focused primarily on observations instead of interviews. This choice in methodology does not allow the researchers to thoroughly explore with the teacher the process of how they changed over time. The researchers were only able to describe the phenomena they were able to observe and draw conclusions from those observations. By focusing on the teachers and their stories I obtained a more complete picture of what facilitates reform-oriented changes in teacher practice.

METHODOLOGY

The following section describes the methodology of this study. The Epoche process is described along with process for the data collection and data analysis.

Phenomenology allows for the researcher to describe the lived experiences of individuals (Bogdan & Taylor, 1975; Creswell, 1998; Maynard & Clayman, 1991). Since I am attempting to understand the experience of change towards reform-oriented teaching, phenomenology is an appropriate methodology to allow me to study that change. A phenomenological study allows me to understand how the teachers view the change they have gone through. It also allows me to understand the experiences that have allowed the teachers to create change in their classroom.

Epoche

Phenomenology requires the researcher to go through the process of Epoche or bracketing. Epoche is the process of setting aside all prejudgments so that the researcher is unbiased and receptive to all aspects of the phenomenon. "Epoche is the first step in coming to know things, in being inclined toward seeing things as they appear, in returning to things themselves, free of prejudgments and preconceptions" (Moustakas, 1994, p. 90). By completing the Epoche process I made myself aware of the biases I have towards my research. The following paragraphs describe these biases.

Because of my experience in the classroom I have certain biases towards the research. I taught for three years in 3 very different situations. My first year teaching was in a middle school. Although I was given a traditional text to teach from, there were many teachers who were in the beginning stages of implementing reform ideals. These teachers had many ideas for me on how to bring more participation into the lessons. My

second school had the option to teach from traditional material or from a reform curriculum. I chose to teach from the reform curriculum. While I was there, I realized the struggles and the payoffs of attempting to implement a reform curriculum. My third school was a traditional charter school that had traditional texts and mostly traditional teachers who wanted something different than what their traditional teaching experiences had offered their students.

One strong bias that I have is that I feel that teachers should want to be changing. The experience of being a student and teacher has shown me that traditional teaching is not adequate to help students understand the mathematics they are being taught. I feel it is not enough for students to be able to memorize facts. If students understand the concepts behind the mathematics they will be able to understand what the algorithms mean. Understanding what the algorithms mean is more important than being able to compute an answer with memorized procedures.

Also, I know that it is difficult to begin the changes that I advocate. When teachers attempt to try something new in their classroom there is always a chance that it will not work according to the teachers' desires. But, as a former teacher, I feel that taking the risks to try something new is valuable. I have more respect for a teacher who has tried something new and failed than for a teacher who keeps their teaching the same year after year not attempting to improve.

Because of my experiences with attempting to create change in my own classroom and the research I have read on teacher change, I began this study with hypotheses about the experiences teachers would describe. I felt many of the teachers would have had similar experiences in creating change but they would probably describe

the change in different ways. The interviews allowed me to elicit rich descriptions of these experiences, which in turn allowed me to compare these experiences across teachers. My personal experiences caused me to expect that many of the teachers created change through a three-step process. First, they would have had some experience that would motivate a need for change[1]. For many it might have been an experience with reform: observing a reform-oriented teacher, participating in a professional development that discussed a reform-oriented classroom, or working as a pre-service teacher in a reform-oriented classroom. An experience might also be recognizing a conflict between how they teach and what they want their students to learn (Wood, et al., 1991). These teachers recognized the value of some reform ideal and realized that their teaching style did not allow for these reform experiences to occur. The second step would be contact with a mentor teacher (Wood, et al., 1991). To be able to follow through with the ideas that these teachers have seen, they would need a mentor to guide and help them in their everyday teaching. Without a mentor, it is difficult to stay focused on the reform, since teaching is a complicated and time intensive practice. The third step would be actively seeking out professional help to continue to improve their teaching. The teacher would seek out professional development opportunities or other teachers with similar desires for change.

Data Collection

In the data collection section I describe how the study was set up and conducted. The first section describes the selection of the initial set of participants. These initial

[1] After thinking through the expected results I realized that I had nothing in my protocols to bring out the fact that they will possible have some experience that motivated the need for change. To remedy this, the question of "what made you aware of better teaching styles?" was added to the interview protocol to allow this aspect to come up.

participants were then observed as described in the second section. After the observation the participants were narrowed down to the six used for the study. These six participants are also described. The third section describes the interviews that were conducted with the six participants.

Participants

Creswell (1998) explained that phenomenological studies use between 5 and 25 participants to come to an understanding of the essence of the experiences. In accordance with this recommendation, but to stay within the scope of a master's thesis, I studied six teachers.

The six teachers either are or were secondary mathematics teachers, each of whom experienced the phenomenon of changing their teaching practices from traditional to reform. Each teacher was purposefully chosen to ensure the sample of teachers would represent a broad range of attributes. These attributes included age, gender, level taught, years taught, and when they began implementing reform in their classroom. This selection allowed me to look at a smaller selection of teachers and still generalize to a larger population. I limited this study to secondary teachers because of the distinct differences in the daily activities of college, secondary, and elementary teachers. In addition, I was most interested in the secondary level because of my personal experiences teaching secondary mathematics.

To identify possible participants I created a questionnaire to give to professors of Mathematics Education and Secondary Education at Brigham Young University (see Appendix A). The questionnaire was originally designed in an open-ended format asking the participants to describe reform teachers. The questionnaire then asked for names of

secondary teachers that fit the descriptions. After a thorough analysis of the questionnaire, it was decided that it did not appropriately fulfill its purpose. To help focus the questionnaire, it was rewritten to include a predetermined list of attributes that were drawn from my definition of reform. The participant was asked to think of a reform teacher and then check off the attributes they felt accurately characterized the teacher. The attributes were ordered so that the more critical aspects of reform were listed first (see the definition of reform in the Theoretical Framework Section for a discussion on critical aspects). There is also space for the participant to elaborate on why the teacher could be considered a reform-oriented teacher.

Once the questionnaire was rewritten, it was piloted with one professor from the Department of Mathematics Education at Brigham Young University. Piloting the questionnaire allowed me to conclude that the attributes were diverse enough to include many aspects of reform that would describe many different teachers. Each teacher that was recommended had a unique set of attributes assigned to that teacher. All of the attributes were assigned to at least one teacher leading me to believe that there were no extraneous attributes. The description section was filled to its capacity and so it was determined that the form could be redesigned to allow more room for comments.

The questionnaire was then distributed to 11 professors in Brigham Young University's Department of Mathematics Education. These professors were chosen because of their contact with mathematics teachers and their experiences with reform teaching; some of the professors had taught in local school districts for many years while other professors worked closely with in-service teachers. Because of the professors' contact with the teachers, pseudo-reform teacher recommendations were limited.

The questionnaires yielded 24 unique recommendations. The first step was to select approximately 10 teachers to observe. The rest of the teachers would be held in reserve for observations if the first selection did not yield at least 6 teachers to interview. Eight teachers were initially selected because they received strong recommendations from multiple professors. Then 3 teachers that were at the same schools as the first set of teachers were included because it would not add much time to observe two or more teachers at one site. Two teachers that were recommended were currently teaching at BYU, and so they were added because of their proximity. A fourteenth teacher was added because he was recognized by UCTM as an outstanding teacher in 2009. I then put these teachers into a spreadsheet (see Figure 2). The spreadsheet included gender, level taught, and the reform principles that the questionnaires showed the teachers as implementing. From the spreadsheet I could see that I had a variety of males and females across multiple grade levels. I could also see how the teachers varied in the reform procedures they were reported to implement.

	Sex	JH	HS	Other	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	F	x			x		x	x	x			x	x	x		x	x	x	x	x	x
2	F		x	x	x	x	x		x	x	x	x	x			x	x		x		
3	M	x			x		x	x	x		x			x		x	x	x	x	x	x
4	F	x			x			x	x							x	x				x
5	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6	M		x		x		x	x		x					x	x	x	x		x	x
7	F	x			x		x	x	x							x	x				x
8	F	x			x				x						x	x	x				x
9	F	x			x		x	x	x							x	x				x
10	M	x	x	x			x	x	x		x			x	x			x			
11	F		x		x		x	x			x	x	x	x	x					x	
12	F	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	
13	M	x			x	x	x	x	x	x		x	x	x	x	x	x				
14	M		x		Questionnaire was not filled out for this participant																

Figure 2 Attributes of teachers for observation.

The column head numbers refer to the numbered reform attributes from the questionnaire (see Appendix A). JH and HS indicate Junior High and High School respectively.

Once I had narrowed down my selection, I sent out an initial contact (see Appendix B) to find out which teachers were willing and able to participate. Eleven of the 14 teachers responded that were able to help. (Teacher 14 felt he was too busy and teachers 11 and 13 never responded to any of my contacts.) Teacher 12 was held in reserve because of the long distance to travel to the school site. These teachers can be seen in the bottom portion of Figure 2. Teachers 1-10, as seen in Figure 2, were selected to move on for observations to verify if they were appropriate candidates for interviews. Teachers 2 and 5 were not observed teaching because they were not currently teaching secondary classes.

Observations

The data from the questionnaires gave me an initial idea of which reform principles were reflected in the teachers' classrooms. With this knowledge, I observed each of the 8 current secondary mathematics teachers' classroom teaching. The observation was a second filter for pseudo-reform teachers and it allowed me to gain a deeper understanding of the reform principles the teachers implemented.

I used an observation protocol (see Appendix C) to help me identify aspects of reform teaching. The protocol contains a list of indicators, drawn from the definition by MTT (National Council of Teachers of Mathematics, 2007), that helped determine if the classroom was a reform-oriented classroom. As with the initial questionnaire (see Appendix A), the observation protocol was organized so the most important aspects of reform are listed first. I looked for classrooms that contained enough essential indicators along with a combination of other indicators, to insure that the classroom was appropriate for this study. Since the purpose of the observation was to inform the interview and verify

that the classroom was appropriate for this study, I did not find it necessary to record the observation or sit down and meet with the teacher after the observations.

Based on the observations, I was able to narrow the selection to 6 teachers. Teachers 7-10 were not chosen. Teacher 7's classroom was focused on student understanding, but it was very teacher centered. The justification and risk taking that occurred seemed forced upon the students for her sake, not theirs. Teacher 8 was a possible candidate but because she taught at the same school as teachers 3 and 4, I didn't want to over represent that one school. I went to a colleague at the same school as 3, 4, and 8 and after discussing the background of these teachers it appeared that teachers 3 and 4 had more varied experiences to share. Teacher 9 appeared to be going through all the correct motions for a reform teacher: she used task based lessons, the students worked on the tasks in groups or pairs, and she was focusing more on understanding than computations. It seemed, however, as if the teacher was doing these lessons because that was the curriculum that she had. The questions that she posed to the class were very leading and she still seemed to be the mathematical authority. Teacher 10's lesson was more traditional in nature. The class spent 10 minutes on an opener, 15 minutes grading the homework, 10 minutes on a quiz, and the rest of the class on practicing skills. Although the students spent much time at the board presenting their solutions, the discussion was focused on the computations to find the solution.

The teachers that were chosen were teachers 1-6 (see the top section of Figure 2). These 6 teachers comprised varying experiences and backgrounds. Teacher 1 (Laura) was one of the early teachers in Utah to begin making reform-oriented changes in her classroom. In the observation I found that her class was focused around student thinking

and justification. Any conclusion that was stated by the students was generally followed by their justification without prompting from Laura. When students raised valuable questions that were not directly in line with the lesson, Laura was able to keep the class engaged in the students' inquiry and then effectively get the class back on task. Teacher 2 (Holly) was not observed because she had taken a few years off to work at the university level, although she would be returning to her same school at the beginning of the following school year. She was chosen because she was a teacher leader in her school, taught in a different district than the other teachers, and had never taught with a published reform curriculum. Teacher 3 (Larry) was chosen because his class was very student centered. The lesson I observed required his students to find triangles that would prove or disprove the different triangle similarity theorems. The discussion focused around whether they had enough to prove the theorems. Larry was able to prod the students towards complete proofs without giving away too much information.

Teacher 4 (Denise) was chosen because of her path into teaching. Denise did not originally go to school to become a teacher and became licensed as she taught her first few years. She also moved into Utah from a very traditional school to a school that used a reform curriculum. I chose her to see how this background affected her change towards using and believing in the reform ideals. Teacher 5 (Eric) was not observed because he had left the public school system to teach at the university level. Eric was chosen because he was one of the originators of much of the change towards reform in his school district. He has been a teacher leader for many years. He also began making many of the changes towards reform before others saw the value of reform ideals. Teacher 6 (Jason) was chosen for two reasons. First, he began teaching reform straight out of college. He was

introduced to the reform ideals as an undergraduate and was able to jump into teaching and implement a reform curriculum. Second, his classroom was very centered around technology and I was curious as to how technology had helped him implement reform. In order to accommodate attrition the other teachers were held in reserve.

Interviews

After the 6 teachers were chosen, I analyzed the reform principles that were and were not observed in order to create personalized interview protocols for each of the participating teachers. (Appendix D shows the generic version of the interview protocol.) For example, with Eric and Holly, I did not conduct observations and so I presented them with the list of reform attributes from the observation protocol and asked them if I were to observe their high school classes, which of these would I notice. From these questions we were able to discuss the aspects of reform they felt were valuable and in what areas they still felt they were lacking. With the other teachers I included questions that asked about the reform principles they implemented. For example, I asked Laura "In your class I noticed a lot of questioning between you and the students and from student to student. Why is that important to you? How did you come to use that technique?" This personalized question, and others like it, allowed me to discuss with Laura the reform principle I saw in her classroom, why it was valuable to her, and how she developed the skill.

The interviews consisted of open-ended questions that allowed the individuals to describe their experiences (Valle & Halling, 1989). Because the purpose of the interview was to get the individual to tell their perspective on their change in teaching practices, the interviews were detailed and extensive. In order for the interview to be detailed and

extensive, it was necessary to create an atmosphere that was open, relaxed, and not rushed. The interview started with broad ideas and funneled to narrower, more specific ideas (Brenner, 2006). The first questions asked the teacher to describe their first years of teaching. Questions about their first few years of teaching allowed me to gain a picture of what the teacher was like before reform ideals entered their teaching. It was important to know how their teaching practices started so I could understand what had changed in their classroom.

The questions then focused on what happened to cause the teacher to begin changing and what allowed them to begin their changes. It was also important for me to recognize when the teacher was talking about other aspects of their teaching that have changed (i.e., change in beliefs about mathematics, teaching or learning, change in their own thinking of what mathematics is, change in how they perceive their students learn mathematics) to know what effected their change. For example, many researchers (i.e. Ambrose, 2004; Cady, Meier, & Lubinski, 2006; Cross, 2009; Hollingsworth, 1989) have discussed how teachers' beliefs impact the change that occurs in classrooms. Because change in practice cannot happen unless a teachers' beliefs change as well, these researchers have studied how teachers beliefs are changed so that others can know how to best foster teacher change. Exploring these changes in beliefs with the teachers helped me to understand why each teacher took the route they did in their process of change.

After each teacher had exhausted the description of how they changed and what allowed him/her to make the changes, I pursued questions about what I saw in their classroom. For example, in Larry' observation, I noticed that much of the discussion in the class was student directed so in the interview I asked him "In your class I noticed the

students decided where the class went, why is that important to you? How did come to use that technique?" This line of questioning allowed me to pursue specific reform principles I noticed in the class and how that teacher came to use and improve upon those principles.

Following any discussion about what I saw in the classroom, each teacher engaged in an activity that brought other tools and experiences into the discussion. The teacher was given a stack of cards where each card had a separate tool listed on it. The teacher was asked to sort each tool into three piles: never used, use occasionally, and use regularly. As the teacher was in the process of sorting I asked them their reasons for why they used the tool with that frequency, how they used it in their classroom, how they came to use that tool, and other questions that allowed me to understand their experiences with each tool. The interviews were video recorded so that the card sorting process could be recorded.

The interview closed with asking the teacher which tools they would recommend to new teachers and why. Responses to this question were intended to provide additional triangulation on what tools the teachers felt were most valuable and most accessible.

At the conclusion of each interview a Contact Summary Sheet was filled out (Miles & Huberman, 1994). The Contact Summary Sheet recorded any thoughts I had about the interview while they were still fresh in my mind. The sheet also gave me an area to write the main themes that I saw emerge. These themes were helpful as I began the analysis process. Finally, the contact summary sheet gave me a place to reflect on how the interview went and how I could improve for the next contact with that teacher or an interview with a different teacher.

Data Analysis

The methodology of phenomenology has specific guidelines for analysis of data. The first process is the Epoche, then Phenomenological Reduction, which is the process of describing what the researcher sees. The researcher uses the language of the participants to create Textural Descriptions. Imaginative Variation is the next step in the research process. The researcher is looking for meaning from the Textural Descriptions using "imagination, varying the frames of reference, employing polarities and reversals, and approaching the phenomenon from divergent perspectives, different positions, roles or functions" (Moustakas, 1994, p. 98). The purpose of Imaginative Variation is to come to understand how the phenomenon is being experienced. During Imaginative Variation the Structural Description is written. The final step is the synthesis of meanings and essences. Synthesis involves taking the textural descriptions from the Phenomenological Reduction phase and the structural descriptions from the Imaginative Variation phase and combining them into a unified statement that captures the essences of the experiences of the phenomenon.

Phenomenological Reduction

I began the analysis of the data once I completed the interview with the first teacher (Bogdan & Taylor, 1975; Miles & Huberman, 1994). By beginning the analysis early I was able to work with the data while it was still fresh and before the data became overwhelmingly large. The analysis process began with me personally transcribing some of the interviews. I had initially planned to transcribe all six interviews, but for the sake of time, four were transcribed for me. As I verified the accuracy of the transcriptions (by listening to the tapes while I read the transcriptions) I looked for initial themes. For

example, one common theme was the need for collaboration in conjunction with self-reflection. Each teacher seemed to continually refer to the value and importance of these two tools. I also noticed that many of the teachers took very different routes to get to similar places in their teaching. Some started by looking into technology, others conferences or professional developments, but all them emphasized collaboration and self-reflection.

After the transcription was completed, the horizonalization process began. Horizonalization is done individually for each participant and is the process of pulling out the statements that have value for answering the research questions. These statements are recorded in the language of the participant. First, each transcript was thoroughly read and I then noted the important statements. The statements were then compiled into a new document and were organized into the following sections: The reason the teacher wanted to change, what the teacher first tried, what changes and tools this led to, and what the most important tools were for the teacher. I chose to organize the document into these sections because I felt it would allow me to tell each participants story in a cohesive way. After the data was horizonalized, it was put though the reduction and elimination process. I sifted through the expressions to ensure that each enlightened the understanding of the phenomenon of change. I eliminated expressions that were vague, repetitive, or overlapping. Many teachers referred to the same experience multiple times and so I kept only the expressions that were most clear.

The themes from the horizonalization, reduction, and elimination processes were used to create the Individual Textural Description for each participant. The Individual Textural Descriptions uses the participants own words to capture their experiences in

working towards a more reform-oriented classroom. They begin with how each individual became a mathematics teacher and what their teaching looked like the first few years. The description then goes on to tell their story about how they began to change their teaching, the tools that helped the teacher change and why each tool was helpful to the teacher and/or what that teacher learned from the experience with the tool are described. Each description concludes with a discussion about the most important tool(s) to that teacher in creating change.

After the textural descriptions had been written, they were given back to each respective teacher for member checking and phenomenon checking (Moustakas, 1994). It was originally planned for the member checking to occur in a second interview, but after the descriptions were written up, it was determined that a questionnaire (see Appendix F) would be just as effective. This decision came about because the clarification questions could just as easily be done in a written form instead of taking the teachers' time to conduct a second interview. The questionnaire allowed me to clarify important missing pieces. For example, Laura described her background to teaching. The information about why this person got into teaching mathematics seemed to be important for that persons change and so every other participant was asked about their undergraduate studies and why they went into teaching mathematics. Similarly, when the descriptions were being written, there were times when I noticed that a tool the participant described was not discussed in enough detail for me to understand how that tool effected the change of the teacher. For example, Larry described how his National Board Certification helped him to see the importance of task-based learning. It was unclear how the National Board Certification had helped so in the questionnaire I asked him to elaborate on that.

The descriptions were revised to include any additions, deletions, or clarifications that resulted from the participants' feedback. The feedback was very positive. For example, one participant responded, "It was great to read something that didn't take my quotes out-of-context and say something I didn't intend." Such comments assured me that I had captured the stories as the participants would have intended.

Once these individual descriptions were completed, they were used to develop a Composite Textural Description of the experiences for all the teachers. The Composite Textural Description describes the general experiences all the teachers had. To create the Composite Textural Description I designed a chart where the columns were the teachers and the rows included the tools, why each teacher got into teaching, what exposed the teachers to reform ideas and what they wanted their teaching to become. A description of what the row header meant to each teacher was entered into each cell. The rows that described what the tools meant for each teacher allowed me to see what tools were useful for all teachers, what tools were key for the teachers, and how the tools compared across teachers. I used this chart to see similarities and differences in what the tools meant for each teacher. The description was then written as a composite story of what was valuable to all the teachers.

Imaginative Variation

The next process in the analysis of the data is the Imaginative Variation. By going back to look at each individual separately, I looked at the data from different perspectives to see different themes that emerged and the underlying dynamics of the experience. The goal was to understand not just what happened but how it happened. This understanding contained information that allowed me to understand why certain tools were most

common or how tools led to further reform changes. After the data from an individual is analyzed with Imaginative Variation, it was written up as a Composite Structural Description which is a universal description of the experience for all teachers.

In writing the Composite Structural Description I took a different perspective than when writing the Textural Descriptions. With the Textural Descriptions I had attempted to tell the story using the timelines from the teachers. With the Composite Structural Description I looked for main themes that ran through each teachers' story. For example, all of the teachers described the importance of reform curriculum; Jason had access to the curriculum early, Holly had never been able to teach from a reform curriculum, while all the others found a reform curriculum after years of using traditional curricula. In the Composite Structural Description I took what the teachers said about reform curriculum and combined it into a composite narrative on what having a reform curriculum might mean in general for teachers attempting to change their teaching practice.

Synthesis

The final part of the analysis process is to take the Structural and Composite Textural Descriptions and to "intuitively and reflectively integrate [them] to develop a synthesis of the meanings and essences of the phenomenon" (Moustakas, 1994, p. 181). This process consisted of taking the descriptions I had written and verifying them against the framework I had originally set out. I also took the ideas from the Structural Description and searched out literature that supported or refuted the results I had found. The results of these analysis activities can be found in the following results section.

RESULTS

The following section includes the Individual Textural Descriptions, Composite Textural Description and the Composite Structural Description. Thus we start with the individual stories of each participant, move on to their combined stories and end with the generalization of their stories.

Individual Textural Descriptions

This section includes the Individual Textural Descriptions that were written in the analysis process. Each data story of the participant is told through many of their own words.

Holly

As Holly grew up she always had the desire to be a teacher. Her dad was a math teacher and her mom an elementary teacher. "I used to picture myself running my own classroom, grading papers, etc. . . . I never wanted to do anything else." In college she majored in math and computer science because "I always had really good math teachers, and I enjoyed it. . . . My mom always told me that if I was a math teacher, I would never have to look hard for a job-she was right!" Holly began her teaching career in Texas where the curriculum was strictly aligned. Within her district she was given an outline of what to teach, when to teach, and how to teach.

> Texas had (and still has) a very rigorous teacher evaluation system. At that time, it was new, and many principals really did not know how to watch for student learning within a mathematics lesson. They just went down a checklist when they came to watch you. . . It wasn't focused on what you were teaching, just if you were following the correct 'lesson cycle'. . . . You just teach the curriculum. You don't care who is sitting in front of you.

The layout was very traditional and it left Holly frustrated because it wasn't working. "This doesn't teach kids math. It teaches them a bunch of tricks." To help the students

enjoy the mathematics more, Holly tried to find engaging ways to present the mathematics so the students would "want to learn more of the 'real' math" and focus less on the end of year tests.

Before she began her twelfth year of teaching, Holly moved to Utah. She got a job at Hill High school where "it was totally opposite. You are the teacher, you decide" what to teach and how to teach it. Once Holly was "out from under that rigorous way to evaluate teacher performance" she began to think that "there has to be a different way to do this." Holly realized she "needed to present [the math] in context of how students would encounter it daily, and how they could use it to find cool patterns or express their ideas about how they think something might work."

Holly began by "signing up for any kind of workshop . . . that I could sign up for." These workshops introduced Holly to many projects and activities that the students could do. Many of the projects that she began to implement were used as summative assessments. This was not ideal for Holly because it was just adding to the curriculum. "I needed to shift the focus from doing a project for the sake of a project, to doing it so the students would learn some 'real' math." But, the students were beginning to enjoy mathematics more; they had the opportunities to express their ideas in ways that fit better with their personalities.

As Holly kept looking for better ways to engage the students in the mathematics, she began attending the Wilhelm Institute, a weeklong intensive professional development that took place in the summer. The focus of the Wilhelm Institute is to help the teachers look at everything from the "big idea" and write units that helped the mathematics to surface in inquiry atmospheres. Holly attended the Institute almost every

year for 6 years. (4 years as a participant and then 2 years as a facilitator) She was able to slowly add units to her curriculum that allowed her students to explore and understand the mathematics. “I’d rather the kids [work on tasks] that makes [the mathematics] their own because that will stick with them.” Her years at the Institute taught Holly that “if you help kids to communicate through reading and writing, then they really do deeply understand” what you are attempting to teach them. She also learned how shallow the questions that she posed to her students were. “Instead of just interjecting, now I at least start with ‘tell me what you did, how did you get here’. And have them explain their thinking and try to . . . [ask] why did you chose to do that. And just ask them a whole bunch of questions to clarify what they are doing and they usually just figure it out by themselves.”

There were other teachers in Holly’s school that wanted to better their practice and “were feeling the same kinds of frustrations that I felt. An English teacher decided to get together a group of differentiating instruction, and I decided to participate.” These teachers started to get involved with the Wilhelm project and kept working together to better their teaching practices. “Our principal would buy the books for us and gave us money once a month for us to have lunch together and discuss things. Our administration helps us make it work.” One of the topics they chose to focus on was action research. They began to look more into how their classrooms were functioning and reflect on their own teaching.

Holly has focused much of her energy on trying to understand how to “use [technology] to help [the students] think deeply about a topic. And is there a way that I can efficiently use technology so that something can go faster.” Holly realized that

technology could allow her to accomplish more in her classroom because it removes some of the tedious calculations. The technology also could give the students a way to interact with the mathematics. Graphing calculators and Geometers Sketch Pad are tools that can help the students visualize difficult concepts. “Having Sketchpad to show the relationship between the wave and the unit circle, I cannot pay enough money to have that light bulb come on. [Instead of me] slowly drawing those points.” Similarly, when teaching transformation of functions, the students can quickly see the effects of changing the parent function has on the graph “instead of getting lost in the tedious graphing of cubic functions.”

> For Holly, the biggest factor in allowing her to change was self reflection. You have to do reflection about the way your teaching in all of those ways (manipulatives, technology, lesson study, and thinking about how students think about mathematics) to be better next time. You need to think about whether or not what you thought you were presenting got presented in that way. What the activity that you pulled in did that really made the kids think about math in the way you were hoping they would think about it.

Along with self reflection is the need for peers with which to collaborate. Holly has a network of teachers that she can go to at any point and discuss what how to improve her lessons.

Denise

After graduating college with a business degree, Denise became a stay at home mom for many years. During this time, she “spent a lot of time volunteering at my children’s school and working alongside many of the teachers there. Every time I was on campus I felt at home.” When the time came for Denise to go back to work, she was “naturally drawn to the school. I started out as a district substitute. I did that for two years, and then because the permanent sub at an elementary.” While a permanent substitute, Denise went back to school to become a teacher. She had an equal number of

credits to take to certify in social studies, science or math. She chose math and spent the next 1 ½ years finishing her certification.

When she finally had her own classroom, her only help in how to teach was the book that she was given to teach from and the *Principles and Standards*. "Because I did not go the traditional route to teaching, I knew very little about what was expected for me as a teacher. My first principal gave me a copy of the NCTM *Principles and Standards* to study. This was very eye-opening and helped me to get a feel for what was expected of me as a teacher." She spent time attempting to pair her state core to the ideas in the *Principle and Standards* and "tried very hard to include all the pieces" NCTM found valuable. "For example, in my textbook there was very little real-world contexts, but the NCTM *Principles and Standards* talks about using real-world contexts, so I tried to find as much as I could to share with my students." The first year was difficult as Denise discovered what teaching really entailed. After taking a few years to find her footing, Denise began to put her classes into groups and tried to find ways to "make math more interesting." Denise had personally learned math better when she was in groups and so she hoped that groups would help her students who were struggling.

After her fourth year of teaching, Denise moved across country and began working in the Park School District where she was given books (Connected Mathematics Project) to teach from that

> didn't look like any math book I had ever used before. It was very, very difficult and I just struggled and struggled. It took me probably three years of teaching 'connected' math books before . . . I finally felt like I was doing a decent job.

As Denise attempted to understand the program that she was teaching from, there were many resources that allowed her to succeed: district math specialists, conferences, and colleagues. "Luckily I had some really good people here at the school and in our district

that set up supports . . . that helped teach me how to be better." The district math specialist would come weekly and work with Denise. The specialist would watch the lesson and then they would spend time after school reflecting on what went well and what could be improved. Denise went to conferences every summer to understand the ideas behind the curriculum and learn how to more effectively implement the program.

> I was lucky. I went to this conference [in Michigan put on by the authors of CMP] and talked to other teachers from around the world that were teaching this curriculum, and getting some nice ideas from them on what to do.

She also "started planning more with the people in my department . . . and a couple of teachers here . . . really took me under their wings and really started helping me to see how to do this better." Collaboration was a way for Denise to talk through the difficulties of implementing a new teaching style. It also was a way to help her put together an effective lesson.

For Denise, the effort was worth it. Her students were coming up with their own strategies to solve difficult problems, the students were engaged in the mathematics, and the students were asking questions of each other that she had never seen in a classroom before. One of the great turning points was when a student was struggling. This student asked if she could come to the board and have the class help her with the problem. She began explaining what she had done and the class all came to her aid and helped her to understand where she had gone wrong. "That's a turning point I never had with a student. . . . It's powerful, it's really powerful."

In creating her reform-oriented classroom, the most powerful tool was self-reflection; reflection that centered around the mathematics in the lesson and how the students think about the mathematics. "I think these are the most important things that have helped me the most: going back and reflecting what went well, what didn't go well,

how I can improve, what would I do different next time, and making notes to myself. I have sticky notes all over my binder of how to change" the questioning for the next lesson. In Denise's case, the reflection did not happen alone. She reflected with the district math specialist, collaborated with colleagues, attended as much professional development as possible, and read research.

Books and research have been powerful for Denise. Denise discovered research through her studies as a master's student, through NCTM, and from recommendations by her colleagues. "Understanding the *Principles and the Standards* and understanding their focus has been a huge support and a good resource. They [NCTM] have some really nice books on certain strands like number strands and geometry. I started with those because they have some really nice activities and lessons and things." Denise attended a district professional development course where they studied *Implementing Standards-Based Mathematics Instruction*, a book of case studies. "We took a case study, we talked about it, we brought in students work. . . . It was really powerful for me looking at those case studies. . . . Being able to look through another's eyes at what is happening and why something is happening helped me to see mathematics in a new way."

Although much of Denise's change in teaching is centered on adopting a new curriculum, the curriculum is not what caused her to want to change. The curriculum was a tool that was in line with the ideals that Denise had for her mathematics classroom. Before Denise was introduced to the curriculum, she was already heading towards a reform oriented classroom, but the curriculum allowed the change to happen much more fluidly and quickly. "I'm not teaching the way I am because of the curriculum; I'm teaching the way I am because I believe it to be good mathematics teaching."

Eric

Eric's original plan for college was to study science: chemistry and physics. "I've always wanted to teach, but anything *except* mathematics since school mathematics was so boring." But after some personal investigation and a lecture at BYU for "gifted" high school students, Eric realized that mathematics instruction could be more and he changed his major to mathematics education and physics education. Eric was always looking for ways to connect his mathematics instruction with what he was learning in his science classes.

When Eric began teaching math in the 1980's, his classroom was very typical: "review homework, answer students' questions, present a few examples, have students try out an example or two and have students work on homework for a few minutes in class. But there always has been some kind of underpinning in my belief system that mathematics teaching should be about understanding and not just memorizing procedures and steps. I do know that I tried to do things, even those very first few years that focused on understanding not just memorization." But, the things that Eric did were very teacher based. He presented the ideas, he told his students how to understand, and he led his students through the process.

In 1989 when the *Standards* came out, Eric was excited "to see some suggestions as to what I could be doing differently to make [mathematics] more impactful in my classroom. . . . I saw in them that mathematics instruction could be more activity based, more hands on." So, Eric started to implement more activities in his classroom. Many of these activities came from NCTM publications. Eric came into contact with the *Mathematics Teacher* while earning his undergraduate degree. While working on his

masters' degree he realized "there were a lot of resources available . . . that kind of help teachers think about different ways of teaching, or at least thinking about the mathematics more deeply. Those early publications weren't as focused on discourse and how an activity could be a worthwhile task. They were more just activities."

"The *Standards* made me aware, but I didn't understand the *Standards*…. Reading the TIMSS report, it really hit me.... I realized that I was probably in that category" of teachers who thought they were implementing the *Standards* but were not. "I guess I didn't really realize that it wasn't the hands on nature of the activities that was important, but the way the tasks were designed that would help open up understanding." So, at this point, Eric began to shift his activities to tasks, focusing on "how is [the task] going to engage students in the mathematics". It was important that the tasks provide a context for the students to do mathematics, or invent some strategy to solve the problem.

As Eric was working on implementing and creating these tasks, a new teacher was hired at Freedom High School where he worked. This teacher had just finished her student teaching experience and they decided to work together. It was the first time Eric " had ever collaborated, to work with another teacher in designing a curriculum and think about how we were going to teach" His ideas for the lessons were very structured and it was this new teacher that suggested they design the lessons to be more open-ended and see what the students did with the work. "It was just a real eye opener to me. I look back at that set of work from that class and realize what a big shift that was in my thinking". Eric realized that he was being too directive of the tasks and "would step in and intervene rather than leaving it to see what they ended up doing. I think I intervened too soon before they had time to kind of think about." His attention was turned to wondering how

other teachers were able to "implement good tasks and keep them open ended" while still supporting the intended learning outcomes.

In the early 1990's Eric became the district math specialist for all grades for K-12. While at the district office, Eric continued to teach part time in his own classroom. This was valuable since he was able to apply what he was learning at the District Office to his own classroom. The position at the district office

> forced me to kind of broaden my perspective about K-12 mathematics instruction. . . . my reading and interactions with elementary mathematics . . . started to impact my secondary teaching. . . . Encountering the elementary curriculum was helping me see a piece of curriculum that I thought I knew very well and realizing that there was a lot of work going on behind the things I thought I knew. And I really didn't understand.

Eric began taking classes at BYU that focused on how elementary students thought about mathematics. "It was just a real eye opener to me that this work with elementary aged children was surfacing ideas that I hadn't thought about yet in my own teaching." He took the ideas from these classes and tried them out on his own high school students. "It was just interesting to see that high school students could respond in the same way with ways to think about these tasks, and discourse, and the big ideas rather than focusing on little fragmented step by step types of things."

Also while at the district office, Eric began to interact with other people that held similar beliefs about how mathematics should be taught. "I've had a lot of interactions with people that have had profound influences on me. It helped to hang around with other people that had similar feelings about teaching mathematics for understanding." Eric organized a math alignment committee to help create coherence among the many schools in the district. The committee met bi-weekly to look at the draft of the 2000 *Standards* and discuss how the ideas in the *Standards* could help them be more productive.

> All of us for some reason felt we were not being as successful as we wanted to be. . . . We all had these initial concerns as to why this instruction [that] we all thought was good instruction was not working, and what could the *Standards* have to say.

When in the district offices, Eric (and those he worked with) met resistance from others as they tried to bring about reform change in their district. Parents, administrators, and the school board all questioned whether the changes that were being made were in the best interests of the students in the district. "The act of defending this work required me and the members of the math alignment committee to deepen our own understanding of the reform movement in order to talk about it with 'outsiders'."

Key for Eric was exploring mathematics at a deeper level because "you have to recognize that the rules you memorized aren't deep enough. That they don't reflect real authentic mathematics." Once a teacher realizes that there is more to mathematics, it is necessary to reflect on their teaching and collaborate with other people.

> I see a lot of the collaboration that is going on . . . and I don't think it's moving people. So [just implementing collaboration] is not enough . . . . It is collaboration around case studies, and self reflection, and thinking deeper about math, and around the reform curriculum. . . . I guess I am saying [collaboration] is not the piece that makes the difference, but it is the essential piece once you start to think differently.

Laura

Growing up Laura had been good at math and enjoyed helping her friend understand. So when she got to college she graduated in Mathematics Education. "I thought I would enjoy helping all students learn math." Laura started teaching the way most mathematics teachers do: grade the homework, show a few examples from the book, show the way to solve them, let students practice, finish up with homework. But, Laura was not content with this way of teaching, it did not get her students involved in the learning of mathematics. They were observers of her understandings. Laura wanted

her students to be able to think about the mathematics, she wanted them to be problem solvers. “I was continually looking for something that would involve the students more in the mathematics instead of just taking notes and doing problems.”

Laura’s first attempt to change was to implement group work. “I knew that if I could get two kids talking about the same mathematics, they would help each other explain it and explore it.” When she started out using group work, it resembled help-sessions more than problem-solving strategies. She knew she needed something better to engage the students so when they worked together they had something they could think about and explore.

This need led Laura to implementing activities that she found at conferences and professional development courses. The students were now working together and more involved in the mathematics, but “they weren’t making connections between the activity and the mathematics that I wanted them to be learning.” Laura kept looking for better tasks in conferences, professional developments and publications by NCTM. But, she really wasn’t satisfied with just the activities. They were “just something fun that had math in it, but didn’t really help a student lean new mathematical ideas” so Laura cut back on the activities she did with her classes and turned back to more lectures, with the students coming to the board and showing their solutions and sharing their ideas.

The real change came when she became part of a math alignment committee, a group of teachers from K-12, that spent time once or twice a month discussing the draft of the 2000 NCTM *Standards*. “As we looked through the rough draft of the new *Standards*, that’s when I started to see more of a vision of how I wanted my kids to be able to think and talk about mathematics. So it wasn’t always just me telling what I

thought." Then, as the committee they started to look at curricula that were more in line with the vision that they saw from NCTM. These new curricula, IMP and CMP, allowed the students to have tasks that could be explored and discussed.

The new curricula gave Laura access to the tasks she had been searching for. She now had to turn her focus to learning how to correctly implement and guide her students through the tasks. "It was now, how do I make the curriculum do what I want it to do. . . . I personally spent a lot of time wondering how I could ask kids questions to get them to do mathematics. They would say, 'I don't get it. I don't know where I'm going.' So I looked at questioning them to get them from where there were, to where I wanted them to be. . . . I started to read articles about how people questioned. I was always looking for the next questions that I could ask them that would help them think about the problem without giving them the steps to do." Laura found these articles from NCTM journals, colleague recommendations, and online searches.

Laura began taking university classes to "learn about how children think and learn mathematics, as well as to be a better teacher." The first class Laura took "actually watched students do mathematics and then . . . discussed what [they had accomplished] and how they had done it." In subsequent classes, she spent a lot of time looking at case studies and reading literature (NCTM *Standards* and other reform publications) that focused on how students think about mathematics. The university courses gave Laura the tools she needed to analyze how students reasoned about mathematics. She was able to take the ideas from the case studies she had studied and bring them into thinking about how her students were thinking about the mathematics. The case studies also gave her tasks that she could use to elicit better reasoning in her classes.

> As I learned to think about how student's [think] about mathematics, I started to make a whole lot of connections on my own at a deeper level and [to] see how understanding one concept could help a student solve another concept better.

The biggest help to Laura was "being part of a group of people that wanted to change." This group formed a district study group, took university classes together and reflected on what was going on in their classrooms. There were times that Laura "liked the problems [from their reform curriculum], but they weren't always working as well as I wanted them to be. I started to think about what I needed to do and how to change it. How do I get my kids where I needed them to be? That happened through reflection, collaboration" and having a person that she could talk to everyday. Through working with other teachers, they were able to bring all their ideas and experiences together and help each other build the classrooms they desired.

Jason

While attending college as an undergraduate Jason took a class that required him to observe different mathematics classrooms in the local school districts. In this class, he spent time observing Eric's class and was introduced to an inquiry style classroom. After observing the class for an extended period of time, Jason realized "I can do this. It kind of got me on fire to see just by the question you ask, how you can kind of frame the learning." Jason began his internship in 2004 and was very excited to teach mathematics from a sense-making and inquiry based perspective.

> The first year in all my classes I tried to do all of this reform stuff. I followed what other teachers had done, and it didn't work quite so hot. I didn't have the realities of what teaching really is or the complexities of student thinking. . . . And so all of my illusions of reform as being perfect and it's going to make everybody learn, came crashing down.

The complaints that parents had about "how their students weren't learning, and [the students] didn't know what we were talking about" caused Jason to take 2 of his 4 Algebra 2 classes and make a 180 flip to teach them completely traditional.

> And I actually found that in the traditional classes, most of the complaining continued. They were still bored, they still didn't know what they were talking about. . . . And in the more reform [classes] they were actually engaged.

This experiment gave Jason his commitment to the reform movement.

> I always think back to which model do I want to go after. The one where they didn't learn, they didn't have fun, they hated it; or the one where they actually did okay, they learned, they had knowledge by the end.

When Jason first began teaching, his first focus was on student questioning. He realized that in order to get good thinking from the students, it would require good questions from him.

> I have a really good ability to kind of see the big picture and so I could kind of read through the assignments and see where it's going. I think I actually have the ability to try to ask the question that would lead from point A to point B. I was okay at that. My biggest problem with the questioning was I would ask this really open-ended question to the students, and they would go 'I don't get it. What's happening? What are you even asking me?' And so my big focus my first year was kind of getting it into the smaller step type questions; Scaffolding those questions to let [the students] take the next smaller step.

Jason explains that to improve at this, it took a lot of practice. "It was just practice, . . . trial and error and a lot of trial and a lot of error that went into it." Along with the practice was the collaboration with a fellow teacher, Addison. Addison helped Jason in setting the curriculum, the order, and the pacing of the classes they taught. Through talking with her and listening to her philosophy on questioning Jason was able to figure out how to phrase his questioning so that he didn't lose his students.

Another focus of Jason's was social learning. Jason believes that two heads are better than one and in order for students to really learn mathematics they must discuss

their ideas. He arranged his room so that the desks were in constant groups. He felt this would tie the learning of that group together. Later in his first year of teaching he was forced to move the students back into rows because of management problems; he wasn't able to keep 'control' over the students and they would continually be off topic. With the experience of time, Jason learned that by knowing his students better, he could minimize the management problems that he was experiencing and he was able to move his classroom back into groups. He now has acquired tables and his classes are arranged in groups from the first day of school.

Jason also emphasizes the importance of collaboration in making reform teaching possible. Collaboration for Jason includes discussing best practices with teachers at his school. "I did have huge amounts of departmental collaboration when I first started, but it has since changed to collaborating with one or two individual teachers" that have his same ideals. Being a part of NCTM has given Jason a national organization that backs up the sense-making approach that he values and opened up opportunities to discuss these values with teachers outside of his school around the state that he meets at the many conferences and professional developments that he attends.

Jason also describes getting his master's degree as one of the biggest impacts on him. Because Jason had teaching experience, he had a different take on being a student in his masters program than he did in his undergraduate program. In his graduate program, he chose to take a Statistics course. He was not excited for the course because he felt statistics was the "armpit" of mathematics. The course he took was project based and involved using real information to analyze, discuss, and conjecture. This class changed his view on statistics and he saw the value and enjoyment in studying the subject. This

experience made Jason realize that if a project based approach could interest him in a subject he hated, it could also do the same for his students.

The key to making Jason's classroom work is self reflection. "If you don't really look at what you are doing and want to improve, then change can't happen. [Self reflection] is the ultimate changer." In Jason's experience, the tools that are powerful are the tools that cause self-reflection. "I think the reform curriculum has most caused me to self reflect. Lesson study [and collaboration], which has created my kind of reform curriculum, causes reflection. NCTM is kind of an avenue for collaboration." Jason sees the resources that he has used as valuable because it has caused him to think on his own teaching and discover ways that he can help focus his lessons on building his students' understanding.

Larry

Larry has always enjoyed studying mathematics. He went to college with the intent of working towards a PhD in mathematics. After taking 2 years from his study to serve his church as a missionary, Larry realized how much he loved teaching and seeing peoples lives change as a result. "Upon returning home I decided to pursue teaching at the secondary level so that I could continue to influence young lives, and teach math because of the enjoyment I had learning math."

As an undergraduate, Larry was exposed to the vision of NCTM. His education courses discussed the 1989 *Standards,* showed portions of the TIMSS study, and engaged him in task-based learning. While watching a portion of the TIMSS video that contrasted an American lesson with a Japanese lesson he remembers thinking "Okay, we've got to change things. This is not okay."

Once Larry began teaching in his own classroom, his lessons stayed very traditional because of the "lack of support and resources that [were] aligned with the vision of NCTM." He described his typical day as "a day out of the teaching gap for a U.S. classroom: drill skills, memorize this rule, and memorize that rule."

After his second year teaching, Larry received a scholarship to attend Algebra Academy, a professional development focused on task-based learning. While attending the academy, he decided "okay. I'm throwing out the first month, where you always do three chapters out of the front of the textbook that are review stuff that the kids should already know. I'm throwing it out and doing this [Algebra Academy material] instead." His students became excited to come to class and explore and they began thinking deeply about the mathematics. Algebra Academy "gave me some ready to use activities and tasks that allowed for me to have some successful experiences to go along with the vision I began forming while an undergraduate."

Larry' experience with the Algebra Academy unit made him realize that his students were capable of thinking more deeply about the mathematics and so Larry began to focus on finding ways to "facilitate, enhance, and improve student thinking. It's all about what the kids are thinking and doing that counts." His National Board Certification, the Connected Mathematics Program (CMP) curriculum, and the Jeff Wilhelm Institute were tools that taught Larry how to focus his teaching on student thinking. The National Board Certification helped Larry see the importance of focusing on student thinking. Through his work towards achieving his National Board Certification, Larry came to understand the importance of using students' work to understand their thinking. The Wilhelm Institute was an intensive week-long professional development that helped

Larry learn how to write units that focused on "student thinking, student learning, what the kids are doing, and how do you facilitate their learning." But the Wilhelm Institute was still not enough to help change his entire curriculum.

> CMP was by far the most impactful when it came to implementing tasks in a meaningful way. I had the vision and desire from undergraduate work, a glimpse at the possibility from Algebra Academy, but did not have the full resources until a reformed curriculum was available.

The CMP curriculum gave Larry tasks that he could use in his class to emphasize his students' thinking. He described one instance of attempting to get the students to present their thinking in class:

> I asked a question and waited and waited, and finally a kid goes 'well, I think I could maybe show that.' . . . He came up to the board and took a couple of little overhead copies [and explained how he thought about the problem]. The other kids in the class were just mesmerized by him. . . . So the next period came in, and I tried to get the same thing going, but nobody would [participate]. So I just thought I would do the same thing that he did. It did not go as well at all. And I think it's simply because it was me and they automatically assume that 'yeah, you're the teacher, you already know.

Getting his students involved in the class is so important because "if other kids are the ones talking, and saying, 'This is what I'm thinking,' . . . they are 100% more engaged. They can see what their peers are thinking; they can see how their thinking compares to that."

To help bring out the student thinking, Larry spent one year focusing on his questioning techniques. He "wrote questions all over the place" so that he could figure out what types of questions were working and what questions were not. With other teachers in his school "we decided to record the questions we asked during lessons on sticky notes." By taking note of the questions he was asking and the timing of the questions, Larry

> would make revisions to the types of questions and the timing of different questions based on the student thinking they produced. This process caused me to develop an awareness of the types of questions and the timing for which asking them would best focus student thinking. I developed my ability to press on student thinking and clarify it so that [solution] strategies became more explicit and accessible for all learners in the classroom. By focusing on questioning I really improved my ability to orchestrate conversations and allow for access to greater understanding of the mathematical goals by all learners in the classroom.

Once Larry had decided to focus his classroom around student thinking, he sought help to create the classroom he desired. Larry has found professional development to be very helpful. "Some of the most helpful professional developments have been centered on case studies." These case studies have allowed Larry to reflect on how the classrooms in the studies compare to his own classroom. Larry also sees NCTM, a reform curriculum, and collaboration as key to facilitating his vision. The *Principles and Standards* from NCTM gave Larry the vision of what could be possible for him in his classroom. He also has used other books and journals published by NCTM to help him reflect on his own teaching. The reform curriculum was not the key to creating change in Larry' classroom, but it gave him a foundation he could use to build student thinking. When Larry was introduced to a reformed curriculum, he valued the curriculum because of the tasks "that [would] help give kids a context, and have meaningful experiences, and really be thinking about developing strategies for solving problems."

The key to Larry' ability to change his teaching was collaborating with another teacher. "You've got to have another person that shares the same vision. Otherwise, the amount of work, and the frustrations that come, can overwhelm . . . very easily, would overwhelm you." With his peers, he was able to have discussions about how to use the information from books, journals, or the lessons from their curriculum to help build a lesson that could emphasize student thinking.

Composite Textural Description

The Composite Textural Description is the data story of all the teachers combined. It is a generalized description of the change process for the teachers. This section describes how the stories of the six individual teachers compare to each other.

The teachers I interviewed went into teaching for many different reasons. Many teachers were like Holly who "never wanted to do anything else. . . . I always had really good math teachers and I enjoyed [math]". Denise "spent a lot of time volunteering at my children's school" and when it came time to go back to work, she was "naturally drawn to the schools". Eric went into teaching because he felt like it could be a different experience than the experience that he had as a student. Although each became a teacher different reasons, they all wanted their classrooms to be more than just listening to the teacher and memorizing their rules. They wanted the students to be engaged in the mathematics, to see how math could be useful, and to understand what they were doing. They wanted their classroom to facilitate, enhance, and improve student thinking. They wanted their students to think deeply about the mathematics.

In order for their classes to think deeply about mathematics, the teachers needed to think deeply about how students think about mathematics. "It's all about what the kids are doing and thinking that counts" (Larry). This idea of thinking about how the students were thinking about mathematics guided the teachers' decisions about the focus of their classrooms. They each tried to create classrooms that revolved around how their students thought about the mathematics, although they used many different sources to help them come to understand how students think; case studies, publications from NCTM and other books, and university courses were a few of the tools that helped. For many of the

teachers, seeing the students from other classrooms think deeply about mathematics started them pondering about how their students were thinking about mathematics. Larry and Jason were exposed to student thinking in their undergraduate programs. Larry watched portions of the TIMMS study and realized that certain classes were very different because of the student thinking that was involved. Jason observed Eric's class and was exposed to deep student mathematical thinking. Laura and Eric were exposed to deeper student thinking in university classes. They took university classes that explored how elementary students understood mathematics. During the courses, Laura thought,

> If younger kids are thinking about [mathematics], there's also got to be a way that in junior high or high school kids are also thinking about mathematics. How do we access that knowledge and help them get them to where we want them to be?

So Laura and Eric formed a district cohort that could look at student thinking from case studies and attempt to understand how they could get their students to really think about mathematics.

Each teacher came to the realization that in order for their classes to think deeply about the mathematics, they would need tasks that could elicit better thinking from their students and "engage the students in the mathematics" (Eric). The tasks needed to be more than activities that were "something fun that had math in it but didn't help a student learn new mathematical ideas (Laura)". The students needed situations where they were engaged in the mathematics, where they invented some strategies and had the opportunity to learn new mathematics. These tasks were found from many different sources: conferences, professional development, colleagues, case students, and publications from NCTM. Many of the teachers also focused on how they could use technology to create better tasks. They wondered how technology could allow students to solve more difficult

problems, or visualize and gain a greater understanding than if the students had not had the technology. The teachers added in tasks to their curriculum as they found them. Many described their curriculum as "piecemeal" as they attempted to integrate as many tasks as they can. The problem was the lessons did not flow from one topic to another and there were not over arching ideas or goals that tied learning from one topic to another.

But, what brought all the pieces together for most of the teachers was a reformed curriculum. Larry stated that he "did not have the full resources until a reformed curriculum was available". Once the teachers had an entire reform curriculum, they had lessons that flowed from one topic to the next and ways that built students' thinking across topics. Holly was the only teacher who did not have a published reform curriculum. In her geometry course, she has created her own curriculum that uses tasks to help bring out the learning. But, because the rest of her department uses traditional books, Holly was forced to teach certain topics at certain times so that she would stay on schedule. She also encountered problems because her curriculum consisted of worksheets and the parents kept pushing for a book so they would have examples of how to solve the problems. In Holly's other courses, she used traditional textbooks supplemented with tasks. These classes were more traditional looking and much of her preparation time was spent trying to find tasks that would help bring out the student learning. If she had a reformed curriculum, teaching would be "easier" since she would have tasks that would engage the students, make teaching more fun for her, and free up her planning time to focus on better teaching practices.

Before the teachers had a reformed curriculum, most of their preparation time was spent creating tasks, and working them into their curriculum. But, by having a reformed

curriculum, the teachers were able to focus their preparation time on improving other aspects of their teaching, especially their questioning techniques. At some point, the teachers realized that the questions they had been asking students were shallow and ineffective. For some teachers, participation in a professional development brought them to the realization, and for others, it was experiences in their classrooms. Through professional developments, reading books, and collaborating with others, the teachers were able to find ways to improve their questioning.

The big idea that each teacher continually emphasized was the importance of reflecting on their own teaching; and not just reflecting, but reflecting with others. “If you don’t really look at what you are doing and want to improve, then change cannot happen (Jason).” Each teacher stressed the importance that creating a support network was for them. “You’ve got to have another person that shares the same vision (Larry).” Teachers found their support at conferences, professional developments, and within their own schools. It was important for these teachers to have someone close that they could talk to regularly, even every day. Collaboration “is the essential piece” (Eric). With their colleagues, the teachers were able to form groups that found many ways to reflect on their teaching. Some took university classes together to learn how to build on their students’ thinking, some formed discussion groups to look at the current research in education. Others formed smaller focus groups to look into specific topics (e.g. action research, questioning,) or look at case studies of other mathematics classrooms. With their colleagues, they looked at what they were doing in their classrooms and how they could continue to improve towards their individual goals.

Composite Structural Description

The Composite Structural Description documents the themes that ran throughout the six Individual Textural Descriptions and the Composite Description. This description is different because it is not told through the words of the participants. It is analysis of the themes that arose from the other descriptions. The Composite Structural Description also uses language that generalizes beyond the experiences of the six participants.

Introduction

Teachers that begin the process of change have similar attributes. They feel that learning mathematics entails more than merely observing and then practicing a procedure; mathematics should be learned for understanding. These teachers also believe that students need to be invested in learning and that students can create meaningful mathematics. Once a teacher begins the process of change, they take varying paths to accomplish similar goals. This description explores the experiences that teachers have as they progress towards reform. Section I describes the guiding principle behind these desires to change and two implications of the guiding principle. Section II describes the tools that were most valuable in helping teachers create classrooms focused on student thinking. Section III concludes the description.

Section I: Guiding principle

Thinking about how students are thinking about mathematics is more than just a tool teachers use to create change; it is the underlying principle that guides all aspects of the desired change. In order for teachers to accept and come to understand the importance of the guiding principle, they need to have experiences with deep student thinking. These experiences allow them to catch a glimpse of the thinking that can be possible for their

students. Once teachers understand that their students can think deeply about mathematics, they are not satisfied with the way their classes have been taught. They begin to look for ways to change towards reform-oriented mathematics teaching. The teachers begin to look for tasks that will allow their classrooms to be centered on student thinking. The guiding principle also directs the tools that the teachers use to create reform-oriented change. Without thinking about how students think about mathematics, the tools are not effective in creating lasting change.

For students' thinking to be central in the classroom, the teacher must move from the traditional role of authoritarian and become a facilitator. Because of this shift, teachers want more than the lessons presented in traditional textbooks. Teachers must search out tasks that facilitate student thinking. Along with the tasks, they need to focus their efforts on improving their questioning techniques. This section explores the role of tasks and questioning in reform classrooms, as well as common tools used to improve these skills.

Teachers that truly want change are looking for more than summative projects or activities that make math fun, but want worthwhile mathematics tasks that engage the students on a day-to-day basis in investigating, creating, and understanding new mathematical topics. Tasks must be implemented in a way that allows students' thinking to be the center of the activity. A teacher that has not placed their students' thinking first will often implement an activity that fails to allow students to take real ownership of the mathematics. The activity may be fun and it may be different than a traditional lesson, but it is pseudo-reform.

Tasks are found in different sources. Many teachers first work with "ready-made tasks." They might attend a conference or read publications and apply the suggested tasks directly into their curriculum. Teachers can also create tasks with the help of professional developments or conferences. The tasks that are found or created are often placed into the curriculum wherever they are most applicable. The goal of a reform teacher is to find enough tasks so they can supplement each lesson they teach.

Effective reform teachers shift from telling their students how to do the mathematics to questioning the students. Teachers realize that their questions must get to the bottom of what the student does know, what the student does not know, and then direct the student towards a way to solve the problem. The teachers find value in such questioning because it allows students to continue to think about the mathematics of the lesson. If a teacher were to tell the student the next steps to take, it would take away the opportunities that the students have to think and explore the mathematics at hand. Teachers can attend professional developments that help them examine their questioning and work towards developing more substantive questions. Literature is also available to help teachers improve their questioning.

Section II: Most valuable tools

Once a teacher is committed to the change, they find the most value in collaborating with colleagues and reflecting on their lessons. Using these two tools in conjunction with the guiding principle allows teachers to create lasting change towards reform mathematics. If these tools are used outside of the context of thinking about how students think about mathematics, there is little value in the tools for creating reform-oriented change. If teachers are collaborating with others or reflecting on ideas other than

the guiding principle they may be making changes in their teaching, but the changes are not grounded in student thinking, and thus cannot lead to true reform-oriented change. A reform curriculum is another tool that allows teachers to build cohesive lessons. These three tools are used by successful reform teachers to facilitate the many changes they make.

To be able to create the classroom that teachers desire, they need to collaborate with others. Teachers need a colleague in their school that they can go to regularly to discuss the daily concerns they face—someone that can give them the encouragement needed to persevere. Teachers also need larger support networks where they can find new ideas. These larger networks can be found by attending district professional developments, becoming part of district committees, and attending state and nationwide conferences. Also by attending large scale meetings the teachers find they are part of a bigger movement where they realize they are not alone in the struggles they face as they implement changes.

Although collaboration can focus on many topics, collaboration is most valuable when focused around students mathematical thinking. When collaborating on implementing tasks, the focus of how to implement the tasks should be centered on how the task can allow for student thinking to be the center of the lesson. Teachers can also look at the "big ideas" to help write more cohesive units. By focusing on the big mathematical ideas, teachers are focusing on the most important topics that students need to be thinking about and the most productive ways to think about them. Collaboration can also look at how to better question students.

Without looking at how a teacher is personally teaching, there is no way to know how to improve. As a teacher reflects on each lesson, they are more aware of how their students think about the mathematics. This allows the teacher to anticipate some of the student thinking and prepare themselves with questions to help the students move past potential road blocks. Also, by thinking about how the students think about the mathematics the teachers are aware of the underlying concepts that are required to truly understand the topic. This reflection can take place alone, but is enhanced by working with others. When teachers unite collaboration with self-reflection they are able to incorporate others' ideas on how to improve their lessons and are made aware of shortcomings they may not realize on their own.

In the process of change towards reform, teachers become attracted to a unified reform curriculum. With a reform curriculum, teachers have the foundation they need to build up student thinking. A reform curriculum may be a published curriculum or it may be a curriculum that the teacher has developed. Until a teacher has a reform curriculum their lessons tend to be "piecemeal" and lack the flow and coherence that an entire curriculum offers. A curriculum provides the tasks and the overarching goals that free up teachers to use their time to improve other aspects of their teaching. If a teacher is in a school that does not use a published reform curriculum, it does not mean the teacher cannot teach in a reform style. Over time, teachers can write their own curriculum that fits the format their school requires, but allows them to build up understanding the way they prefer. It takes teachers years to create a cohesive curriculum for one subject. Once one subject has been completed, they must then focus on the next subject. Besides being extremely slow and time consuming, there are other downfalls. Teachers do not always

teach the same subjects and so they may not be able to have consecutive years to improve one curriculum. Also, once a curriculum is written, they may not teach that subject again. Teachers who have to write their own curriculum are more reform in the class that they are writing the curriculum for and tend to fall back on traditional practices in their other classes because so much preparation time goes into the one subject. A published reform curriculum speeds up the change and although a reform curriculum is not necessary, it is the piece that brings it all together and seems to make the change much more likely.

Section III: Remarks

Teachers attempting to implement reform take varying lengths of time to come to the point where they feel comfortable in their new style of teaching. If teachers have strong support from colleagues and curriculum, they make quicker progress towards reform. Also, teachers who are able to begin the change within their first years of teaching do not have years of a traditional teaching style to overcome and can make quicker progress. As teachers are in the process of changing, they find times when they feel like a lesson has "failed." But the teachers that truly believe in the power of reform continue to take the risks and improve a little with each passing lesson. They persist through all the struggles they face and come out more convinced of the value of reform teaching.

Conclusion

Although teachers experience change towards reform in different ways, there are common threads that allow insight into the change. Teachers are guided by the principle that the important aspect in teaching is the students' mathematics. This principle causes teachers to search out tasks and better questioning skills to bring out student thinking in

their lessons. But, each teacher does not find access to the tasks or questioning skills in the same way. Teachers find that self-reflection and collaboration are essential to continue changing their practices and that a reform curriculum can bring all the pieces together and speed up the process towards change. Without the guiding principle of thinking about how students think about mathematics, tasks, questioning, collaboration, reflection and the reform curriculum cannot lead to lasting change towards reform-oriented mathematics.

DISCUSSION

This section discusses the results of my research and how it connects with available literature. The first section, comparison to change framework, discusses the change that each teacher experienced and how it compares to the framework I previously described. The second section, comparison to reform definition, describes the differences between how reform was seen before and after the research was completed. The following five sections—guiding principle, tasks, questioning techniques, most valuable tools, and reform curricula,—discuss the generalizations from the Structural Description and its relations to the literature.

Comparison to Change Framework

Although there were variations in overall change process, each teacher experienced the same type of change—planned, continuous, internal change.

Each teacher came about reform ideals at different times, some before they began teaching and others long after, but they each made a conscious decision to begin the process, they planned these changes. Each day as they planned their lessons, they made conscious decisions to throw out some traditional techniques and include more reform-oriented practices.

In addition, many of the teachers assured me they were not done with their change, it was a continuous process. Holly stated

> For me, am I reformed? No! I was really traditional, and do I do everything inquiry? No! I'm in the middle and I don't know that I'll ever get out of the middle. Do I want to get more inquiry driven? Yes!

Holly and others felt there was never an end to the change process. When teachers in this study started to include reform ideas, they realized that they could always find some way to bring out better student thinking or improve their questioning techniques.

The teachers also discussed that the changes they made were not easy, and they personally had to be convinced of the importance of the change. They used other people to help, and for some the administration was valuable in allowing them to make the change, but the change was internal. Laura said,

> It's not always an easy path. And it has to really be something that you want to do and see, but it has to be more than just for the teacher himself. It has to be because you want students to succeed. Because if it's just for the teacher, when it gets hard, "Forget it, I'm done. I don't need this anymore. I don't need this hassle in my life." If you really see how it helps students learn better and that's your ultimate goal, that's when you persist and go, "I want this because they do better. They understand more. They can make connections. They can start to think mathematically.

Because of the difficulties of making reform changes, the decision to change cannot be forced upon a teacher. If a teacher is forced into making changes in their classroom they often will adapt the new ideas to their old ways of teaching and do not incorporate significant change in their classrooms (Cohen & Ball, 1990). For example, if a teacher that values traditional teaching is given a reform textbook, often they will not implement the lessons as the authors intend. They may walk the students through the discovery part of the lesson. They may take the lessons and tell the students the ideas and then give them the homework to practice or supplement with worksheets since the book may not have enough practice.

Although each teacher in this study took a different path towards change, they all experience planned, continuous, internal change.

Comparison to Reform Definition

When I began this research I defined reform teaching as meeting the following critical aspects of Mathematics Teaching Today's (National Council of Teachers of Mathematics, 2007) definition:

- The teacher uses meaningful math tasks.
- The teacher and the book are not the sole mathematical authorities.
- The teacher focuses on student understanding more that student computations.
- The teacher requires the students to justify their thinking.
- Lessons are discussion based and focus on problem solving.

As I conducted the observations to narrow down my potential candidates, there were teachers that fit these descriptors, but their classroom still seemed to be pseudo-reform. After analysis of the data, it is apparent that in these classrooms the primary focus was not on student thinking. This observation has caused me to reflect on the definition of reform.

Hiebert et al. (1997) described a reform classroom as more than a classroom that meets certain physical features (examples of physical features may be seen in the observation protocol in Appendix C). Their framework consists of

> five dimensions that work together to shape classrooms into particular kinds of learning environments: (a) the nature of the learning tasks, (b) the role of the teacher, (c) the social culture of the classroom, (d) the kind of mathematical tools that are available, and (e) the accessibility of mathematics for every student. (p. 2)

In order for a teacher to be the teacher described here, they must think about how their students think about mathematics. The nature of the learning tasks must be such that they allow for students to contribute their thinking to the lesson. In order for teachers to successfully implement such tasks, teachers must have previously anticipated the thinking that may or may not occur because of the task. Also, the culture and the tools that make up the classroom must allow for students to be open thinkers. They need to have a variety of tools that allow for the variety of thinking and the culture must be such that it is open to mistakes and discussion. Heibert et al. also describe that if the mathematics is not accessible to all students, the classroom will not be successful because the students will not be in a place where they can think about the mathematics.

One approach to reform-oriented mathematics teaching that focuses on students mathematical thinking is Cognitively Guided Instruction (CGI) (Fennema, Carpenter, & Franke, 1992). In a CGI classroom teachers "build on the math knowledge of your children according to what they know" (p. 5). The authors of CGI, have not created a traditional mathematics program that states what should be taught, when it should be taught, and how to best teach it. Instead they have created a program that focuses on how children think about mathematics. Through their research and experiences, they have discovered that successful classrooms are focused on the thinking of the students. Their strategy to help teachers improve their teaching is to help teachers "learn how the knowledge about children's mathematical thinking can help them learn about their own children. . . [and] how to use that knowledge to make instruction decisions" (p. 5). For the authors of CGI, a reform classroom is one that is centered around thinking about student thinking. Although there may be other similarities in CGI classrooms (i.e., the majority of classroom time is spent having the children solve problems, multiple tools are available to help solve the problems, children are not shown how to solve the problem, and there is discussion and questioning among students and between students and teachers), decisions regarding all such activities are mediated by a focus on students' mathematical thinking.

Based on this research and the research of others, it appears that the checklist type definitions of reform may not be an adequate way to describe a reform-oriented classroom, but a more accurate description would include looking for a class where the focus of such activities is the student thinking and where it is apparent that the teacher has spent time thinking about how their students think about mathematics.

Guiding Principle

The teachers in this study all found that it was most important for their classroom to focus on their students' mathematics, and it wasn't until they had accepted this guiding principle that they began to make real changes towards reform-oriented mathematics teaching. This meant that the teachers had to step away from being the authority and allow their students to explore the math. They also had to allow for student thinking to be the center of the lesson. The idea that students' mathematical thinking is most important becomes the guiding principle as the teachers plan their lessons and reflect on how their lessons went. This guiding principle is seen in Romberg and Kaput (1999) when they discuss mathematics as a "human activity" (p. 5). The authors described mathematics as being more than a path that students should follow, but it should "reflects the work of mathematicians" (p. 5).

Once these teachers adopted the guiding principle, they realized that they needed more in their classrooms than practice problems. The teachers noticed a need for instruction that focused on "mathematical concepts, multiple representations of those concepts, and connections among them" (Sherin, 2002, p. 121-122). Each of these teachers recognized the importance of tasks and appropriate questions. Tasks and questioning were used together by the teachers to improve their teaching. The use of tasks made the teachers realize the inadequacy of their questions. By improving their questioning techniques, the teacher realized the need for better tasks. The following sections describe the importance of tasks and questioning techniques in making changes toward reform-oriented mathematics teaching.

Tasks

Once the teachers in this study began to view mathematics as a human activity (Romberg & Kaput, 1999, p. 5) they began to involve the students in exploring what techniques work and why, inventing new techniques, justifying their results and reflecting on how to solve problems. For this type of mathematics to occur in classrooms, teachers needed more than practice problems, they needed tasks that could facilitate these types of activities.

Many researchers have discussed the need for tasks and what tasks should be (Hiebert, et al., 1997; National Council of Teachers of Mathematics, 2007; Stein, Smith, Henningsen, & Silver, 2009) . Worthwhile tasks "demand engagement with concepts and that stimulate students to make purposeful connections" (Stein, et al., 2009). Tasks allow students to come up with their own solution method. For a task to be worthwhile it needs to

- Be problematic for students
- Lead students through a mathematical concept
- Allow students to model the solution
- Require students to question the process and think deeply about their solution strategy
- Require students to justify their ideas
- Allow for flexible use of technologies
- Be relevant to students

Such tasks are not easy to implement and require much preparation time and practice to be able to execute effectively (Orrill & Anthony, 2003, April). All of the teachers that I interviewed encountered frustrations as they began implementing tasks in their classrooms. Common frustrations included that the students were not prepared to think about mathematics in these new ways, the students wanted to just know how to do it, parents were not accustomed to this "new" math, the extra time required to plan task

based lessons, and the extra time required in class to complete task based lessons. But, more powerful than the frustrations was the commitment each teacher had to task based learning. It is hard work, but for each of the teachers the payoff was worth the effort.

Tasks are found in different sources. Most teachers in this study first worked with "ready-made tasks." Many attended conferences or read publications and incorporated the suggested tasks directly into their curriculum. Teachers also created tasks with the help of professional developments or conferences. The tasks that are found or created are often placed into the curriculum wherever they are most applicable. The goal of the teachers was to find enough tasks so they could supplement each lesson they taught.

Questioning Techniques

When teachers in this study began implementing tasks in their lessons, they began to recognize the need to improve classroom discourse (Sherin, 2002). The one area of discourse that all the teachers described as important in their efforts to change was their questioning techniques. Once the teachers began implementing tasks they became aware of how shallow their questions often were. Stein, Smith, Henningsen, and Silver (2009) stated the importance of questioning techniques:

> Teachers can promote sense-making and deeper levels of understanding by consistently asking students to explain how they are thinking about the task. Or, conversely, they can cut off opportunities for sense-making by hurrying students through the tasks, thereby not allowing the time to grapple with perplexing ideas (p. 15-16).

Successful questioning techniques allow teachers to help students stay on task (p. 20) and help students see ways that they can organize their data, make conjectures, and test their conjectures as they attempt to solve problems.

One of the difficulties of questioning that many of the teachers in this study encountered was finding appropriate and helpful questions to ask. The students attempt to

push the teacher to break down the problem into explicit steps. If the teacher gives in and tells too much in the questions they ask their students, then the value of the task has been diminished and the meaningful mathematics is lost. The teachers I interviewed stated that they had to

- spend time anticipating student's questions so they could anticipate questions to respond with
- listen closely to their students so they could really understand where the student was in the solution process
- pay very close attention to the questions they asked their students to understand what questions were most beneficial.

Many of the teachers attended professional developments that helped them examine their questioning and work towards developing more substantive questions. Laura also described that literature was also available to help her improve her questioning.

Most Valuable Tools

Although each teacher had different experiences as they worked through their change, they all found the most value in the same tools. The teachers found that self-reflection and collaboration became the foundation for creating lasting change in their classroom.

Self-Reflection

Self-reflection was the basis for making change for the teachers in this study. The reflection they described had many different components they deemed valuable. These components included reflecting on their teaching, the lesson, and students' understanding.

When teachers reflected on their teaching, they thought about their role as the facilitator and how they can best move the class through the day. In this study, this included how they interacted with the students, questions they asked the students, and

how they presented the material. Denise described reflection as one of "the most important things that has helped me the most: going back and reflecting what went well, what didn't go well, how I can improve, what would I do different next time, and making notes to myself." When the teachers reflected on the lesson, they usually questioned how the activities contributed to the effectiveness or ineffectiveness of the lesson—was the task appropriate, was it correctly situated in what the students already understood, did it allow for the goals of the lesson to be reached, and was it appropriately difficult for the students?

While teachers discussed the importance and value of reflecting on the lesson and their contributions, they agreed that even more valuable was reflecting on their students understanding. "Sometimes teachers have a tendency to focus too much on themselves….While self-scrutiny is important, teachers can also learn about their effectiveness by scrutinizing what their students are doing" (Stein, et al., 2009, p. 28). Laura stated that

> as I learned to think about how student's [think] about mathematics, I started to make a whole lot of connections on my own at a deeper level and [to] see how understanding one concept could help a student solve another concept better.

By reflecting on how students are thinking about the mathematics, the teachers became aware of what was required for the students to understand the mathematics being taught. This reflection allowed the teachers to design lessons based around deeper mathematical understandings

Reflection can take place alone, but the teachers found it was enhanced by working with others. When the teachers united collaboration with self-reflection they were able to incorporate others' ideas on how to improve their lessons and were made aware of shortcomings they may not realize on their own.

Collaboration

The teachers in this study also discussed the value of collaboration in allowing them to make reform changes. Discovering that collaboration was powerful was not surprising since many authors have already discussed the value of support networks (see literature review). But, it was interesting to note that the teachers in this study found value in collaboration that included similar themes. Each of the teachers discussed the value in collaborating with another teacher at their same school, creating larger support networks, using student work as a discussion base, and collaborating around a specific topic that was of interest to all teachers involved.

The first theme was the need for another teacher to collaborate with *at the same school*. Teachers in this study needed at least one teacher they could go to for daily support—someone they could plan lessons with, someone they could bounce ideas off of, someone that could come into their classroom and critique, and someone that could give them the encouragement needed to persevere.

These teachers also needed larger support networks where they could find new ideas. These larger networks could be found by attending district professional developments, becoming part of district committees, and attending state and nationwide conferences. Also by attending large scale meetings the teachers found they were part of a bigger movement where they realize they are not alone in the struggles they face as they implement changes.

When teachers form these collaboration groups, there are activities that are more valuable to the teachers. The first of these activities is using student work as the basis for discussions. Laura discussed a university class where they "actually watched students do

mathematics and then . . . discussed what [they had accomplished] and how they had done it." Laura was amazed by the connections the students were able to make and the mathematics they were able to work with. She discussed these connections with other teachers and together they found ways to push their own students to the level that she saw in the students from her class.

Collaboration can also form around a specific topic that all the teachers are interested in. Larry pointed out that he and other teachers wanted to improve their questioning techniques and so together they were able to discuss effective and ineffective questions. Through collaboration he was able to learn from others how to improve. Many teachers also discussed the value of discussing current literature. Eric and Laura were part of a group that discussed the draft of the *2000 Standards*. Their discussions allowed them to see the vision of what their students could be accomplishing. They were able to discuss how to implement ideas from the readings into their classrooms and later discuss how the implementations went.

Collaboration was a valuable key to teacher change since it allowed teachers to find access to new ideas, to discuss the ups and downs of their teaching, and become a part of a larger community of change.

Reform Curriculum

Reform curricula played a different role for each teacher in the study. Although most found reform curricula after a few years of teaching, Jason started teaching from a pre-published reform curriculum the first year he started teaching and Holly still teaches without a pre-published curriculum. All teachers, except Jason, began teaching with a traditional text and began supplementing their curriculum with individual tasks or entire

units (like Larry's Algebra Academy unit). The work of creating the curriculum and writing these lessons took much of the preparation time of the teachers. With their preparation time spent writing lessons and searching for tasks there was little time for much else. When these teachers were able to adopt a pre-published curriculum, they felt much like Larry who stated,

> If there is a whole program out there that I can use, that's going to give me tasks . . . that will help give kids a context, and have meaningful experiences, and really be thinking about developing strategies for solving problems, that'd be great.

An entire reform curriculum provided the teachers with cohesive lessons that focused around big mathematical ideas. By having cohesive units, the teachers were able to focus their students' thinking around these big mathematical ideas.

If a teacher is in a school that does not use a published reform curriculum, it does not mean the teacher cannot teach in a reform style. Holly teaches in a school that has not adopted reform curriculum. Over many years she has succeeded in creating her own reform geometry curriculum. But, as with any teacher, she teaches more courses than geometry and for many years wasn't teaching geometry at all. So, she must continually prepare multiple reform curricula. Many days the lessons do not go as planned and she finds herself falling back on her traditional styles that are quicker and easier (see also Cavanagh, 2006).

> I'll be honest, some days I'll be like, 'Look, we need to do traditional . . . You have those days when you teach. There's a thousand things. What do you default to? You default to traditional. And it is the easiest thing to do.

A published reform curriculum speeds up change. Although a reform curriculum is not necessary, it is the piece that brings it all together and seems to make the change much more likely.

CONCLUSION

The following sections describe the implications of the study and directions for future research. The implication section describes what can be done to help teachers make reform oriented changes. The section on future research takes the limitations of this study and suggests what others can do to further the research into teacher change towards reform-oriented teaching.

Implications

The results of this study have many implications for professional developers, administrators, and teachers. First, in order for teachers to be successful reform-oriented teachers, they need to be guided by the principle of thinking about how students think about mathematics. Reform teachers can have many different attributes and emphases as they are guided by thinking about how their students think about mathematics. For example, Jason's lessons are extremely technology driven, but he uses the technology to allow the students to think about complex problems. Larry's classes revolve around cooperative learning, but it is not the cooperative learning that makes him a reform teacher. The cooperative learning is a resource that allows him to let student thinking surface. Once teachers believe in this principle, they need to be encouraged to form collaborative groups (and be supported in doing so), they need to be taught how to effectively reflect, and they need access to a pre-published reform curriculum that will help them think about how their students think about mathematics.

My research has shown the importance of teachers forming collaborative groups that focus on how students think about mathematics in order to create change towards reform teaching. Teachers should be encouraged to find others in their departments they

can work with as they make reform-oriented changes. Teachers also find great support by having access to wider support networks. Districts should create opportunities for discussion groups that teachers can join to discuss the concerns they face, the successes they have, and current literature that can help them progress as they make reform-oriented changes. Teachers should have time set aside for collaboration with colleagues of their choosing to discuss the topics that interest them. The results of this study support what others have found (Feikes, 1998)—collaboration and building support networks are vital for teachers to create change in their classrooms. Many Utah schools have collaboration time set aside but in general it is filled with tasks from the administration that require the entire department to meet together. These tasks fill up the time so that teachers are not free to spend the time as they see fit. As Secada and Adajian (1997) point out, for collaboration to be successful, it needs to happen with teachers that share a sense of purpose and have collective control over how their time is used.

This study shows the importance of teaching teachers how to effectively reflect. "Teachers often report that, without guidance, it is difficult to get a handle on how to think about their own instruction…they lack the coherent focus and thus experience reflection as . . . frustrating" (Stein, et al., 2009, p. 23). Teachers need to be taught how to reflect on their students' thinking. The teachers in this study learned to effectively reflect by participating in professional developments and then collaborating with other teachers on what they had learned in the courses. It would be valuable for teachers to have guidance in learning how to critically look at their teaching and at how their students understand the mathematics. Teachers also would benefit from more access to professional developments that allow them to reflect on student work.

This study suggests that in order to facilitate a quicker more effective change, teachers should have access to a curriculum that fits their changing values. By having a reform curriculum, these teachers that desire change will have tasks, lessons, and units that they can use to build the student thinking they desire. Schools and districts should offer teachers access to different curricula.

Future Research

This study had limitations that warrant further research. The small scale and limited scope of the study provide opportunities for others to investigate further.

Because this study was done as a Masters thesis, only 6 teachers and 2 school districts were included. Because of this small scale these teachers had contact with one another at their schools, at district meetings, and at larger conferences that they attended and presented at. This contact may have caused the overlap that was seen in the valuable tools. A larger study that cuts across an entire state or across multiple states may provide insights without biases of overlapping experiences, validate the tools and themes that emerged in this research, and verify if there are other valuable tools that did not emerge in this research.

As the teachers discussed their process of changing to become more reform oriented, they all mentioned setbacks and difficulties that occurred throughout the process. Research that helps us to understand why some teachers are successful in overcoming these setbacks and others return to their traditional teaching methods would be valuable. Limited data from this study suggest that if a teacher is fully committed to the guiding principle they are more likely to succeed and push through the difficulties that arise. Eric even made mention of teachers that had begun making changes with him

and then returned to their traditional ways. He stated that these teachers seemed to be overwhelmed by the misunderstandings that surfaced in teaching reform mathematics and felt they were failing. Eric stated that he valued these misunderstandings coming to light because he realized it wasn't his teaching that was causing the misunderstandings, but he was allowing for these misunderstandings *that were always there* to surface so he could help to correct them. When he didn't teach reform, the misunderstandings still existed, but because his teaching didn't focus around how his students thought about the mathematics, these misunderstandings stayed within the students and he was not given the opportunity to correct them.

Research that looks into how teachers come to internalize the guiding principle is also needed. My research showed that for some of the teachers, it was internalized by seeing deep student thinking. But, during the interviews not all teachers addressed how they came to believe so strongly in thinking about how their students think about mathematics. If we could understand how teachers come to believe so strongly in this guiding principle, we could help more teachers become more strongly committed to reform-oriented mathematics teaching.

More research that uses the framework for change could be completed. This study used the framework to help me classify the teachers experiences and only showed teachers with one type of change—planned, continuous, internal change. To better understand the change that teachers go through it would be of interest to identify teachers that have been successful in creating reform-oriented change that experienced other classifications of change.

Studies that look into the effects of reform curriculum would also be of interest. This study was not designed to look deeply into the effects reform curriculum have on the likelihood of successful change towards reform teaching. The connections that this research did surface between change and curricula brings up interesting questions: Are teachers more likely to make this change with a reform curriculum? What is the likelihood of making reform-oriented changes without a reform curriculum? What are the effects of reform curriculum on teachers beliefs about reform mathematics? Research that also examines what allows reform curriculum to be effective would be of value.

These successful teachers have given us insight into the tools that can be used to help teachers that do not know to reform their classrooms. We can see that teachers need access to self-reflection, collaboration, and reform curriculum and they need support as they learn how to implement these tools in their classrooms. Teachers need support from their administration to attend the professional developments that will teach them and support them on their road to change. Teachers need support from other teachers as they collaborate and reflect on how to improve their teaching. Teachers also need the support of further research that explores the process of change. This research will help all involved in the process better understand what can be done to help teachers more effectively transform their teaching.

Appendix A

Questionnaire

Think of secondary mathematics teachers you know who exhibit some aspects of reform-oriented teaching. These teachers may or may not be currently teaching. Keep these teachers in mind as you fill in the following table

In the **Teacher Section**, fill in the teachers' names and contact information.

In the **Attributes Section**, write in the numbers of the attributes that describe that teacher and his/her classroom. You may add any missing attributes to the list that you feel describe the teacher and/or classroom.

1. Requires justification of thinking
2. Uses meaningful math tasks
3. Is NOT the sole mathematical authority
4. Focuses on student understanding more than computations
5. Implements discussion based lessons
6. Focuses on problem solving
7. Is a reflective practitioner
8. Encourages risk taking
9. Has a deep knowledge of mathematics for teaching
10. Uses multiple teaching strategies
11. Engages all students in the learning process
12. Creates an environment of respect for all students
13. Uses technology
14. Uses a reform curriculum
15. Collaborates with other teachers
16. Utilizes group work
17. Utilizes pair work
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____

In the **Description of Teacher Section**, elaborate on why you would describe this teacher as a reform-oriented teacher.

Teacher:	Name: School: Email:
Attributes:	
Description:	

(Table has been shrunk to fit on one page)

☐ I give permission for my name to be used when these teachers are contacted

☐ I do not give permission for my name to be used when these teachers are contacted

Appendix B

Teacher Contact Email

Dear _____,

My name is Linnae Williams and I am a Masters student at Brigham Young University. I am working on my thesis and trying to document how teachers change from basing their teaching on traditional style to including a more reform-oriented approach to teaching. My goal is to find out how teachers create change so that other teachers that are looking to make change will know what other teachers have done to be successful in creating change.

To help me with my study I am looking for teachers who have changed their teaching to include reform principles. You have been recommended by _____ as a teacher that implements reform procedures in their teaching. I was hoping that you would be able to help me by participating as a research subject for my thesis. Participation in the study would consist of one observation of your class during the first month of school and two separate interviews. The first interview would take place before Thanksgiving break (and might take two sessions to complete) and the second interview would come after the first of the year.

If you could respond by (date 1 week later) and let me know if you would be willing to participate.

Thank you for your time,

Linnae Williams

2nd email if response is no

Dear _____,

Thank you for informing me that you will not be able to participate in my thesis research. I hope you have a wonderful year teaching

Linnae Williams

2nd email if response is yes

Dear _____,

Thank you so much for your willingness to participate in my study. I am looking for a small sampling of teachers with varying demographics. If you could please answer the following questions to allow me to get to know you. Once I have selected the teachers that will participate in the study I will let you know.

Thank you for your participation,

Linnae Williams

1-Gender: _____
2-Age: _____
3-Total Years Taught: _____
4-Currently teaching: High school or Junior High or Other (please specify): _____
5-Years taught in a High School: _____
6-Years taught in a Junior High: _____
7-Years taught in a _____: _____

Appendix C

Observation Protocol

Things to notice that will hint at a reform style of teaching:

Things I'll see in the Classroom

- Norms Posted that are in line with reform
- Reform curriculum
- Environment of respect and collaboration
- NCTM publications
- Other reform style publications
- Chairs to easily facilitate discussion
- Technology
- Manipulatives
- Posters on the wall

Things I'll notice about the teacher

- Requires justification and reasoning
- Questioning from teacher
- Asks for and requires student input in lesson
- Teacher using student work and thinking
- Not the sole mathematical authority
- Encourages risk taking
- Close listening
- Multiple teaching strategies

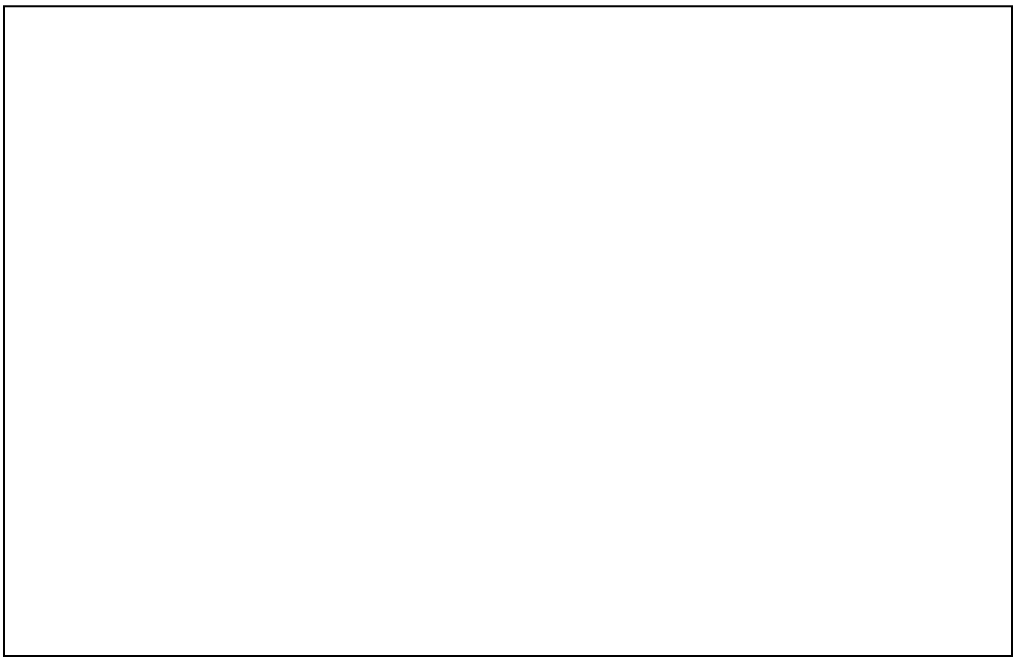
Things I'll notice about the students

- Student discussion/communicating
- Questioning from student to student
- All students are engaged
- Students helping other students

Things I'll notice about the lessons

- Balanced between procedures and concepts
- Multiple solution strategies/Multiple representations
- Engages students all lesson (not just a quick blurb)
- Connections are drawn to other ideas
- Focus on student understanding not processes
- Open-ended problems
- Project based problems
- Task requires more than one class period to solve
- Group Work
- Pair Work
- Student directed to fit their needs
- Multiple modes of assessment

Sketch the layout of the room:



General flow of the class:

Reform Principle Implemented	Where it fit in the lesson	What was involved	Who was involved	Did it seem to come natural to the students and teacher	How effective was it? Is the teacher learning or mastered that skill

Appendix D

First Interview Protocol

This interview has three phases: first, I'm going to ask you to describe your teaching when you first started teaching, before you implemented reform procedures. Second, I'm going to ask you about how you went about making changes towards reform teaching. Third, I am going to talk with you about the resources that you used to make these changes.

The goal of this interview is to discuss your process of change so that I can come to understand what resources allowed you to change. This information will help other teachers that are attempting to make reform oriented changes. The questions are designed to create a flow of discussion that is individualized to your experiences.

REMEMBER, "YOU MAY HAVE ALREADY ANSWERED THIS QUESTION, SO PLEASE LET ME KNOW IF YOU HAVE."

Describe your teaching style in your first year of teaching.
    What would a typical day look like?
    What *did* you do?
How has your teaching changed from when you first started teaching?
What made you aware of this new teaching style?
Why did you think to make those changes?
    What made you realize those were important changes?
When did you begin to make reform changes? (What year of teaching.)
How did you begin to make changes?
What helped you begin the process?
How did you know (or decide) where to begin making changes?
What was the first reform principle you remember implementing?
    How have you improved that principle over time?
Were there any setbacks that you encountered as you began the process?
    Describe these setbacks.
    What made you keep trying even though you encountered these?
    How did these setbacks affect your attempt to reform your teaching?
In your class I noticed _____ (or others have pointed out you do _____), why is that important to you?
    How did come to use that technique?
What resources have you used to help change your teaching?

Give the teacher cards with a different tool on each card. Ask them to sort them into 3 piles: never used, use occasionally, use regularly. Place all the cards then talk about them. Talk about experiences with each card, good, bad, neutral.

In regards to use regularly pile:
Can you sort them most helpful to least helpful?

How has _____ been helpful in allowing you to change?
When did you discover that using _____ might be helpful for you to change?
What is it about _____ that made it so you use it regularly?

In regards to the use occasionally:
Can you sort them most helpful to least helpful?
How has _____ been helpful in allowing you to change?
When did you discover that using _____ might be helpful for you to change?
Why do you not go to these more often?

In regards to the never used pile:
Why have you never used these tools?
Are there any of these that you wish you had taken advantage of?

If you were to help a teacher transform their teaching, which of these tools would you recommend?
Why?
Is there anything that has not come up in regards to how you've changed your practice?

Cards for sorting
These are the tools that have helped teachers create reform in their classroom.

NCTM
UCTM
Mentor Teachers
Reform Curriculum
Case Studies
Lesson Study
University Classes
Collaboration
Self-Reflection
Professional Development
Technology
Manipulatives
Exploring math at a deep level
Thinking about how your students think about the mathematics
Administration Support

Appendix E

Contact Summary Sheet

Teacher Name_____ School _____

Date of Contact_____ Today's Date _____

1. What were the main themes in the contact?

2. Which research questions were the most valuable to the discussion?

3. What ideas do you have for the next contact with the teacher?

4. How could this interview be improved?

Appendix F

Questionnaire to Accompany Descriptions

Thank you for your continued help in my study. Attached you will find a description of how I understood your experiences as you created change in your classroom. I would appreciate your help in making sure that my description is an accurate portrayal of your experience.

If you would read the description and then fill out the following questionnaire, it will help to insure that I have an accurate and complete description. Once you have completed the questionnaire, please email it back to me.

Thank you again,

Linnae

Questions:

1. General impressions of the description:
2. Do you feel there is anything I left out of your experience?
3. Do you feel there is anything I underemphasized?
4. Do you feel there is anything that is portrayed incorrectly?
5. In regards to each experience I describe (list of the experiences), did I appropriately capture what they meant to you?
    a. : bullet out the experiences listed
6. Any questions that help clarify the description

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