ASSESSMENT CONCEPTIONS AND PRACTICES OF FIRST-YEAR SECONDARY MATHEMATICS TEACHERS

by

KANITA KIMMONS DUCLOUX

(Under the Direction of Patricia S. Wilson)

ABSTRACT

Research has indicated a disparity between teachers' beliefs and their actual assessment practices. One suggested approach to understanding the mismatch is to examine the impact of teachers' beliefs on their teaching practices. The purpose of this study was to understand the factors that influence teachers' assessment practices.

Using a framework developed by Ernest (1988) describing the impact of teachers' beliefs on the teaching of mathematics; this study examined the assessment beliefs and practices of three beginning secondary mathematics teachers. Using case studies, the three teachers were observed and interviewed over a 12-week period. Data also included a collection of artifacts from each teacher.

Findings indicated that some of the teacher' beliefs were aligned with their assessment practices, and that a complex mix of influences and factors impacted the first-year teachers' assessment practices. The influences included their beliefs about mathematics and its teaching and learning, the powerful influence of the social context of teaching, and their level of reflection.

The findings suggested that preservice and inservice teacher could benefit from help implementing various assessment strategies, including alternative forms of assessment. More importantly, teachers need help developing reflective strategies so that they can improve the teaching, learning, and assessment of mathematics.

INDEX WORDS: Assessment, Secondary Mathematics Teaching, Teacher Beliefs, Teacher Reflection, First-year Teachers

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A Disserttion Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2009

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August 2009

DEDICATION

To my husband, Frank Oliver DuCloux, IV, I love and miss you - may you rest in peace and to our beautiful girls, Alexandra Jonté and Kristin Olivia, I love you and now that this dissertation journey is over, you can have your mommy back.

ACKNOWLEDGEMENTS

First, I would like to acknowledge and thank God for helping me and often carrying me through this journey towards completing my doctoral degree. I have experienced many setbacks and losses during this process, including a car accident that confined me to a wheel chair for short period of time and the illness and subsequent loss of Frank Oliver DuCloux IV: my husband, my friend, my biggest cheerleader, the father of my children, and the man who I thought would be my lifelong partner.

Frank always knew what to say to encourage me to continue when I often wanted to quit. He would say that "this degree is not just for you but it's for all of us, so that we can all have a better life so do what you need to do!" Thank you for the wonderful times that we shared, the many trips, and for our little girls, Alexandra and Kristin. You taught me about forgiveness and that life is short so enjoy it and live it to the fullest.

Alexandra and Kristin, thank you for loving me unconditionally and being patient with me during this process. You girls bring me so much joy. I am proud of both of you and I love you very much. Always remember that your daddy loved you very much and he told you daily that he loved you. He is always watching over you. Remember that God loves you too and He will always be there for you.

Mom and Bob, thank you for all of your love, prayers, encouragement and support. You helped make this dream a reality in many ways including praying me through difficult times, giving me much-needed breaks in the summer and taking us to Florida to relax on the beach. MeMe, thank you for your prayers, support and traveling to Stone Mountain to take care of your granddaughters so that I could attend conferences. Robin, thank you for your friendship, for loving the girls and me and for being a wonderful godmother to my girls. Roosevelt, thank you for your friendship, for helping me take care of the house and vehicles after Frank passed and for organizing my office so that I could comfortably work from home. I would also like to thank my wonderful neighbors for tending to my lawn, watching the house, helping me, and encouraging me to continue my studies. I also want to thank the rest of my family and friends for all of their love, prayers, support, and words of encouragement.

Dr. Patricia S. Wilson gave me my first graduate assistantship to pursue my degree full-time. Her positive emails and constant calls after the accident encouraged me to return to school as soon as possible. Upon my return, I asked her to be my major advisor and have never regretted my decision. She challenged my thoughts and helped me as I developed into a researcher and teacher educator often making it possible for me to attend professional conferences. Her constant compliments on my writing skills made me believe that I could actually write and encouraged me to work on improving my writing skills. While attending a conference in San Francisco, she shared a room with the girls and me and even volunteered to watch the girls for me one night. She also opened her home to me allowing me to spend several nights so that I would not have to travel back and forth between Athens and Stone Mountain. She has truly been an inspiration for me. I appreciate all that she did for me especially coming to visit me after Frank passed and attending his memorial service.

Dr. Dorothy Y. White who was once one of my professors is now one of my friends. We are sounding boards for each other, lunch buddies, shopping partners, and conference roommates. She taught me about university life, research, and surviving as an African-American female professor. She also opened her home to me too. I will never forget her card or words of encouragement both after the accident and after the loss of my husband. One day I hope to develop her desire "to take back the schools." She is an inspiration, source of knowledge, and role model for African-American females pursuing a doctoral degree. I want to thank her for our numerous talks and for sharing her knowledge and wisdom with me.

Dr. Nicholas Oppong has inspired and encouraged me to continue striving to do my best. He has offered his house as a place for meetings or as a refuge if I needed it. He let me know that I could always come to his office if I needed to talk. I truly appreciated his words of comfort and encouragement for me after the loss of my husband. He is also a role model and source of valuable information for men of color interested in pursuing a doctoral degree.

Dr. Nancy F. Knapp helped me think about how to better present my research findings. She offered interesting ideas and sound advice as to how to improve my dissertation. I want to thank her for her input.

Dr. Denise Mewborn, Dr. and Mrs. Jim Wilson, Dr. Heide Wiegel, and Danie Brink, thank you all for traveling to Stone mountain to attend the memorial service for my husband. Thanks to the faculty members who made contributions to the American Cancer Society in memory of Frank and for your encouraging words of comfort.

Lastly, I want to thank some of the doctoral students in the mathematics education department. I appreciate Sharren for encouraging me, struggling through Abstract Algebra with me and for providing feedback on parts of my dissertation. Thank you, Nick for allowing me to stay with you, for the lunches, and for the fun times in the office. Thanks to those who attended my practice defense, your feedback and advice made my actual dissertation defense much better.

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CHAPTER 1

INTRODUCTION

Assessment of student learning is important to the teaching and learning process. Information gained from assessment allows teachers to reflect on and make improvements to their practice. Given the importance of education and increasing student learning, teachers need to develop assessment strategies that provide the necessary information to make instructional improvements. To do this, an understanding of how teachers, particularly beginning teachers think about and implement assessment in their classroom is necessary. In an era of No Child Left Behind (NCLB) and other high-stakes tests, emphasis is on measurable student learning outcomes (Ohlsen, 2007). However, most assessments of student learning occur at the classroom level (Ohlsen, 2007). Yet, according to Stiggins, (1991, 2002) and Popham (2009), today's classroom teachers continue to receive little assessment training resulting in limited knowledge of educational assessment. As a result, the assessment practices of both experienced and beginning mathematics teachers are often limited to more traditional assessments (ie., textbook or teacher-created tests, quizzes, and homework that focus on skills and procedures) (McMillan, 2001; Ohlsen, 2007; Zepeda, 2001).

Efforts to reform mathematics assessment practices and prepare prospective mathematics teachers to assess conceptual understanding as well as skills and procedures, strongly encourage teachers change the focus of assessment and to use multiple forms of assessments. Despite the reform efforts, not all mathematics teachers have integrated multiple assessment practices into their curricula (McMillan, 2001; Ohlsen, 2007; Zepeda, 2001). Some research also shows that even recent graduates from mathematics teacher preparation programs that support and endorse reforming mathematics teaching and assessment struggle with assessment (Zepeda). Due to the increased emphasis on assessment, a number of studies have examined mathematics teachers' assessment practices including their use of alternative assessments (Borko, 1993; Flexer, 1994; Herrington, Herrington & Glazer, 2002; Lowery, 2003; McMillan, 2001, 2003; Ohlsen, 2007; Sanchez, 2001). Some researchers have also investigated the impact of teachers' beliefs and conceptions on their assessment practices (Ernest, 1988; McMillan, 2001, 2003; Stiggins, 2004; Thompson, 1984; Wilson, 1998). Other researchers have reported a mismatch between teachers' beliefs and conceptions and their actual classroom practices (See eg., Cooney, 1985; Ernest, 1988, Simmons et al., 1999). Herrington, Herrington & Glazer (2002) concluded that even when teachers' pedagogical beliefs do not translate into classroom practices, one must not conclude that their non-traditional beliefs about assessment revert to traditional practices. Related studies have suggested several factors that act as influences or constraints to teachers' instructional practices in general or to implementing alternative assessment practices in mathematics. Such factors include time constraints, external pressures, school culture, teacher's reflection level, teachers' lack of knowledge and conflicting beliefs as well as their fear of losing control of the class (Borko, 1993; Cooney & Shealy, 1995; Ernest, 1988; Herrington, Herrington & Glazer, 2002). These factors are important because they can offer a lens to understanding and improving beginning as well as practicing mathematics teachers' assessment practices.

The current study examined the assessment conceptions and practices of beginning secondary mathematics teachers. More specifically, this study examined the following questions: Since the most frequent assessment of student mathematical learning occurs at the classroom level,

1. What types of alternative assessments do first-year secondary mathematics implement?

As my research unfolded, I added the following two questions.

2. How do first-year secondary mathematics teachers conceptualize mathematical assessment?

3. What influences first-year secondary mathematics teachers' assessment practices?

Teachers' conceptions included their conceptions about mathematics, its teaching and learning, and assessment. A study of mathematical assessment without also studying mathematics and its teaching and learning is difficult since assessment is the central aspect that links the mathematics, teaching, and learning (National Council of Teachers' of Mathematics, NCTM, 1995). The teachers' assessment practices included all forms of assessment that teachers used to evaluate student learning and assess their instructional practices.

Classroom observations and interviews were conducted in three secondary mathematics teachers' classrooms. The three first-year secondary teachers were selected because they graduated from a program that emphasized learning to assess mathematics using a variety of methods and they all expressed a desire to use alternative assessment practices when they began teaching. They were observed during instruction and assessment-administration. The interviews asked teachers about their conceptions and practices. All teacher handouts including assessments, study guides, and graphic organizers were collected and analyzed for type of knowledge (ie., skills and procedures or conceptual understanding) that they assessed. The resulting data were analyzed using Ernest's (1988) model. Ernest wrote that reforming the teaching of mathematics required changing teachers' deeply held beliefs about mathematics and its teaching and learning. His model explained how teachers' stated beliefs are not always enacted because of the constraints due to the powerful influence of the social context of schooling and the teacher's level of awareness of his or her own beliefs and the extent to which the teacher reflects on his or her teaching practices. Analysis of the data indicated that some of their beliefs were aligned with their practices, and that a complex mix of influences and factors impacted the first-year teachers' assessment practices. When prompted on various assessment strategies, two of the teachers either changed their assessment practices or tried an alternative assessment approach. Understanding the influences on teachers' assessment practices can allow administrators and mathematics coaches to better understand teachers' use or lack of use of a multiple assessments and alternative forms of assessment. This understanding can also offer insight into helping teachers overcome their constraints and achieve a better alignment between their espoused non-traditional assessment views and their enacted classroom assessment practices. Since more research exists at the elementary level than at the secondary level, this study can also help teacher educators, administrators and others working with secondary teachers to acknowledge and reflect upon their beliefs and overcome the constraints, real or perceived that can hinder attempts to improve their current or future assessment practices. This study can also have implications for the structuring of secondary mathematics methods courses, the extent to which they provide prospective teachers opportunities to produce and develop particular assessment and related practices and indirectly the modes of pedagogy used in the methods courses.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Research on assessment is important to the development of mathematics instruction and curricula supporting student learning (Adams & Hsu, 1998). Adams and Hsu provide several reasons for the significance of focusing on assessment. First, improving student learning is a current and worthy focus in mathematics education and assessment is the primary means of determining student learning. Second, teachers' assessment conceptions may be incompatible with changes in assessment practices promoted by mathematics education leaders. Third, mathematics teacher educators have the potential to assist the development of teachers' conceptions. Lastly, what happens in the classroom influences the views, development, and implementation of large-scale reform. An understanding of teachers' conceptions of assessment is also important since teaching and student learning are affected by assessment systems (Crooks, 1988). The following literature review further establishes the significance of studying mathematics assessment conceptions and practices, particularly at the secondary level.

The literature review is organized into three categories: (1) assessment, (2) beginning mathematics teachers, and (2) teachers' conceptions. I summarize and critique each topic as it relates to mathematical assessment. Finally, I present the framework used to organize, collect, and analyze the data.

Assessment

Assessment Practices

The assessment of mathematics learning remained virtually unchanged throughout most of the last half century (Shulman, 1986). In most classrooms assessment was limited to evaluations such as (1) classwork where student completed practice problems that mimicked the skills and procedures demonstrated by the teacher during instruction, (2) homework that usually consisted of more skills- and procedural-based problems to be completed at home for further practice, (3) quizzes and other tests given at the end of chapters, units, and semester that were periodic assessments of skills and procedures demonstrated in class and (4) standardized tests that were normed assessments so that comparisons could be made among students, schools, districts, states, and countries. Student usually completed these assessments individually using only paper and pencil as tools (Shulman, 1986; NCTM, 1989, 1995, 2000). Traditional assessment items focused on a single skill or fact and were often presented in a multiple-choice format on a test. These assessment practices were based on the notion that learning mathematics meant mastering a series of isolated bits of knowledge disconnected from other subjects or the real world.

Berenson and Carter (1995) said that traditional assessments have contributed to students' pursuits of grades rather than pursuits of learning. They suggest that broadening the system to include alternative assessments that provide an opportunity for students to make conceptual connections and reflect on understanding can refocus students towards the pursuit of learning.

Assessment Purposes

Assessment not only links curriculum, teaching, and learning (Glaser & Silver, 1993; NCTM, 1995; Lowery, 2003) but also allows students to demonstrate their knowledge. Furthermore, NCTM (2000) states "because different students show what they know and can do in different ways, assessments should allow for multiple approaches, thus giving a well-rounded picture and allowing each student to show his or her best strengths" (p. 23). Assessments should not be used only to sort students or to identify the select few (Shulman, 1986). Traditional tests should not be abandoned since they still have a role in assessment like measuring some aspects of achievement such as factual recall (Berenson and Carter, 1995). However, they suggest that good alternative assessments give teachers a better idea of how their students think and understand and involve students in their learning and reflection on their progress. Alternative assessments can help to take the focus off of the computation, speed, and accuracy aspect of mathematics, and can help encourage mathematical thinking (Lowery, 2003) and are more conducive to developing understanding as opposed to merely developing a student's memory (Berenson & Carter).

"It is essential that mathematics teachers be informed and proactive in addressing issues of assessment in mathematics classrooms" (Lowery, 2003, p. 1). Despite the difficulties inherent in changing assessment practices, mathematics teachers can no longer afford to rely strictly on traditional formats (Lowery, 2003). Alternative assessments like portfolios, open-ended questions, focused observations and performance tasks offer more opportunities to reveal students' perceptions and conceptions of mathematical knowledge by asking them to create, perform, or produce; tap higher-level thinking; and involve problem-solving skills (Lowery).

Effects of Implementation

When researchers studied mathematics teachers who implemented newer forms of assessment, they not only reported how they implemented them but some of the effects of the implementation. Researchers reported on how the use of various assessments techniques affected students' grades, teachers' instructional practices, and students' preparation for future examinations.

Determining Grades

In their intervention study of third-grade mathematics teachers, Flexer, Cumbo, Borko, Mayfield, and Marion (1994) reported that although the teachers thought that alternative methods of assessment were interesting activities for the children, they did not give them the same weight for assessment as a computational (traditional) test. Likewise, in their dissertations, both Wilson (1993) and Nash (1993) who studied the assessment practices and perceptions of secondary mathematics teachers had similar findings. In her case study of one mathematics teacher, Wilson reported that the teacher used informal or alternative assessments like observations and interviews in her class. However it was the formal assessments like written work (homework, quizzes, tests, and exams) and external exams that were recorded in the grade book and that constituted each student's grade, with the informal methods used to inflate those grades. Later, Wilson (1994) reported that the value that teachers placed on informal assessment impacted how the students valued the assessments. For example, one secondary mathematics teacher frequently implemented writing assignments in class and for homework, student self-evaluations, and higher-order thinking questions in addition to more formal assessments. However, the students rarely completed the alternative assessments and only paid attention to the formal quizzes, tests, examinations, and an occasional homework. Wilson concluded that the teacher only grading the formal assessments suggested to the students that these assessments were valued while all other class activities and assessments were not seen as important. Consequently, this had the effect of lowering expectations of the students' work on these other class assignments and assessments and became a major determining factor in which activities the students put their energies. Similarly, Nash (1993) reported that mathematics teachers were using alternative assessments, like math journal writing and mathematics projects; however, it was the test, quiz, and homework scores that primarily determined their students' grades. In the mixed methods study by Senk, Beckman, and Thompson (1997) investigating the assessment and grading practices of 19 high school mathematics teachers, over half of the teachers reported using written tests and quizzes as the primary determinant of students' grades, with homework being the third most important contributor. Seven of the 19 teachers relied exclusively on tests, quizzes, and homework to determine the grades. Twelve of the 19 teachers reported using other assessments but they only accounted for 12% of the students' grade and usually had items that covered a single concept even though they asked higher-level questions and required the use of physical materials. Virtually none of the teachers used open-ended test items or items that could have more than one correct answer (0% -10%) and the reliance on the textbook for test items was very strong. There was no mention of teachers in these studies using tests for any purpose other than to determine grades.

Borko, Flory and Cumbo's (1993) study of third-grade teachers' ideas and practices about assessment and instruction revealed that the teachers' focused more on skills than conceptual understanding. All of their assessment strategies were quite dependent on traditional forms of assessment, particularly when it came to assigning grades. One major difference Borko, Flory, and Cumbo discovered was in how teachers kept track of information gathered during observations and listening periods. In reading lessons, the teachers had well-developed system for keeping track of the information and used the information when determining grades. However, in mathematics lessons, the teachers lacked a system for keeping track of the information and did not consider the information when determining grades.

Even though more research exists on elementary mathematics teachers' practices than on the practices of mathematics teachers at the secondary level, these findings are often applicable to the teachers at the middle school or secondary level. These studies suggested that some mathematics teachers are using informal and/or alternative assessments to determine what their students know and can do. However, the fact that many of the teachers are not grading the alternative assessments like writing assignments, projects, and higher-order thinking questions or are giving them such miniscule percentages towards the students' grades decreases their value to the students and the effort that students put into completing them. These results may also have implications for what and how mathematics teachers think and believe about assessment and its purposes.

Improving Instructional Practices

According to the NCTM Standards (1995), another purpose of assessment is to provide information to teachers' that can help them improve their instructional practices. One of the teachers from Lowery's (2003) study stated, "Assessment does alter instruction." After trying a variety of alternative assessments in her class, the teacher started experimenting with various teaching strategies like allowing her students the opportunity to play the role of the teachers and explain a lesson. She also began to implement different instructional strategies when she noticed students struggling with new mathematical concepts. In a study by Miller (1992) that examined the benefits of using impromptu writing prompts in first- and second-year algebra classes, the participants described the impact of using journal prompts on their instructional practices. The three teachers from the study used impromptu writing prompts either at the beginning of or sometimes during mathematics class. Based on what they learned about the student's mathematical understanding from their responses to the in-class, impromptu writing prompts, the teachers made adjustment to their instruction. Some of the changes included making decisions to reteach material immediately, to design and schedule a review, to delay an exam, to initiate private discussions with individual students who held misconceptions, and to use writing prompts during a lesson rather than at the beginning to ascertain students' understanding of material presented in that lesson. One example of the analysis of a student's writing implied that "factoring a binomial, like $6b^2 + 7b$, is a subtractive process". One student stated that "because $7 + b$ is $7b$ [the] b [can be] taken out". This type of misconception caused the teachers from this study to be very explicit and to provide examples when using everyday language in a mathematics context. "Specifically, discussion and illustrations of what "taken out" means in this instance was reinforced by the teachers whose students' writings revealed confusion and misconception" (Miller, 1992, p. 335).

According to Miller, (1992) writing to learn is an active process that promotes students' procedural and conceptual understanding of mathematics. The teachers discovered that although many of their students were able to manipulate numbers and symbols to produce the correct answer they did not understand how or why they had arrived at the answer. The research team, consisting of the three teachers, two university professors, one mathematics educator, and one writing specialist, concluded that the students were memorizing facts and manipulating numbers without understanding the underlying mathematical concepts. By using in-class, impromptu writing prompts, the teachers were able to identify the extent of understanding or lack of understanding of the students' knowledge. One teacher wrote, "From my students' writing, I learned that when they say they understand, they sometimes don't" (p. 334).

Bagley and Gallenberger (1992) similarly reported the impact of using student writing in their mathematics lessons. They claim that they were able to make improvements to their teaching methods based on the students' written journal responses. Flexer and others (1994) reported that 14 mathematics teachers from their study shifted their instructional practices toward using manipulative, hands-on small-group activities, problem solving, and explanations and away from using the text after they began implementing performance assessment in their classes.

These studies involved researchers using some type of intervention and then studying its effectiveness on the teachers' instructional practices. For instance, journal prompts used as an end-of-class assessment that required students to write how they felt about, what they learned and what still confused them from the lesson become viable tools for making instructional decisions. This information provided teachers with a quick synopsis of each student's mathematical knowledge and disposition as well as direction for the next lesson. The information could also be used to make adjustments and improvements in instructional practices.

Assessment, curriculum, and instruction are inextricably linked such that a change to any one affects the others. As shown in the previous studies, a change in the assessment practices can promote changes in the instructional practices. Unfortunately, there is some conflict between current reform efforts to revamp mathematics assessment and teaching practices and teachers' conceptions about mathematics' reform efforts, assessment, teaching, and learning. One place to begin affecting change in teachers' beliefs is to start during teacher education and the first years of teaching.

Beginning Mathematics Teachers

Research on beginning teachers (first 2 or 3 years) is of particular interest to the teacher education community since many beginning teachers repeatedly experience similar issues and problems. Beginning teachers, equipped with subject matter knowledge, few practiced skills, and limited planning skills experience an array of emotions – exhilaration, frustration, confusion, uncertainty and isolation (Ensor, 2001; Zepeda & Mayers, 2001). Their problems and concerns run the gamut as well – classroom and time management, presentation of content, curriculum development (Adams & Krockover, 1995), administrative and teaching responsibilities (Forgasz & Leder, 2006), planning (Brown, 1993) and transitioning from student/preservice teacher to beginning teaching (Ensor, 2001; Cady, Meier, & Lubinski, 2006).

In the Zepeda and Mayers' (2001) qualitative study of 31 first-year teachers that included 8 first-year mathematics teachers, the teachers found the assessment of students to be problematic for several reasons. For instance, the first-year teachers thought that traditional pencil and paper tests were not adequate to assess gains in student learning. However, Zepeda and Mayers reported that performance-based assessments, based on what students could do - were missing from the teachers' assessment practices since the teachers relied on individual seatwork to maintain classroom control. They also feared losing control of the classroom-learning environment. Analysis of the data revealed two reasons to explain the difficulties experienced by these teachers – diverse instructional strategies were not used to promote student learning and the first-year teachers lacked a sound working knowledge of how to implement diverse learning strategies that would allow for more authentic types of assessment. One first-year teacher stated, "The grade book doesn't lie ... grades tell a story of what has been mastered ... what the student knows (p. 7)."

When the first-year teachers tried using assessments other than paper-and-pencil assessments, they encountered many struggles. They were not confident with assigning a value on assessments "other than what could be handed in and graded. (p. 7)". Or as one beginning teacher commented, "Keeping grades other than test and quizzes just becomes too complex (p. 7)." Some teachers thought that they were the only ones capable of providing an accurate assessment of students' learning and thus would were not open to student self-assessments. For example, one first-year teacher believed that "students should be able to assess their own work" and that student self-assessments provided stronger evidence of student learning, (Zepeda & Mayers, 2001, p. 7), she could not relinquish the thought that it was her duty to be the final judge in assessing student learning. Another first-year teacher indicated that he would not be in a defensible position if a student or parent challenged a semester grade when using assessments other than paper-and-pencil assessments. The first-year teachers' assessment problems were furthered complicated by the administration's stressing accountability and student achievement.

Zepeda and Mayers (2001) concluded that the first-year teachers not only lacked experience with designing activities that could be alternatively assessed and but also felt the pressure of accountability and thus "played it safe" and only used paper-and-pencil assessments. The results from this study may apply to other first-year teachers however one difference was that these first-year teachers were teaching on a block or extended teaching schedule.

In Benken's (2005) investigation of the role of two beginning secondary mathematics teachers' beliefs in shaping their practices, she reported that using teachers' beliefs as a lens to study teachers' practices was not sufficient to completely explain the complex nature of teaching. Thus she simultaneously investigated teachers' actual practices and other contextual factors (eg., subject matter knowledge, social context of schooling, perception of mathematical ability) to understand the role beliefs and other factors play in influencing teacher practice. She concluded that, *"aspects related to mathematics* [italics in original] (beliefs about mathematics and mathematics learning, depth of knowledge of mathematics, and perceptions of mathematical ability) were pivotal in shaping teachers' practices" (p. 3). For example, Laurie's (a third-year teacher) traditional views about mathematics and its learning, limited conceptual knowledge, and low self-efficacy related to teaching high level mathematics, resulted in teacher-centered lessons and discussions reinforced memorized skills and procedures. On the other hand, James' (a first-year teacher), strong understanding of the content, confidence in his ability to learn mathematics and belief that mathematics involved making connections and using multiple approaches to solve problems, were evident in his emphasis on students' verbal and written communication during both whole-class and small group discussions and encouraging students to use and construct multiple approaches to solve and generate new problems.

Feelings of isolation and perceived constraints were characteristic of the mathematics teachers in Ensor's (2001) study of seven first-year teachers. Four of the seven beginning teachers taught in schools where there was little sharing of resources among teachers and they worked in relative isolation. One teacher commented: "I have felt very alone in the department, like I don't really know what's going on. I don't know if I'm doing the right thing" (p. 308). The other three teachers shared their frustrations about constraints imposed by other teachers regarding instructional materials to use, such as worksheets to assign or tests they were obliged to administer. On the other hand, they commented on the benefits of working with highly experienced teachers who shared materials and allowed them to make contributions to communal ideas and materials.

The first-year teachers' instructional practices were constrained by their perceptions of their students as learners (Ensor, 2001). Based on the analysis of the interviews and videotapes lessons, Ensor developed two categories of pedagogic approaches: *interpellator* and *relayer* [italics in original]. Ensor classified three of the teachers, relayers since they used an instrumental approach by emphasizing procedures and rules and reducing the complexity and interconnectedness of mathematics. The teachers justified their approach to teaching on the grounds that their students lacked the ability to grasp conceptual ideas and were poorly behaved. Another teacher taught in a similar manner but did not emphasize the characteristics of his students in the interviews. Two teachers fell into both groups. When teaching younger and less able students, they were relayers. However, when teaching more mature and more able students, they were interpellators who emphasized mathematical connections and conceptual understanding. Only one teacher consistently focused on developing conceptual understanding for all of her students.

Beginning teachers are often overly concerned about the subject matter content and their teaching of it (Rodgers, 2002). New teachers often totally miss what is going on around them – most important, the learners and their learning (Rodgers, 2002). Rodgers also suggested that beginning teachers might have difficulty distinguishing between the two questions -- "Where was the learning in today's lesson?" and "What did I teach today?" According to Rodgers, the more important question is the first question since it depends on a teacher's ability to make observations about student learning without being preoccupied with subject matter knowledge or the lack of subject matter knowledge.

The literature on beginning mathematics teachers illuminated the number of difficulties that they face and the factors that contribute to those difficulties and impact their practices (ie., beliefs, constraints). These studies also raise important questions concerning the education of teachers suggest that researching them is viable to making improvements in teacher education, professional development, and educational policy as well as in increasing the mathematical achievement of all students.

Teacher Conceptions

Pajares (1992) views beliefs as speaking to an individual's judgment of truth or falsity of a proposition. All teachers hold beliefs about their work, their students, their subject matter, and their roles and responsibilities. Many of the beliefs held by teachers and others are well established by adulthood and are very hard to change unless proven unsatisfactory (Pajares, 1992).

Thompson (1992) examined how teachers' beliefs and conceptions affect their instructional practices. Two conclusions were that

> "belief systems are dynamic, permeable mental structures, susceptible to change in light of experience' and that the 'relationship between beliefs and practice is a dialectic, not a simple cause and effect relationship." (p. 212)

Thompson (1992) also reported that many inconsistencies were found between teachers' beliefs and conceptions and how they taught.

Changing teachers' beliefs requires more than just a single training course or staff development class (Pajares, 1992; Thompson, 1992). The views described above relate to teachers' perceptions in general. The next section will focus specifically on mathematics teachers' perceptions of assessment.

Mathematics Teachers' Assessment Conceptions and Practices

Several studies have examined mathematics teachers' conceptions of assessment. The studies range in form and size from qualitative studies with few participants to mixed methods studies to large-scale quantitative studies. In the following brief review of the literature on teachers' conceptions of assessment one can also see the influence of teachers' conceptions of mathematics, teaching, and learning on their assessment conceptions and practices.

A survey study partly designed to address associations between twenty-one upper elementary mathematics teachers' beliefs and their classroom practices, showed that their beliefs were consistently associated with the reported practices (Stipek, Givvin, Salmon, & MacGyvers, 2001). For example, teachers with traditional beliefs reported having traditional practices. The study also found a significant association between the teachers' self-confidence as mathematics teachers and their students' self-confidence. The data sources were limited to teacher self-reports and did not include actual observations of classroom teaching.

Lowery (2003) found that change in teacher beliefs and/or practices can occur through reflection and discourse. Participation in learning activities that encouraged deep reflection and discourse led the teachers from her study to confront their own perspectives about the nature of mathematics. Teachers then developed a better conceptual understanding as they explored mathematics topics to better inform instruction and assessment. Eventually, they acknowledged that their current testing procedures were inadequate and realized the need for further research. This realization led teachers to conduct their own personal action research, and they discovered why there was a need for reform in assessment.

Philippou and Christou (1997) investigated the assessment conceptions of 762 Cypriot and Greek 5^{th} and 6^{th} grade mathematics teachers. Using a 37-item mailed questionnaire and 10 semi-structured interviews, they sought to answer questions about the role of assessment, grading criteria, most common item format and objectives tested, and alignment of assessment and instruction. Their data analysis showed that both groups of teachers thought that the main purposes of assessment were to determine students' difficulties and to assess the effectiveness of instruction. Cypriot and Greek teachers used a variety of criteria to determine students' mathematics grades including class participation, performance on classwork, test scores, and student effort. The teachers reported using a variety of test item formats including but not limited to items for understanding, novel problems, items requiring applying concepts to novel situations. The teachers' answers showed a high correlation between their assessment practices and instruction. Their responses also indicated that their tests included investigations, applications problems, and problems similar to textbook problems more than problems that require the use of algorithms. Philippou and Christou concluded that though the teachers thought that assessment was good for determining the effectiveness of instruction, they were reluctant to change their instructional practices or modify the curriculum when the results were unsatisfactory without permission from their superiors. The teachers' responses were limited to common assessment approaches since the questionnaire did not include items about new assessment techniques such as projects, portfolios, and interviews. The study was limited in that it did not include actual observations of classroom instruction.

Delandshere & Jones (1999) examined the assessment conceptions of three elementary teachers in the context of their teaching. After conducting 14 in-depth, individual interviews over the course of three months, Delandshere and Jones made three assertions about the teachers' beliefs about assessments. First, teachers' beliefs are shaped by externally defined functions and purposes of assessment. More specifically, the teachers viewed assessment as having three main purposes: 1) to place students in the appropriate mathematics class, 2) to formally describe student achievement and defend their grading system, and 3) to prepare students for state-mandated tests. During the interview, they expressed dissatisfaction with their current traditional instructional and assessment practices. Similar to other studies (eg., Nash, 1993; Wilson, 1993,1994) the teachers seemed to distinguish between formal assessment, which resulted in grades, and informal observations that were not used to determine students' grades. Second, teachers' beliefs about assessment were influenced by their perceptions of the official curriculum and of the relevance and difficulty of mathematics. The teachers reported struggling with the mathematical content and thus felt safer adhering to the official curriculum that focused on skills and procedures. Third, their understanding of students and how they learn shaped the teachers' views about assessment. The teachers' comments revealed their notion that student learning was based on a fixed level of ability. Delandshere and Jones concluded that the combination of the teachers' perception of an externally defined assessment and skill-based curriculum, their limited content knowledge, and view of fixed learning ability resulted in summative assessment practices similar to the state-mandated assessments. The teachers' assessments were aligned with their instruction since both were skill and procedure-based. The beliefs and practices that these teachers or other teachers hold can act as either a barrier or facilitator to the teacher's assessment practices and to their attempts to reform their practices.

Cooney and Shealy (1995) reported similar findings in their study of a group of five 7-12 grade teachers who participated in 3-year project to support the rethinking of their assessment practices. The teachers in their study had assessment conceptions and practices that were aligned with their mathematics and learning conceptions. For example, three of the teachers' believed that mathematics consisted of computation, problems, skills, and concepts. Consequently, their tests were primarily computational in nature. On the other hand, the two remaining teachers viewed mathematics as a puzzle, challenging, analytical, patterns or colorful and regularly involved their students in open-ended projects or concentrated more on process than procedures. This type of thinking was reflected in their view of assessment as getting a better understanding of how students think or determining what goes on in students' heads. Cooney and Shealy also reported that the teachers with peripheral beliefs about learning were more likely to change those views and subsequently change their assessment conceptions and practices than those with deeply seated views. They concluded that the "nature of belief systems – central beliefs about mathematics and learning … have critical effects on the ability of teachers to rethink and change their [assessment] practices" (p. 7).

Brown (2002, 2003) reporting on data from his dissertation study that surveyed 525 teachers' instructional conceptions developed a four-factor assessment conception model using structural equation analysis. Four main instructional conceptions were identified; assessment influences learning and improves education, assessment is an external imposed tool that measures surface learning, student-centered deep learning can not be assessed, and teaching for society and life. Some teachers from this study agreed that assessment not only influenced their teaching and student learning but also has the ability to improve both.

Brown's (2002, 2003) model could be used to describe the teachers from Cooney and Shealy's (1995) study. The first three teachers from Cooney and Shealy's study, who used computational tests, used assessment as an external tool to measure surface learning since they mainly assessed skills and concepts. The remaining two teachers, who focused on process and used open-ended projects, viewed assessment as a means to influence learning and improve the education of their students.

These studies highlight some factors that can have a direct influence on teachers' assessment conceptions and practices (i.e., teachers' conceptions of teaching, learning, mathematics, curriculum; external influences; peripheral vs. deeply-rooted beliefs). Understanding teachers' conceptions of assessment in isolation from their conceptions of teaching and learning will only provide a partial understanding of teachers' significant educational beliefs (Brown, 2003). Conceptions of teaching and learning are significantly influenced by experiences with mathematics and years of schooling prior to entering the formal world of mathematics education (Thompson, 1992). The relationship that exists among teachers' conceptions of teaching, learning and assessment is of particular interest and was part of the focus of this study. The next section will briefly discuss some literature on teachers' conceptions of teaching and learning as related to assessment.

Teachers' Conceptions of Teaching and Learning

A study of teacher's beliefs about teaching is often combined with a study of their beliefs about learning since the two are inextricably linked. These beliefs of teaching and learning tend to be a collection of deeply held conceptions and views generated through years of experience in the classroom (Handal, 2003; Thompson, 1992) that are perpetuated in their teaching experience (Handal) and may have a profound affect on how they assess student learning.

Teachers' Conceptions of Learning

Entwistle (2000) proposed using the surface-deep approach to examine teachers' conception of learning. Teachers who critically examine new facts and ideas, tie the ideas into existing cognitive structures and make numerous links between ideas implement a deep or preferred approach to learning. Here the intention is to extract meaning thereby producing active learning processes that involve relating ideas and looking for patterns and principles (Entwistle). On the other hand, teachers use the surface approach to learning when they uncritically accept new facts and ideas and attempt to store them as isolated, unconnected items for recall at a later date. The intention here is just to cope with a task (Entwistle). A third category, the strategic or achieving approach, was later added which can be defined as a very well organized form of the surface approach in which the motivation is to obtain high marks (Atherton, 2005). Here learning is viewed as a game in which the acquisition of technique improves performance. Teachers' instructional practices can foster or encourage a particular approach to learning.

Teachers can facilitate deep or surface learning through the use a various assessment methods (Entwistle, 2000). Teachers who want to encourage deep learning can use assessments that require thought and require ideas to be used together versus isolated bits of information. Teachers can establish trust by being consistent and fair in assessing stated learning goals. On the other hand, teachers who assess for the acquisition of independent facts, which is typical in many traditional mathematics classrooms, tend to foster surface learning. Brown (2002) argued that teachers who believed that the purpose of assessment was for accountability purposes only measured surface learning of isolated facts. This view of assessment impacts the type of assessments used which in turn effects or encourages the surface approach to learning. Unfortunately, this happens often in many mathematics classrooms.

Teachers' Conceptions of Teaching

One way of describing teachers' conceptions of teaching is to use one of two different models: teacher-centered or student-centered. Samuelowicz and Bain (2001) call the teaching-centered model one that involves imparting information, transmitting structured knowledge, and providing and facilitating understanding. The second model is the student-centered model that emphasizes conceptual understanding. It can also be classified as helping students develop expertise, preventing student misunderstandings, negotiating meaning, and encouraging knowledge creation (Samuelowicz & Bain).

The primary school teachers from Brown's (2002) study strongly agreed with student-centered conceptions of nurturing, apprenticeship, and developmental teaching more so than the teacher-centered transmission approach.

Theoretical Perspectives

Drawing on the literature about beliefs, Ernest (1988) suggested that three key elements impact teachers' beliefs about the teaching of mathematics: (1) teachers' mental schemas, particularly their beliefs about mathematics and its teaching and learning, (2) the social context of teaching and the (3) teachers' level of reflection. Ernest asserted that mathematics teachers' have one of three philosophies about mathematics: instrumentalist, Platonist and problem solving. He described instrumentalist teachers as having a view that mathematics is merely an accumulation of facts, rules and skills to be used to pursue some external end. Thus an instrumentalist considers mathematics a set of unrelated but utilitarian rules and facts. The second group of teachers consists of those who possess a Platonist view of mathematics as a fixed but unified body of certain knowledge. For them, mathematics is discovered, not created. Ernest's third group of teachers has a problem solving view of mathematics as dynamic, continually expanding field of human creation and invention, a cultural product. They view mathematics as a process of inquiry and coming to know, not a finished product, for its results are always open to revision (Ernest). In addition to a teacher's beliefs about mathematics, Ernest thought that their beliefs about their role in the classroom and their use of curricular materials in mathematics were also of central importance to their instructional practices. Ernest further classified mathematics teachers based on their role in the classroom. A mathematics teacher whose role is to ensure that students master skills to correctly perform them when necessary is an instructor. When a teacher focuses on students having a conceptual understanding of mathematics with unified knowledge, then the teacher is an explainer. When the role of the teacher is to build students into confident problem posers and problem solvers, then the teacher is more of a facilitator in the mathematics classroom. Ernest also described three patterns of a teacher's use of the curriculum. Ernest did not give curriculum uses names but I will for convenience (strict follower, modifier, constructor). A strict follower does not deviate from the text or scheme rarely if ever seeking other sources for lessons, activities, and/or problems. The modifier uses the textbook but make modifications where necessary to enrich the lessons with additional problems and activities. A constructor may individually or in cooperation with fellow mathematics teachers create a new mathematics curriculum.

Closely associated with mathematics teachers' beliefs about mathematics, their role, and the use of curriculum, is their belief about learning and students (Ernest, 1988). Ernest described two views of the process of learning: (1) learning as passive reception of knowledge where the student is viewed as compliant and submissive and (2) learning as active construction where the teacher attempts to develop autonomy in the student and their interest in mathematics. Ernest identified two models of learning within each process of learning. Figure 2.1 summarizes Ernest's classification of teachers and their beliefs.

Relationships exist between teachers' views of mathematics and their models of its teaching and learning (Ernest, 1988). Ernest provided three examples of possible links. First, the instrumentalist view of mathematics is likely associated with the instructor model and with strict following of the text. It may also be associated with the child's compliant behavior and mastery of skills model. Second, the Platonist view of mathematics as a unified body of knowledge is likely associated with the view of the teacher as explainer and with the learning as reception of knowledge. Third, the problem solving view of mathematics is likely associated with the view of the teacher as a facilitator and with learning as active construction of understanding, possibly even as autonomous and confident problem posing.

Beliefs	
Mathematics	**Instrumentalist:** Mathematics is an accumulation of facts, rules and skills to be used in the pursuance of some external end. Thus mathematics is a set of unrelated but utilitarian rules and facts. **Platonist:** Mathematics as a static but unified body of certain knowledge. Mathematics is discovered, not created. A global understanding of mathematics as a consistent, connected and objective structure. **Problem Solving** Mathematics as a dynamic, continually expanding field of human creation and invention, a cultural product. Mathematics is a process of inquiry and coming to know, not a finished product, its results remain open to revision.
Teacher's Role	**Instructor:** Mastery of skills with correct performance. **Explainer:** Conceptual understanding with unified knowledge. **Facilitator:** Confident problem posing and solving.
Curriculum Usage	**Strict follower:** No deviation from the text or scheme. **Modifier:** Modifies and enriches text with additional problems and activities. **Constructor:** Teacher or school construction of the mathematics curriculum.
Learning	**Passive Reception of Knowledge:** (1) Compliant behavior and skill mastery model (2) Reception of knowledge model **Active Construction of Knowledge:** (3) Active construction of understanding model (4) Exploration and autonomous pursuit of student interest model

Figure 2.1 Summary of Ernest Teacher Belief Classifications

The links and relationships described above are subject to the constraints of the school context and are transformed in the classroom (Ernest, 1988). Ernest suggested a distinction between espoused and enacted models of teaching and learning mathematics due to the mismatch often observed between the two models. He provided two major reasons for the mismatch: (1) the powerful influence of the social context of schooling and (2) the teachers' level of consciousness of her or his own beliefs.

Social Context

First, the influence of the social context results from the expectations of others including students, parents, fellow teachers and administrators and the school curriculum including the text, system of assessment, and the overall system on schooling. Due to these sources, teachers often internalize a powerful set of constraints that affect their enacted models of teaching and learning mathematics. Ernest thought that the constraints were so powerful that teachers in the same school but with very different espoused beliefs about mathematics and its teaching were often observed to adopt similar enacted practices.

Reflective Thinking

Second, Ernest thought that a teacher's level of consciousness of her or his beliefs and the extent to which the teacher reflected on her or his practices impacted the teacher's practices. Ernest outlined five elements of teachers' thinking and its relationship to practice.

1. Awareness of views and assumptions about the nature of mathematics and its teaching and learning.
2. The ability to justify views and assumptions.
3. Awareness of viable alternative views and assumptions.

4. Context-sensitivity in selecting and implementing appropriate teaching and learning strategies based on espoused beliefs.

5. Reflectivity or being concerned to reconcile and integrate practices with beliefs and to reconcile conflicting beliefs.

Ernest also showed links between teachers' beliefs and their level of thinking. For example, the adoption of the role of a facilitator in a problem-solving classroom requires reflection on the roles of teacher and learner, on the context suitability and possibly on the match between beliefs and practices. On the other hand, an instrumentalist view of mathematics and associated models of teaching and learning requires little self-reflection or awareness of the existence of viable alternative views.

Ernest (1988) concluded that the autonomy of a teacher depends on three variables: beliefs, social context, and level of thought. Critical use of the text is a key indicator of autonomy and beliefs can determine if the teacher critically uses the text or not. How the teacher negotiates the social context of schooling can also affect the autonomy of the teachers. Lastly, higher level thought, like self-evaluation, is another key element of autonomy.

Ernest (1988) did caution the reader that due to constraints and opportunities of the social context of teaching, there is a possibility of a mismatch between a teacher's set of mathematics-related belief and their practices.

CHAPTER 3

METHODOLOGY

Previous research on teachers' assessment practices in mathematics has focused on mathematics teachers' attempts to reform their assessment strategies or on a teachers' use of one particular strategy (i.e., open-ended items, portfolios, writing tasks). The present study focused on the analysis of three beginning secondary mathematics teachers' instructional assessment strategies as well as explored their beliefs about mathematics and its teaching and learning that influenced their assessment practices in mathematics. The nature of the research questions and the interest of the researcher led me to use a qualitative design to analyze the mathematics teachers' assessment strategies and to explore their beliefs. For this study, the interpretive case study was suitable to explore the teachers' beliefs about assessment because of the nature of belief systems. In this chapter, I describe the selection of the participants, data collection, data analysis, and other methodological issues.

Participants

Three first-year secondary mathematics teachers were selected for this study. The criteria for selection were: to be a recent graduate from the same university in the southeast; took similar courses during their teacher preparation; be willing to discuss and share their beliefs about assessment and discuss their actual assessment practices. The teachers also expressed a commitment and desire to use alternative assessment when they began teaching in the fall. To achieve this goal, I used a purposive selection of participants. Silverman (2000) explained that "purposive selection allows us to choose a case because it illustrates some feature or process in which we are interested" (p.104). Because the initial research questions in this study concerned first-year teachers' use of alternative assessment practices and their beliefs concerning assessment, choosing teachers who qualified as first-year teachers and who expressed an interest in using alternative forms of assessment indicated that they would be good candidates for the study. Initially three participants - Jack, Angel, and Rhonda [1]- were selected for this study from one of two secondary mathematics methods courses that included a field component that was taught in the fall of 2005. Because I taught one of the two field components classes, I had access to the three prospective teachers and had opportunities to discuss their plans for teaching in the fall. My initial interest was in studying beginning teachers' use of alternative assessment practices thus three participants were selected because they expressed an interest in using some form of alternative assessment when they became first-year secondary mathematics teachers in the fall of 2006. During the fall, my class spent more than three class periods discussing alternative assessments in mathematics. Students wrote and presented modified versions of traditional test items that were more open-ended, required more reasoning skills, had realistic contexts, and/or required the use of technology. Additionally, during the spring 2006 semester of student teaching, which occurred the semester following the methods course, all of the student teachers were required to provide samples of alternative assessment they had used as well as student work samples.

Due to circumstances beyond my control, I had to change one of the participants. During the fall 2006 semester, one of the three participants, Rhonda, took a part-time position teaching mathematics at a local high school. Initially, this did not concern me and I still planned to have her as a participant. Rhonda continued to teach part-time during the second semester when she normally would have been student teaching and then continued to teach part-time in the fall of 2006. Recall that the targeted population was first-year full-time secondary mathematics

[1] The participants' names and the names of the schools are pseudonyms.

teachers, so Rhonda no longer fit the criteria. In the fall of 2007, I enlisted Angel and Jack's help in locating a third participant. Angel suggested that I ask Karen who graduated with Angel and Jack and taught at the same high school as Angel.

Karen, a recent graduate from the same university who took similar courses during her teacher preparation, and was also full-time mathematics teacher during the fall of 2007 become my third participant. I emailed Karen, explained the requirements and purpose of my study and asked her to consider being a participant. Later, during a telephone conversation, Karen expressed an interest in using some alternative forms of assessment in her mathematics classes and agreed to participate in the study. Karen fit the criteria to be a participant and the fact that she also taught at the same school as Angel helped with the logistics of data collection.

In July, I completed the university required Institutional Review Board (IRB) training, obtained my IRB certificate and IRB approval to complete the study. In October, the school district and participating schools granted permission for my study. Now with three participants and approval to conduct my study, data collection commenced.

Data Collection

In December, I met with the participants to obtain their teaching schedules for the spring and to arrange observation times. In January, I explained the focus and intent of the study again to each of the participants again and asked each one to sign a consent form expressing their agreement to be a participant in the research study. Each one readily agreed. Two of the participants expressed excitement to be participating in a dissertation study, especially a study by a former instructor. Karen agreed as well but did not express as much excitement as my former students about participating. After collecting the signed consent forms, data collection began with a short informational survey prior to classroom observations that was emailed to the participants in January of 2007. After waiting almost two weeks for the surveys and only receiving one semi-completed survey from Angel, I decided to begin classroom observations in late January of 2007. However, after a few weeks of data collection, it was clear that the teachers were exclusively using very traditional forms of assessment. When asked about their future use of alternative assessments, they were skeptical about using them later in the semester. Thus, the focus of the study and hence, the data collection changed to examining and analyzing the assessment practices that they actually used while still exploring their beliefs.

Data Sources

The data sources included six interviews, including five informal interviews and one in-depth interview, fieldnotes, an average of 26 hours of classroom observations per participants, and a collection of artifacts. The following section includes a rationale and description of each of the data sources.

Interviews

Informal interviews and a more formal, in-depth interview allowed me to understand the teachers' classroom assessment practices and to probe the teachers' beliefs. The interviews provided the teachers with an opportunity to share their thoughts about mathematics, teaching, students, assessment and other areas of interest. Punch (1998) explained that it was a way of understanding the complex behavior of people without imposing any *a priori* categorization that might limit the field of inquiry. Furthermore, "the unstructured interview is a powerful research tool, widely used in social research and other fields, and capable of providing rich and valuable data" (p.178).

The first five interviews were called informal due to timing of the interviews not the type of questions. The informal interviews occurred between classes, after instruction but before the end of class, and/or during planning or lunch periods. For instance, an informal interview can begin before class starts, continue after instruction and finish during a planning or lunch period. The questions were preplanned but other questions arose either in response to a prompt or a reaction to an event that occurred in class. Fieldnotes were taken during the informal interviews and later typed. In May, over a month after the last observation, I returned for the final in-depth interview with each participant that took place without interruptions.

Due to time and school schedules, some of the informal interviews differed for the teachers (e.g., not enough time to address all of the questions with each teacher during the visit so the questions were asked at a later time) (See Appendices for the interview protocols). Also additional questions occasionally arose either from a response to an interview question or from something that happened in class during a classroom observation causing the informal interviews to differ.

The first three interviews focused on the teachers' beliefs about mathematics and mathematics teaching and learning. In these interviews, I asked questions such as, "What does it mean to know mathematics?" and "Would you say that mathematics was discovered or invented?" I also asked about learning mathematics. For example, I asked teachers how they felt about cooperative learning in mathematics and to describe the best environment for mathematical learning. The fourth informal interview focused on mathematics assessment. In this interview, I asked teachers about their assessment practices, including defining assessment in mathematics and stating the characteristics of a good assessment. I also asked the teachers to analyze some items from one of their tests or quizzes and determine the level of each item. The fifth informal interview also focused on mathematics teaching and assessment. In this interview, I asked teachers questions about the best way to assess understanding of skills and understanding of concepts and their ultimate responsibility as a mathematics teacher. I also asked the teachers to choose from a list of choices to describe what the purpose of high school mathematics enabled students to do. Some of the choices were to function (or excel) in college mathematics courses, to function in society, to reason mathematically, and to see mathematics as a connected whole.

The final and only in-depth interview did not have a single focus but addressed many of the previously covered topics related to mathematics to get a more complete view of their conceptions about and practices with assessment. In this interview, I asked teachers questions such as, “How do you define mathematics?” and “What is your biggest dilemma as a mathematics teacher?” I also asked teachers about their strengths and weaknesses as a mathematics teacher, how they would assess their students’ learning if tests were not required, and about the opportunities they provided for their students to discover mathematics on their own. I also asked specifically about their beliefs about mathematics teaching and mathematics assessment.

To further explore the research questions (1) What types of alternative assessments do first-year secondary mathematics implement? (2) How do first-year secondary mathematics teachers conceptualize mathematical assessment? and (3) What factors influence first-year secondary mathematics teachers’ assessment practices? and to gather supporting evidence, I conducted classroom observations. Observational data gathered was valuable in obtaining information about the teachers’ beliefs and practices and providing evidence for or against claims made by the teachers during the interviews. A goal was to regularly observe each teacher teaching two different mathematics classes, one at a higher level and one at a lower level. The purpose for this was to observe similarities and differences on assessment practices between the levels of classes. For instance, I observed Angel teaching an Advanced Algebra Trigonometry class with prerequisites of Algebra I and Geometry and a basic Concepts of Problem Solving class with no prerequisites. During each visit, I attempted to observe each teacher teaching both a higher and a lower level class. Data from classroom observations also provided additional information about their practices and were useful in creating interview questions. For example, after observing Angel for several weeks, I noticed that when she assigned homework, usually from a handout, she never assigned the one and only word problem on the handout. After the observation, I asked Angel why she never assigned the word problem from the homework. In subsequent observations, I noticed that when Angel assigned homework problems, she also included the word problem. Later, she commented to me that she regretted not assigning the word problems sooner because she really enjoyed solving them and the problems not only challenged the students but also helped them see how to use the mathematics in a real-world context. Fieldnotes were taken during each classroom observation and later transcribed.

During classroom observations, I took notes and collected all handouts distributed by my participants. These handouts were artifacts that included any handouts given during the observation as well as some handouts from classes that were not observed, tests, quizzes, homework handouts, classwork handouts, and so on. The archival data provided tangible evidence of the assessment practices of secondary mathematics teachers. It also provided insight into participants' thoughts about assessment. These data were useful for corroboration and exploration of the teachers' perceptions and practices (Johnson & Turner, 2002).

The three participants taught in the same school district in the largest school system in the southeast but in two different schools. Angel and Karen taught at Georgetown High while Jack taught at Columbia High. Both schools were still on the traditional 50-minute class schedule where each student takes 6 classes a day. Each teacher teaches 5 classes and has one period for planning. I visited each school twice a week and observed each teacher teach two classes during each visit for 7 weeks resulting in a total of at least 26 observations per teacher.

Data Analysis

Data analysis was an ongoing task from the beginning of the study. Repeated readings of the fieldnotes and transcripts were conducted to guide the data collection and management. The first step in data analysis involved transcribing the fieldnotes from the classroom observations and fieldnotes from the first two informal interviews. On the next visit after the second interview, I gave the transcriptions to my participants to read for member checking. The participants read the transcriptions, in my presence, and agreed that my notes depicted their actual responses. They did not provide me with any written comments about the transcriptions. They confirmed that what I typed was what they stated and that I was not missing any relevant information. This process helped to ensure that the participant's intended responses were captured as well as to minimize the occurrence of missing information due to the handwritten fieldnotes. During this stage, I also created interview questions based on the classroom observations as stated earlier. In March, the next stage of data collection began.

The second stage involved the open coding of the informal interviews to highlight any pieces of data that seemed significant in terms of the research questions and to create follow-up questions. From this initial coding stage, several preliminary themes emerged related to their beliefs using Ernest's model as a guide. The identified themes were beliefs related to assessment, mathematics learning, mathematics teaching and mathematics curriculum. The theme related to mathematics curriculum was later eliminated because the teachers' comments about the curriculum were not as dominant or relevant as the other themes.

Next, the one-time in-depth interview and the informal interviews were analyzed using Microsoft Office Word 2002 following the procedures described by Ruona (2005) for analyzing qualitative data. Ruona outlined four stages for data analysis. During stage one, data preparation, I organized and formatted the data into charts. In stage two, data familiarization, I began initial analysis and looking for themes. Stage three, coding, involved continued analysis and segmenting of the data and coding it based on the themes from stage two. The final stage, merging and generating meaning, entailed collapsing all the data for group-level or cross-case analysis. Then, following the advice of a committee member, I also analyzed my interview and observation data using NVivo, a qualitative research and data analysis software. The results from NVivo confirmed my themes, helped me create additional themes (e.g., authority, constraints) and helped locate supporting quotes. Later, after continued reading of the data and referring back to the literature, I added school culture and influence of the researcher as themes to help me answer my research questions.

Limitations

As with any study, there were limitations. The study described here was limited in that it only considered a small sample of three beginning secondary mathematics teachers from one school district in a state of over 180 school districts. Another limitation is that the study relied exclusively on interview, classroom observation and artifact data to access teachers' practices and beliefs about assessment and did not include questionnaires or survey instruments that could access other implicit knowledge forms.

CHAPTER 4 - THREE CASES

The Case of Jack

Jack was a white male in his first year of teaching high school mathematics at Columbia High School. Columbia had approximately 2400 students from a diverse population. The student population was 37% African-American, 37% White, 17% Hispanic, 7% Asian, and 2% Multi-racial. Of the approximately 2400 students, 10% were classified as Limited English Proficient, 46% as economically disadvantaged and 13% as having some disability.

Prior to becoming a mathematics teacher, Jack worked in business for several years and began classroom with previous work experience. His first degree was a two-year business degree. When Jack returned to college and decided to become a mathematics teacher, he completed a dual degree obtaining a bachelor's and master's degrees in mathematics education. During his teacher preparation at a large southeastern university he took many mathematics courses. Some of the courses included algebra, geometry and numerical analysis in addition to his teacher education content courses in mathematics. Some of the topics discussed in his mathematics methods courses included instructional strategies, classroom management, lesson planning, diversity and equity issues as well as assessment techniques.

Jack taught 2 periods of Applied Algebra I and 3 periods of Algebra I at the time of the study. His school had not switched to block scheduling like other schools in the district and still operated on a traditional schedule of 6 periods each 50 minutes long. Shortly after the first semester of teaching began, Jack had the opportunity to participate in one of his favorite sports when he volunteered to be an assistant coach for the golf team. He found coaching to be rewarding but time-consuming.

A Typical Day

Upon entering one of the two doors of the modular classroom or trailer where Jack taught, one would notice a few things. Jack's desk and workstation were in the left section of the trailer near one door. Next to his desk were four rows of five desks each facing the front of the trailer. In the right section of the trailer were an additional four rows of three desks that faced Jack's desk. On the back wall was a bulletin board. A long dry erase board was on the front wall between the two doors.

Jack normally began each class by taking attendance, making announcements, and/or returning graded papers. Then students would place their homework on the desk while he walked around with a sheet recording which students had or had not completed the homework. After answering questions about the homework, he began his lecture usually taught from the front of the trailer. While teaching, the textbook lay atop the cart, normally used for an overhead transparency, open to the section from which he lectured. He lectured directly from the textbook. I did not see any prewritten lesson plans or teaching notes. All of the information, examples and homework assignments were from the textbook. Before starting a new chapter, Jack distributed a handout with the dates, chapter sections to be covered, lesson objectives, homework assignments for each section, and review, quiz and test dates preprinted for each student. When asked about the handout, Jack stated,

> Once it's done (the handout) I'm basically teaching to that. That's part of what I use when I plan my lessons. I look at the homework to see what the focus is because they've (the experienced teachers who designed the handouts on the shared drive) been teaching awhile and have taken great care to go through the Algebra textbook and match up the

AKS which is the Academic Knowledge and Skills which is [the school district's] form of the QCC's (Quality Core Curriculum)… (Final Interview, 5/18).

During a lesson, Jack would ask questions while demonstrating how to solve problems like: How do you solve for y? Why do we move the decimal point? What do I do next? Where do I get my restrictions?

Normally, the students seated in the four rows facing the board participated the most during the lecture by answering and asking questions. Jack encouraged his students to use calculators when solving and/or checking problem solutions. He even had a few calculators in his classroom that he allowed his students to borrow for class assignments and during an assessment.

During the observation period, Jack made a few mathematical errors while lecturing. For instance, on January 18, during an Algebra I class, he put the following equation on the board

$$-2^2 = -2 \bullet -2 = 4$$

After the lesson when I questioned him about the equation, he stated that it was written in the textbook the same way, without the parentheses. The quizzical look on my face and my asking him whether he were sure about how the statement was written in the textbook spurred him to open the textbook and search for the section covering exponents. When he located the section, we each read the text silently. The textbook read as follows:

Recall that $(-1) \bullet (-1) = 1$; that is; $(-1)^2 = 1$.

However, $(-1) \bullet (-1) \bullet (-1) = -1$. Thus, $(-1)^3 = -1$.

This pattern suggests the following rule:

Powers of -1

Even powers of -1 are equal to 1.

Odd powers of -1 are equal to -1.

After reading the text section, which did not agree with Jack, only then did he admit that he should have written $(-2)^2 = -2 \bullet -2 = 4$. The following month, on February 26th, during a lesson on factoring quadratic equations, Jack made what he termed, "a rookie mistake." He asked the students to factor $-15x^2 - 21x - 6$. The students thought that using the quadratic formula took too long and was not easy to use. However, after several attempts using the guess and check method, they decided to use the quadratic formula. Jack wanted everyone to try it individually before they completed the problem as a class. After allowing the students to work independently for a few minutes, Jack wrote the following information on the board:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-21) \pm \sqrt{(-21)^2 - 4(-15)(-6)}}{2(-15)}$$

$$= \frac{21 \pm \sqrt{441 - 360}}{-30}$$

$$= \frac{21 \pm \sqrt{81}}{-30}$$

$$= \frac{21 \pm 9}{-30}$$

$$x = \frac{12}{-30} = \frac{2}{-5} \qquad x = \frac{30}{-30} = -1$$

$$x = \frac{2}{-5} \qquad x = -1$$

$$5x = -2 \qquad x + 1 = 0$$

$$5x + 2 = 0$$

When he checked his answer, he and the class were confused since $(5x+2)(x+1) = 5x^2+7x+2$. He looked at me and asked if I saw his error. I motioned for him to come to the desk and showed him that he should have simplified first by dividing a factor of negative three from the original problem: $-15x^2 - 21x - 6$. If he multiplied his answer by negative three, he would get the original problem since $-3(5x^2+7x+2) = -15x^2 - 21x - 6$. He said that he saw the problem in the textbook and decided to try it without having worked the example beforehand. Jack relied heavily on experienced teachers in the department and the school curricula including the textbook and test bank as his main source of authority and information for mathematical content and examples.

Jack thought that knowledge of some concepts was mainly necessary to pass assessments and/or to complete secondary school mathematics. When asked about students' need for knowledge the Pythagorean Theorem, Jack replied,

> To pass the test, the benchmark. It's on the benchmark and on standardized tests. What do they need to know about any math? Students have no opportunity to discover math. Some don't care to discover math. Escher probably used math (ratios) to create tessellations. Students with a passion for the arts, humanities need enough to get through high school math. In general, need to understand common ratios, like π, used to find Golden Triangle. Pi can be applied to any circle. You can apply it [Pythagorean Theorem] to every right triangle because of the common ratio (Informal Interview 2, 2/7).

Given the fifty-minute class period, Jack's lessons took the following format: Jack took about 10 minutes for administrative duties then another 5 – 6 minutes walking around checking for homework completion not for accuracy. He then took 5 – 7 minutes to review the homework, leaving roughly 20 minutes to teach a lesson. The remaining 7 to 10 minutes was allotted for the students to begin working on their homework. Some students would work on their homework but the majority of the students would sit and talk or put their head on the desk until the bell rang indicating the end of the class.

Typical Assessment Activities

When selecting classroom assessments, Jack strictly adhered to the school's mandated curriculum. All of the homework items were pre-selected by the Algebra department. As mentioned above, he distributed a handout with all of the homework assignments for each new chapter. When it was time for a test or quiz, Jack would go on the school's shared drive and print the test or quiz. Homework items and the test or quiz items were traditional questions that required memorized responses and/or skills and procedures only. Jack said that he always worked the problems before giving the test. If he had not discussed some mathematical content in class that was on the test/quiz, he presented the information during the review session prior to administering the test/quiz. Students with an excused absence were allowed to take a missed test or quiz upon the day of their return. Jack would allow her/him to complete the test or quiz if she/he felt prepared to take it. Jack frequently assisted students during classroom assessments. For example, during a quiz on February 28th, Jack spent almost all of the quiz time walking around assisting students with the quiz. Nine of the 21 students sought help on the quiz. Jack helped all nine students, some more than twice. One student asked for help five times during the quiz. When asked about the assistance that he gave to students on class assessments, Jack stated

> I'm not giving them a grade-wise academic advantage over the others in the class who know how to do it, because that student's still not going to have time to finish the quiz, they're not going to understand all the other parts, but maybe I can help them get one part, or get some kind of conceptual understanding of what they're doing, that's kind of my goal when working like that. There are other students who know how to do the process [but] they get suck on the verbiage [and] other students that have test anxiety or

whatever they get stuck, if I can give them a little push over that, they can take off and do the rest by themselves (Informal Interview 4, 2/28).

Jack originally stated that his assistance on classroom assessments was not giving some students an advantage over the other students who did not need assistance. However, with his assistance, Jack thought that his students could achieve some conceptual understanding, which he said was his goal when helping during assessment since some of his students only needed help with the language or had test anxiety and just needed “a little push.” However, he realized that he was giving an advantage to some students who asked questions over those who needed help but wouldn’t ask for it.

During the observation period, Jack mainly used formal, summative assessments to assess student learning. An analysis of the frequency of formal assessment-related activities in Jack’s classroom revealed that on average, he gave at least one formal assessment per week. From January 8 until April 17, he administered 10 quizzes and 7 tests and allocated 21 days for review. Jack devoted approximately 56% of the instructional days on formal assessment-related activities. See Figure 4.1 for an overview of Jack’s formal assessment schedule.

Mon	Tue	Wed	Thu	Fri
January 8	9 Review 8.1-8.3	10 *Quiz 8.1-8.3*	11	12
15 HOLIDAY	16 Review 8.4-8.5	17 *Quiz 8.4-8.5*	18 Review Chapter 8	19 **Test** **Chapter 8**
22	23	24 Review 9.1-9.3	25 *Quiz* *9.1-9.3*	26
29	30	31	**February** 1 Review 9.5-9.8	2 Review 9.5-9.8
5 *Quiz* *9.5 - 9.8*	6 Review Chapter 9	7 **Test Chapter** **9**	8 24-week Benchmark Review	9 24-week Benchmark Review
12 ***Benchmark*** ***Test 24-week***	13	14	15	16
19	20	21 Review 10.1 – 10.3	22 *Quiz* *10.1 – 10.3*	23
26	27 Review 10.4 – 10.5	28 *Quiz* *10.4 – 10.5*	**March** 1 Review Chapter 10	2 **Test** **Chapter 10**
5	6	7	8 Review 11.1 – 11.3	9 *Quiz* *11.1 – 11.3*
12	13	14	15 Review 11.4 – 11.5	16 *Quiz* *11.4 – 11.5*
19 HOLIDAY	20 Review Chapter 11	21 Review Chapter 11	22 **Test Chapter** **11**	23 30-week Benchmark Review
26 30-week Benchmark Review	27 ***Benchmark*** ***Test*** ***30-week***	28	29 Review 12.1 – 12.2	30 *Quiz* *12.1 – 12.2*
SPRING	BREAK	→	→	→
April 9	10	11	12 Review 12.3, 12.4, 12.8	13 *Quiz 12.3,* *12.4, 12.8*
16 Review Chapter 12	17 **Test Chapter** **12**			

Figure 4.1 - Assessment Schedule for Jack's Algebra I Class (Jan. 8 – Apr. 17)

Jack's Espoused Views

Views about Mathematics

Jack described mathematics as being a subject that was so vast that it was always possible to learn more because it was impossible to ever know it all. Saying, "I know mathematics", really meant understanding some mathematical processes, major ideas and important concepts since full knowledge was unachievable. Jack believed that a multitude of mathematical discoveries existed and people had invented a way to categorize and apply them but no one person invented mathematics. He defined the mathematical discoveries as applied mathematics, including the concepts that people currently use to solve problems in their daily lives. He distinguished applied mathematics from pure mathematics, which he described as the process of making discoveries and looking for new mathematics. For mathematics to be a creative subject depended upon how it was presented in the classroom.

Views about Learning Mathematics

Student learning and success in mathematics was a shared responsibility between Jack and his students. Jack realized that he could make improvements to instructional practices so when his students did not perform as well as he thought that they should, he accepted some of the responsibility for their lack of success. He also thought that learning in mathematics was better when learned in interaction. Jack thought that cooperative learning in mathematics could be advantageous for the students stating, "I am not vain enough to think I can reach all [students]. Someone different showing [the] same concept can do better" (Informal Interview 3, 2/12). Later during the same interview, when describing a successful teaching episode, he stated,

> One-on-one is the most successful. I tutor for 30 to 45 minutes after school and I see light bulbs going off. I'll say this, for example I feel like in Algebra I learning and solving

> quadratic equations, most [students] can tell where the parabola crosses the x-axis. I make sure [that] I explained what it meant to solve for *x* [and that] they understand why they are solving for x. The vertex form [of an equation] helps them to estimate what [the] parabola looks like. They can see the big ides of what [the variable] *x* [is] from a graphing perspective (Informal Interview 3).

He felt that all students possessed the ability to learn mathematics but not all of them would be great mathematics students. He likened the learning of mathematics to cooking with a recipe. Learning mathematics involved many necessary ingredients like memorization, opportunity for discovery, practicing processes, and time. He said that when mathematics was learned through discovery methods then "the students will never forget" (Informal Interview 3, 2/12). He said that he did not include all of the necessary ingredients for his students to learn and achieve in mathematics. His role in the mathematics class involved more than just the teaching of mathematics. He felt that he should also teach them to be good, well-rounded citizens who are capable of making contributions to society.

Jack argued more for nurture more than nature when it came to learning mathematics. He said,

> Just like anything. You can be good at piano with a lot of practice or a savant can just sit down and play without any practice … just like mathematics. Everyone can learn. Not all are able to be great. I'm in the nurture category (Informal Interview 2, 2/7).

Views about Teaching Mathematics

A mathematics teacher was like a gardener to Jack. When comparing the two he said,

> Learning math is a continuous growth process. A teacher plants idea to build off,

> the ideas grow and then you take those ideas to plant new ideas. You have to take care of it so they won't get overgrown with weeds [misconceptions] (Informal Interview 3, 2/12).

Jack realized that his idea of the perfect teaching environment for teaching mathematics was very different from his actual classroom environment. In the third interview he discussed his ideal classroom in which students would be able to "see the big picture before learning the process because it helped the process to make sense." Students would also be engaged even though he found it hard to do some days. He also wished that he "had more ideas for projects and more time to do projects but with the curriculum rush there was no time for a constructivist approach". Although he enjoyed using a constructivist approach, "it was definitely missing in all classes." As a first-year teacher, he was "just trying to make sure to cover everything." However, next year he wants o be more engaging and a more effective teacher.

In his final interview, Jack described how his current teaching practices conformed to the school's culture and how swiftly he was required cover the curriculum when he stated,

> As a first year teacher you see the board, right now [on] Monday, Tuesday and Wednesday we're covering three different sections. Thursday is review of what we covered in those three sections, and Friday is the quiz on those three sections. We move so fast through the curriculum in a 50-minute class period. … by the time I get through the lesson these students are so … so used to being spoon fed the curriculum [with] here is what we're doing and this is how you're going to do it. This is what your homework is going to look like, copy this. Do this process and you are going to be successful on your homework and you'll be successful on the quiz and on the test, now on to the next chapter. That's the way its set up and the way it's done and the way I'm doing it right now, which leaves no room for time (Final Interview, 5/18).

Views about Assessment

Jack said that being a first year teacher, feeling pressured to rush through the curriculum and lacking time to do more discovery activities or alternative assessment, hindered him from allowing his students to make discoveries and forced him to have teacher-centered lessons to prepare students to formal assessments. Jack described his current assessment practices as predominantly formal in nature. After an observation, he explained,

> The only other method that I use for assessment right now, that I have this year is informal assessment, verbally asking students questions, to find what responses match the responses that should be given, so at this point I haven't used any other assessment.

When describing how he knew that learning had occurred, Jack spoke about informal assessment, student engagement, student questions and their responses to teacher questions. Jack said,

> Well typically through the lesson, you can see by the answers [to] the questions that have been asked through[out] the lesson that show the development of understanding. Usually towards the end of the lesson, I'll try to have a problem that all students will try to do. At least one or two [problems related to] what we're trying to cover that all students will attempt and I'll walk around and look and tell them not to yell out the answers and I'll walk around and see who's getting the answers and who is not. And the ones who are not getting the answer, I'll ask them questions to see [at] what level they are to kind of see if I can gauge what level they're at of that particular topic. [To see] whether they've got no conceptual understanding of it. For example, when we're solving quadratic equations, I can ask okay we've discussed this many times in class now, 'How many answers are possible?' If they say, I don't know obviously they don't

understand that the parabola can [either] not cross the x-axis, it can hit it at one point, the vertex, or [it] can cross in two places. So there are three different possibilities if they can give me that answer, I can see some conceptual understanding. If they have no clue, then I see that they are not developing where they should. So we'll [see] how many different ways and I'll see if I can engage that answer, the response that I'm looking for, or [ask] some other question. We'll try to work with the individual, obviously in a classroom you can't hit everybody everyday but I try to [talk to] the ones that get the right answer, they seem to have it. So I'll try to check with the ones that aren't getting the right answers and ask them some questions then maybe we'll work the problem again. I didn't realize how much time coaching takes. It takes away from my ability to do more for the students (Interview 4, 2/28).

When asked what it would take for him to do something different for assessment, he replied,

> The right idea, the right time when there is time. But first, there's always time. I know we're always pressed for time. If I can find a different form of assessment that will show or give me information that I need. These students need to be prepared. The main idea and, I hate to say this is to prepare these kids for the end-of-course test, and if there's an assessment that can help me do that. I know that there're plenty of them out there. Just being a new teacher, I'm just trying to stay afloat (Informal interview 4, 2/28).

Jack's thoughts about assessment aligned with some of NCTM's vision of assessment in mathematics as an activity that provides evidence, includes multiple sources, and can be used for instructional improvements. Jack defined assessment as,

> Any activity that allows the student to show their understanding of the material whether it can be an informal assessment, a standardized assessment, [or] it could be activities, it

> could be projects but as long as it allows student to show what they know and it allows the teacher to reflect on what they've taught, and if their instructions has been thorough enough, and to show any gaps or holes in knowledge of the student so the teacher can fill them in (Final Interview, 5/18).

During that same interview, he stated that a good assessment should be an extension of learning for the student, a reflection of the instructors' lesson, and offer different types of or different formats for displaying a lesson right. On the other hand, he described a bad assessment as an assessment that would "set students up for failure when they can't actually show you the information that you really want to see that they've learned."

Jack's Enacted Model

When teaching, Jack mainly focused on transmitting mathematical knowledge and teaching facts, skills, and procedures. During instruction, Jack completed many examples on the board for the students. A portion of the class time was devoted to Jack completing the previous night's homework problems on the board when students experienced difficulties. During instructional time, he dominated the talking done in class. Most conversations were between him and the students. Rarely did the students complete problems on the board, explain solutions to their classmates, or participate in student-to-student conversation during class. During the observation period, I only saw his students work in groups once and he did not mention that he used groups during my absence.

On a few occasions, Jack did play the role of an explainer. For instance, during on Algebra I class, while finding the restrictions for the problem below, Jack wrote following information on the board

$$\frac{x^2+2x-3}{x^2+4x-5} \quad \textit{factor} \quad x^2+4x-5=0$$

$$(x+5)(x-1)$$

$$\begin{array}{ll} x+5=0 & x-1=0 \\ \underline{\ -5\quad -5\ } & \underline{\ +1\ +1\ } \\ x=-5 & x=1 \end{array}$$

One student was absent the previous day, had missed the lesson, and did not understand why the values *x = -5* and *x = 1* were restrictions. To explain why *x = 1* was a restriction, Jack replaced x with the number '1' in the problem and wrote

$$\frac{1^2+2(1)-3}{1^2+4(1)-5} = \frac{1+2-3}{1+4-5} = \frac{\ }{0}$$

Jack told the student that division by zero was undefined. He then reviewed the meaning of asymptotes. The student still did not understand, so instead of continuing the explanation, Jack got a graphing calculator and graphed the expression. He allowed the student to push the graph button on the calculator and discussed the graph. On the graph, at *x = –5*, there was an asymptote which meant that there was a hole in the graph and the expression was undefined at *x = –5*. Jack also told the student to push the table button and examine the table of values of the expression. The student noticed that in the place for the corresponding *y-value* for *x* = –5 was an error message. The error message indicated the expression was undefined at the point and that there was an asymptote at x = –*5*. Jack attempted to show the student multiple ways to look at the solution and a to make connection between the algebraic solution and the graph, including the table of values.

Jack gave total prominence to authority when making instructional decisions. On one hand, Jack thought that it was his responsibility, as the teacher, to decide what content to teach in his mathematics classroom. However, he also thought that if he wanted to retain his employment, then he should follow the county and state curriculum guidelines. In his case, the authority was the curriculum and the experienced teachers at the school. He followed the curriculum without deviation. Recall that Jack planned and taught his lesson based on the handout created by a team of veteran teachers in the math department. The handout was based on the curriculum and county standards. It provided strict guidelines about what content to teach and when to teach it. It also dictated what mathematical content to assess and when to give an assessment.

Jack did emphasize the use of technology in the teaching, learning, and assessment of mathematics. He implemented the graphing calculator as a resource during instruction when solving problems and explaining solutions. Jack encouraged his students to use calculators when doing homework, studying for assessments, and/or completing an assessment. Ensuring the all students had access to a calculator during class was important to him as evidenced by him loaning calculators to students on a daily basis. I also observed him loaning his personal calculator to a student to take a test when the rest of the class had borrowed the class set that he kept in his room.

Traditional summative assessments were predominantly used in Jack's classes. When determining grades, only traditional summative assessments were used (i.e., curriculum-based homework, tests, and quizzes). Some formative assessments were used during instruction. For example, Jack did walk around the room and observe his students as they worked on problems and asked them questions during instruction. He usually used this information to gauge student learning, determine if his instruction was effective, and to decide whether to review the material before introducing new material. Sometimes he would begin a new lesson or administer test or quiz even when students indicated either by their questions or their inability to complete the problems that they had not learned the material or that his instruction was not clear. He tried to stay on pace with the curriculum-based handout even when both formative and summative assessments indicated that student learning was low.

The Case of Karen

Karen was a white female teacher in her first year of teaching secondary school mathematics. The school in which she taught had approximately 2780 students. The student population was predominantly white (66%), with 24% African-American, 5% Hispanic, 3% Asian and 2% Multi-racial. Only 18% of the students were classified as economically disadvantaged, 10% as having a disability, and 3% as Limited English Proficient.

At the time of the study, her teaching schedule including two 50-minute periods of Algebra II and three periods of Concepts of Problems Solving (CoPS) which is a yearlong Algebra I first semester course. Karen felt that she was prepared to teach secondary mathematics. During her teacher preparation at a large southeastern university she took several mathematics courses in algebra, geometry and analysis in addition to her teacher preparation courses in mathematics. She also mentioned discussing many topics including mathematical assessment in her mathematics methods courses. As a first-year teacher, Karen assumed a huge responsibility in addition to her teaching duties. She replaced the cheerleading coach who resigned at the beginning of the school year. Karen graciously accepted her new role and the additional responsibilities not knowing how demanding coaching would be and how it might impact her first year of teaching.

A Typical Day

Upon entering Karen's room, one noticed a few things. Her desk was in the left corner of the room adjacent to a small three shelved bookcase. A few pictures and cards created for her by her students adorned the walls behind her desk. Homework, important due dates for assignments and/or test dates are written on the dry erase board. Students are seated in one of four sets of multiple rows (one set on each side, one in the back and one in the middle) coping pages of notes from the overhead. The overhead projector rests atop a cart at the front of the classroom. There one will also find Karen, standing next to the overhead projector lecturing and presenting information to her students. She normally begins class by asking the students to put their homework, from the practice book accompanying the textbook, on their desk. Often, checking the homework consists of walking around looking at their practice books making a mental note of who did or did not complete the assignment. If only a few students completed or at least attempted the assignment, Karen may mention to the class that not doing the homework usually results in not being prepared for the test or quiz and could negatively affect the test or final grade. After checking the homework, Karen returns to the front of the class and asks if there were any questions or problems with the homework problems. Several students ask her to solve a few problems on the board. While Karen solved the problems, she asks questions related to the problem like, Can we take $\sqrt{-1}$ and get a real number? What kind of polygon is it? How do you know? What is the major axis? What do we need to find the foci of the ellipse? Why? Students feel comfortable yelling out answers. She does not always require them to raise their hands first. After solving a few problems, she returns to the overhead and from this vantage point, begins her lesson by imparting mathematical knowledge usually in the form of numerous pages of notes about how to solve various problems. Roughly eighty percent of the time, Karen wrote the lecture notes on the overhead transparency. The remainder of the time, she presented the notes in a PowerPoint presentation or simply wrote the notes on the dry erase board. Students are invited and seem comfortable asking questions when they do not understand the mathematical procedures. Karen attempted to explain the content in several different ways, if possible. During the lectures, Karen asks questions, similar to the ones asked while reviewing homework, periodically to check for understanding. For instance after lecturing and giving a few pages of notes, she gives them a few practice problems to attempt while she circulates around the room assisting as needed. She encourages them to use their calculators as they solve the problems. On occasion, a few students have an opportunity to present their work to the class. However, Karen usually works the problems on the board, especially when the students experience difficulty with the problems. While she solves the problems for the students, she suggests that they look at their notes and study the rules and procedures that she has given them during the lecture. Then she gives more notes before allowing them more time for practice until the end of the guided lesson. Karen usually leaves a few minutes for them to start their homework and ask any remaining questions. Some students begin their homework while others read, draw, talk or rest their heads on the desk.

Typical Assessment Activities

When designing assessment activities, Karen consulted several resources. The majority of their homework assignments were from the curriculum-based practice books. Karen felt that they would be more inclined to complete the homework if they did not have to carry the large mathematics textbook home on a daily basis. On a test or quiz day, Karen collected the review sheets, that she created, before giving the students her teacher-made test or quiz. When Karen encountered difficulties in teaching or had instructional-related questions, she sought the advice of more experienced teachers. Even though Karen sought assistance with assessment and had access to more experienced teachers' tests and the school's mathematics test bank, she decided what content to assess and therefore, opted to create her own classroom assessments. When designing her tests, quizzes, review sheets, and the one project that she assigned to her Algebra II classes, she searched the internet and other resources for interesting problems and activities. As required by the county and state, Karen did administer any district-required or state-mandated assessments. Informal assessments, like observations of students while solving problems at their desks and teacher questioning were part of the daily instructional practices. Other informal assessments, like students presenting problems on the board or peer teaching were infrequently used. None of the informal assessments mentioned above were documented or had any affect on the students' course grade.

Observation and a brief report of these events only presents a surface level understanding of her instructional practices. Upon closer inspection and when one considers Karen's beliefs, a more complete view is possible.

Karen's Espoused Views

Views about Mathematics

Defining mathematics was hard for Karen but she believed that it was knowledge that consisted partly of a set of rules and truths as well as a personal experience. More specifically, she stated,

> I think it [mathematics] is knowledge. Parts of it are a set of rules and truths because a lot of it is convention. It's how it's defined, I guess. So parts of it are rules and truths. It's a personal experience for me because I enjoy sitting down and solving problems and I guess it's challenging to me and personal. It's numbers, math is numbers and problem solving and thinking and hard to define (Final Interview, 5/22).

When asked whether mathematics was discovered or invented, Karen stated, "it all occurs naturally, but it's discovered. It's abstract. It's all out there already -- just has to be discovered" (Informal Interview 1, 1/31). Asked whether mathematics was creative, Karen replied, "Yes and no. It can be. There is more than one way to solve problems. You can have a creative approach. No, it [mathematics] is predictable. Having one answer stifles it [creativity] (Informal Interview

2, 2/7). During the same interview, Karen stated that student knowledge of certain mathematical concepts, like the Pythagorean Theorem, was important because they needed it "to be able to solve problems involving right triangles and since it was used in other classes like geometry and Algebra I". She thought that student often "go through the motions and processes without understanding and then have no understanding of the applications" the class was doing.

Over the course of the semester, she often considered mathematics to be similar to problem solving. However, based on her comments, it was not the problem solving as described by Polya (1957) of understanding the problem, devising a plan, implementing the plan, and then reflecting. For Karen, problem solving simply meant to solve problems, but others might have called them exercises or practice problems. To know mathematics meant having the ability to sit and solve problems and having problem solving skills. Mathematics was only creative to the extant that more than one approach might exist to solve problems. However, what she liked most about mathematics was using problem solving techniques and trying different approaches to solve a problem. This is where it was a personal experience for her because during the observation period, Karen did not encourage her students to use various problem-solving techniques. Her personal joy of using problem solving techniques to solve problems was not apparent in her mathematics teaching meaning that she did not exude excitement or joy when teaching.

Views about Learning Mathematics

Karen likened learning mathematics to both working a jigsaw puzzle and building a house. Students could use these skills to rule out answers or solution paths and to see how the puzzle pieces fit together like mathematical concepts. Learning mathematics was also like building a house. Karen thought that the first step in both was to build a foundation. Then it was possible to add on and build upon the foundation. Learning mathematics "involves problem solving since you can rule out some pieces, choose colors that match, and fit pieces together like math concepts" and you "need to build a foundation then build upon it. You can't put the roof on before something else. Like you can't do trigonometry without knowing or having algebra skills" (Informal Interview 2, 2/7).

When it came to learning mathematics, Karen said that she sided more with nurture than nature. Though there were at least two engineers in her family, she said that her sisters were bad at mathematics. Furthermore, "most students are capable [of learning mathematics] if they try and have a good attitude but not the technical level students, they try and try and try but can't seem to learn it" (Informal Interview 2, 2/7).

Views about Teaching Mathematics

One of her stated strengths, as a mathematics teacher was the ability to relate to her students and to explain things in a way that they could understand the mathematics. She felt that she could take a concept and break it down to help the students "see" how it works.

Karen compared a mathematics teacher to both a gardener and a coach. Like a gardener, a mathematics teacher "plants seeds of knowledge into students" and then "over time watches as their mathematical knowledge grows." On the other hand, a mathematics teacher is like the coach whose role is to teach skills while the students practice. A coach "gets the players for the game" similar to how a mathematics teacher prepares students for the test. Karen thought that the use of cooperative learning in preparing students to pass their assessments was helpful if properly designed. More specifically she stated,

> [Cooperative learning] can be beneficial. Depends on how they are designed by the teacher. All students should contribute, work together, two to three students, not any

bigger, students can learn from each other than just teacher, can hear [concepts] in a different way; reinforce to stronger learners.

I don't do it a lot. In Algebra II, there is too much content. I give notes, notes, notes and involve my students. Gave a pair quiz. It worked well. They work a problem and check with their partner. In CoPS – not too much content and low motivation. One person would do the work and the others would copy. Be careful, [students] don't want to do work, [students] are not interested in learning (Informal Interview 3, 2/20).

Karen felt that she had no responsibility in deciding what to teach but she did have some control on how to teach the curriculum. During an observation on March 27th, she explained,

It's decided for me, AKS curriculum, information on the final, Benchmark. I don't feel that I decide. … I need to meet the curriculum. It's so hard. There are things I'd love to teach, test conjectures but there's no time because of the curriculum. We have a school written final, if [curriculum] not covered they'll miss so much stuff so I have no choice but follow the curriculum.

Even though she expressed the importance of teaching for conceptual understanding, Karen was aware that she placed much more emphasis on teaching skills than on teaching concepts. She indicated this with the following continuum, where the first 'X' (near the skills end) represents her actual emphasis when teaching and the second 'X' (nearer the concepts end) represents where she thought that the actual emphasis should be when teaching mathematics.

|_______X________________________________X_______________|
skills   concepts

Views about Assessment

Karen thought that assessment served several purposes in mathematics. When asked to define assessment, she stated,

> [It] allows them a chance to show that what they have learned, demonstrate that they have learned the mathematics. Assessment also provides an indication to me what you taught. Maybe you need to go back and teach something again. It measures what students have learned and indicates to teacher what needs to be taught again (Informal Interview 4, 3/6).

During the final interview, she commented.

> I feel like assessment should measure what they know. It's so hard to get inside someone's head to see what they know. But I do think that we have different types of learners and that's why you need different kinds of assessment and give them different kinds of opportunities to be creative and use their different abilities. I feel like it should be thought-provoking, and to be honest a lot of my tests are just like all the problems they've seem before, just like their homework problems or what we did in class. I don't know how thought provoking it is. [Assessment] is so hard.

She thought that a good assessment should "allow for more learning and one can apply previous knowledge" while a bad assessment "was not fair or testing on material that was not covered [in class] but shows up on the test" (Informal Interview 4, 3/6).

Karen shared that her assessments were aligned with her instruction because she similar types of problems. "I have difficulty [aligning] in some classes. If they do their homework, they have no problem. I usually show one [problem] before the test" (Informal Interview 5, 3/13).

Later during the same interview, when asked if the NCTM Standards affected her assessment practices, she replied,

> I haven't thought about them [NCTM Standards]. Everything from college affects practices. I don't refer to them. I don't know much about the assessment part of learning process. They've learned it, now it's time to show it.

During the same observation, Karen shared her thoughts on the assessment of skills versus assessing conceptual understanding. To assess the learning of mathematical skills, she suggested that a teacher should simply "give them problems and see if they can do the skills successfully." On the other hand, to assess the learning of concepts is "harder with pencil and paper. Use questioning, give them a non-routine problem or an open-ended problem." She also said that she would like to have more tests that test conceptual understanding.

In her final interview, Karen shared more thoughts on assessment including what she had hoped to do with assessment her first year as well as her thoughts on time constraints that affected her assessment practices. She explained,

> I think talking is a good way to see what they know. I was thinking earlier in the year that they would have time to do some kind of presentation or something where they can show what they know but I really don't have time to plan it or have class time for them to give the presentation. But I don't know, I also feel like if you learn material, I feel like you should be able to sit down to answer problems. If you only know ½ the material then you should get a 50%. If you are very comfortable with the material have a solid knowledge then you should get closer to 80 90%. I feel like tests are useful but I don't how else you would I mean I like projects and I like things like that and I like group

> work but obvious I don't do a lot of it. So, I don't know it's hard to try to figure our exactly what they know.

Karen's Enacted Model

In Karen's classroom, teaching mathematics consisted of her lecturing and giving a lot of notes. Students were not allowed to use their notes during the tests but could use the notes to help them solve problems when they are away from school and to help them study and prepare for tests and quizzes. She placed great emphasis on her students obtaining mathematical skills and procedures when teaching. Her goal in teaching was to transmit mathematical knowledge and she believed that the teacher's role in the mathematics classroom is to lecture, explain and motivate students by passing on the structured knowledge. She inspired students by enriching the mathematics lessons with additional problems and activities, adapting the textbook approach. Karen demonstrates this characteristic when she searches the Internet and seeks other resources including the test bank and her colleagues when creating assessments and the one Algebra II project.

Based on Ernest's categories, Karen views about mathematics could have her in a number of his positions. In his 1988 table of teachers' beliefs classifications, Karen would be more of a Platonist than an instrumentalist. Similar to an instrumentalist, Karen believed that mathematics was an accumulation of unrelated but utilitarian facts, rules, and skills. On the other hand, as a Platonist, she conceived that mathematics was static but unified body of certain knowledge that was discovered, not created. She believed that mathematics was a structured body of knowledge. She also thought that what was truth did not depend not authority. Karen stated that mathematics was a collection of facts and skills.

Karen often sought the advice of more experienced mathematics teachers on a wide variety of topics, including teaching specific content, managing classroom environment and assessing student learning. Sometimes she tried their suggestions and other times she disregarded them. For instance, Karen said that she struggled when teaching the Concepts of Problem Solving (CoPS) classes so she sought the help of a more experienced mathematics teacher who suggested that she try using individual white boards, 21st century versions of individual chalk slate boards in the CoPS classes. Unfortunately, she thought that the lesson was not successful. She said that the students simply copied answers from each other. Thus, she didn't try the whiteboards again because of her perceived failure of the pedagogical approach. When Karen needed assistance on how to formally assess her students, she asked other mathematics teachers for copies of their tests and quizzes and checked the school's online curriculum network for sample tests and quizzes. After reviewing both her coworkers and the online tests and quizzes, she decided not to use either and to create her own.

The Case of Angel

Angel was a white female teacher who taught in the same school as Karen. In 4th grade, Angel decided to become a teacher. Five years later, while in the 9th grade, she decided that she wanted to teach mathematics. However, it wasn't until after 30 years working in business that she returned to school to pursue her childhood dream of becoming a mathematics teacher.

While working on her undergraduate degree, Angel took several mathematics courses in algebra, calculus, and trigonometry where she reportedly earned all 'A's'. However, during her teacher preparation at a large southeastern university she mentioned struggling through geometry to earn a 'C' even though she really enjoyed the course. While at the university, her mathematics methods courses included many discussions regarding mathematics teaching-related topics including the use of a variety of mathematical assessments.

At the time of the study, Angel had a 1st period planning followed by three Advanced Algebra & Trigonometry and two Concepts of Problem Solving (CoPS) courses, a yearlong Algebra I first semester course.

A Typical Day

Upon entering Angel's room, one noticed the following things. Her desk and file cabinets were in the right corner opposite the door. There were bulletin boards on the wall to the left of her desk and on the back wall. Student desks were divided into two sections. The largest section was arranged in a 4 by 6 array facing the front of the room. Then there was an aisle leading from the door to the opposite wall close to Angel's desk. After the aisle, there were 3 more rows with 4 desks each. In the front of the room was an overhead projector. Angel usually began class with a warm-up activity that consisted of one or two problems related to the previous lesson or with a quiz usually announced. The following problem is the warm-up for her Advanced Algebra & Trigonometry classes on February 20:

Given the formula, $y = \pm A\cos(kx + c) + h$, define A, k, c *and* h.

The problem below is the announced quiz for her Advanced Algebra & Trigonometry classes on February 8.

Draw the graph for $y = \sin x$. Label the x- & y-intercepts. Label y-axis and indicate the maximum and minimum.

Angel made adjustments to the pop quizzes for the following classes if there were many questions from the students or if she thought that she wasn't assessing the mathematical content that she intended to assess. The problem for the pop quiz above was changed to the following quiz for subsequent classes.

Draw the graph for $y = \sin x$. Label the x intercepts. Identify x and y for the minimum and maximum of the curve. Label the y-intercept. Label the y- axis. Identify/label the period.

Students were allowed 5 minutes to complete the warm-up or quiz. After collecting the warm-up, the class would discuss the problem(s) followed by a discussion of the homework. Angel would ask students to put various homework problems either on the dry erase board or on the overhead transparency sheet. While the student(s) wrote the problems, she would sit in an empty student seat and make comments, ask questions, encourage them, and/or guide them if they experienced difficulties.

Angel encouraged diversity in student's mathematical solutions. On March 1st, a student wrote the following problem solution on the board,

$$\frac{\cot x}{\tan x} = \frac{1}{\tan x} \bullet \frac{1}{\tan x} = \frac{1}{\tan^2 x} = \cot^2 x$$

The student's solution was different from what Angel anticipated and she commented, "[Student] always thinks outside of my box." She then asked another student to write his solution on the board. He wrote the solution that Angel had in mind and used θ instead of *x*.

$$\begin{aligned} \frac{\cot\theta}{\tan\theta} &= \frac{\cos\theta}{\sin\theta} \div \frac{\sin\theta}{\cos\theta} \\ &= \frac{\cos\theta}{\sin\theta} \bullet \frac{\cos\theta}{\sin\theta} \\ &= \frac{\cos^2\theta}{\sin^2\theta} = \cot^2\theta \end{aligned}$$

After reviewing the homework, she began teaching new mathematical content. While Angel was teaching, she would engage the students in the lesson through questioning or role-playing. It was not uncommon for her to ask students to come to the overhead projector or dry erase board and explain a problem to the class while she sat at student desk. If a student wrote her/his solution to a problem on the board, sometimes Angel would challenge other students to demonstrate how they solved the same problem. For instance, on March 6, a student wrote the following problem and solution on the board.

$$\begin{aligned} &\frac{1}{\cot\theta} + \frac{1}{\tan\theta} \\ &= \frac{\tan\theta}{1} + \frac{1}{\tan\theta} \\ &= 1 + \tan^2\theta = \sec^2\theta = \frac{\tan^2\theta}{\tan^2\theta} = 1 \end{aligned}$$

Angel challenged the students to present another solution for the problem. When no other student accepted her challenge, she simply returned to the overhead projector and continued teaching, never telling the class whether the student's solution was correct or not. Several times, when a student did not want to put their work on the board or overhead projector, Angel would ask them to talk her through the problem while having them explain their procedure as they told her how to proceed. Students felt comfortable asking and answering questions throughout the lesson or expressing their desire or lack thereof of presenting their work to the class. The students seated in the largest section, closest to the front of the room participated the most and had the most interaction with Angel. During the lesson, Angel would point out the connections between and among the concepts as well as encourage the students to find and make connections between the mathematical concepts discussed in class. Angel taught until 4-5 minutes before the bell rang indicating that it was the end of the class period. Before the end of class, she would assign homework.

Typical Assessment Activities

Angel considered a variety of sources when choosing classroom assessments. Homework was usually a worksheet from the Study Guide booklet that accompanied the textbook. On one side of the worksheet were two or three completed examples from the lesson. On the other side of the homework worksheet were ten problems, including one application problem. Angel only assigned the first nine problems, never the application problem and gave a participation grade for the homework. As a motivational technique, Angel would challenge her students to complete some of the higher cognitive demanding homework problems. Once when several students were selling candy bars as a fundraiser, she offered to buy candy from whoever could simplify $(\sin x + \cos x)^2 + (\sin x - \cos x)^2$ on the board to her satisfaction. She then commented, "I don't think anyone will do it, so my money is safe." When making tests, quizzes, review sheets and other mathematical activities, she looked on the shared drive developed by more experienced teachers in the mathematics department for examples, sought the advice of other teachers, and searched through other textbooks and the Internet. Initially, she used the classroom assessments on the shared drive however, over the course of the school year; she began to develop her own assessments. Often, her assessments would include some of the examples from some of the other sources mentioned if she thought they were good questions. Angel used observation and questioning as informal assessments of student learning. Throughout the lesson, she asked questions inviting the students to explain and share their thought processes with the class. She would also make comments to or about the students' mathematical abilities or efforts for the day. For instance, she would say, "[Student] was really on it today.

Observation and a brief report of these events only presents a surface level understanding of her instructional practices. Upon closer inspection and when one considers Angel's beliefs, a more complete view is possible.

Angel's Espoused Views

Views about Mathematics

Angel focused on mathematics as a way of thinking and on the connectedness of mathematics. She believed that mathematics is more than just solving problems. When asked to define mathematics, Angel replied,

> It's not just a problem to be solved. I think of it, especially a way I try to teach the children is that it's a way of thinking, of organizing thinking, bringing structure into the world. You wonder what these guys would think about when they first started making all these processes and I guess that's exactly what they were trying to do. So it's a separate routine for students. Five years from now they are not going to remember sine, cosine and tangent but hopefully we taught them how to analyze and problem solve. So I guess mathematics is just a way of organizing thinking (Final Interview, 5/21).

She further explained, “I believe that God is a mathematician who put things in place for us to figure it out. We’re still figuring. There are basic truisms in math and we have to figure them out (Informal Interview 1, 1/31). For Angel, mathematics is a creative subject that involved different ways of looking at and using the mathematics. Angel did not differentiate between pure and applied mathematics. She thought that, “the study of math should be applied to life at any level. The study of math is analytical, problem solving [and to] know [the] magnitude of numbers” (Informal Interview 2, 2/6). When asked to choose a phrase that best described her view of mathematics, Angel replied,

> I do not like [choice] A. A set of rules and truths that just seems stagnant. [Choice B] Unquestioned body of useful knowledge, we’re not allowed to question it so I don’t like that one. [Choice C] A body of structured pure knowledge just makes it sound like it is totally useless. Pure knowledge in today’s world, knowledge for the sake of knowledge, there’s some of us who still do that, but many of us don’t. [Choice D] A personal experience I like that and [Choice E] a changing body of knowledge that is socially constructed. I like both of those [choices], so put those two together. I didn’t even think of math as changing until I was working on my master’s degree…. Something to do with the changing nature of mathematics that I really think somebody invented a lot of the math after I got my bachelor’s degree … but a personal experience and a changing body of knowledge, I’m not sure we teach it like that today. We look at it one way but we do the other (Final Interview, 5/21).

Views about Learning Mathematics

For Angel learning mathematics was like conducting an experiment. She made several references to the days when she took her trigonometry class to the computer laboratory and they did a discovery and exploratory activity using the graphic calculator on the computer. She was excited because her average students were engaged and did not want to stop working. She said that "they couldn't get enough" of the activity.

Angel liked the idea of using cooperative learning but believes that it doesn't work that same in all classes. She explained,

> I like it [cooperative learning], works better in some classes, groups of two or three, a group of four is a party. Kids like it. For a test review, they work in pairs. I don't want to dictate. They can learn from each other. Once a week is good. Several [students] liked laboratory [discovery ability] so much. I will try to introduce new chapter [by going to the lab]. We have to follow a pacing chart but I am off 2 days because I was sick (Informal Interview 3, 2/8).

Views about Teaching Mathematics

Multiple approaches to teaching mathematics existed for Angel. Seeing her role as a coach, she thought that her role was to provide students with experiences to work together to develop conceptual understanding and make mathematical connections with the expectation of some level of discomfort. She experimented with lecturing, peer teaching or tutoring, and teacher questioning, and using technology. Her most successful teaching episode was when she took her Advanced Algebra & Trigonometry classes to the computer laboratory for an exploratory lesson with trigonometric functions. She explained,

> I only took my class to the lab about 3 times the entire school year and most of it was January and February when we were into Trigonometry and we were working on graphing the Trigonometry functions. Once I showed them a little bit about sine and cosine [functions] we went to the lab and they did secant, cosecant, tangent, cotangent

> using graphing calculators [on the computer] and it was nice. There were a couple kids that really took to it. That was probably the best part of the high school year, watching the fact that they actually got it. Of course some of the kids were just like "I don't get it. What do you want us to draw?" That's not the point, the point is you put some numbers in and what do you see, and if you are working with your neighbor and your neighbor is working on secant and you're working on cosecant. You can compare and contrast. But some of them just don't think that way especially in math class. Maybe they do in literature class where they compare and contrast all the time but not in math class (Final Interview, 5/21).

Angel realized that student learning was a reciprocal relationship and used assessment results to reflect upon and improve her instruction. For example, when the entire class failed a test, she accepted some responsibility. She thought that on one hand the students were not serious about the test but on the other that her teaching had not been effective enough. She wanted to teach them how to help themselves to learn but didn't want to take the responsibility of learning from them.

On a few occasions, Angel questioned her mathematical teaching abilities. In the third interview she stated,

> Historically girls have performed poorly in math but are improving. I'm not convinced that all can succeed because by the time many students get to me, they will have experienced many years of school mathematics failure and I can't turn over x years of failure in one year.

Angel also expressed her concerns about her mathematical content knowledge and her lesson structure. She stated,

> I spent a lot of time this year very conscientious about my mathematical knowledge and the contents of my lesson, trying to make sure I did not make mistakes. I did make mistakes and I would go back and say, "I did make a mistake on that. Let me clarify" and if anyone would ask questions I would try to incorporate that into [my lesson and if] I can't answer that day then the next day's lesson. I need to deepen my understanding of mathematics and now that I know how to teach the particular lesson I can make sure I tie everything together and also make sure that I present the lessons in a different way. Not just always be "Here is my lesson, here's your problems, here's your homework, now we're done." I want let's do some more projects, let's go the laboratory more often. I would even like my technical level classes to have a project that they can put together some mathematical presentation with PowerPoint and give it to the class because they just don't get that [in] class anymore (Final Interview, 5/21).

She also thought that, teachers "have to keep the mathematics relevant to the kids because you leave the kids with questions a lot about "I'm never going to use this again"" (Final Interview, 5/21).

Angel often emphasized understanding and more importantly making mathematical connections when teaching mathematics. During instruction, she attempted to convey the importance of having her students organize their thoughts about the mathematics and to help them connect their ideas, concepts and previous experiences when solving mathematical problems and when trying to learn new material. Her emphasis on connections often caused an internal struggle due to her perception of external pressure to teach to the test and a limited curriculum. Her frustration was apparent when she stated, "I feel like a gun is put to my back to stay on course, like a forced march… If the content is not on the Benchmark, the teachers will teach that content [after the administration of the Benchmark test]. The content is a mile wide and an inch deep" " (Informal Interview 3, 2/8). Further adverse effects of the school structure and the curriculum on her teaching are revealed in the following comment,

> [You] don't really have the time to teach anything and so often especially the first semester of this year which was Advanced Algebra/Trigonometry and actually in CoPS it was a whole year, these kids have already seen 95 percent of everything I teach them. Trigonometry only got new in January and that's when the Trigonometry stuff came in. Advanced Algebra, which was all last semester was all review, so are we just teaching them the same thing over and over again and I'm not even sure if we have gone to a steeper level than we did over the previous years. If that's the intent to just start them at a shallow level and just start digging deeper and deeper and you don't have time to do that. It feels like we are spinning our wheels, why are we teaching the same thing over and over again? (Final Interview, 5/21).

Angel was not afraid to seek advice for colleagues when necessary however she made the final decision as to what course of action to follow. For example, when asked about how she taught or introduced new mathematical content, like Logarithms, she explained,

> "That would be a topic where I had to go study the chapter first and then figure out how to introduce it. I don't remember much about it. In fact I would probably go across the hallway to Paul and say "How do you start out this chapter?" because I did that a couple of times with the Trig but the Trig stuff I remembered most of that probably because I liked it the first time. Sometimes you have to go and ask another teacher "How do you introduce this?" There's a lady who is the head of Trig here and she has definite

views on how she likes things done. Sometimes I do not like her techniques even though she is experienced. I would go find another teacher and ask how they would do it but it is not necessarily that I would do it exactly the same way (Final interview, 5/21).

Views about Assessment

Angel said that when considering assessment a teacher could ask,

> Can I say that a particular student has learned anything in this class and do I have any type of information to back it up… We have to report back to everybody and the problem is you have to quantify it and then for the student to move onto whatever subject they have to study about, it's just basically trying to quantify what they know (Final Interview, 5/21).

When asked how she knew when someone had learned mathematics, Angel spoke about assessment of student learning, logic, and having number sense. She elaborated,

> We tend to assess short-term memory and superficial knowledge. They have an underlying sense of logic, know that numbers act this way. They have number sense – addition, subtraction, number line, and a sense of the magnitude of numbers (Interview 1, 1/31).

During a later interview, she commented that,

> When they come up [to the overhead or board] and sketch something; I get more than one person to respond; by facial expressions, quizzical looks, brightened faces. It's usually on an individual basis. Class average doesn't tell anything. Smaller class sizes will impact learning more than anything. [There are] different dynamics [in smaller classes] (Interview 3, 2/8).

When teaching, Angel emphasized conceptual understanding and mathematical connections yet said that she "was only giving them a detached view of mathematics" (Final Interview, 5/21) when it was brought to her attention that she only assigned the traditional problems for homework. This realization prompted her to begin assigning and completing the application problems herself. She elaborated on assigning the application problems.

> First of all I started enjoying them [application problems] and then when they [the students] said, "When are we going to use that?" and I said "Here's an example of where we are going to use it." And every lesson I did I said here's an example of this and here's an example of that and some of it was easier than the others. I enjoyed that they stopped asking me (Final Interview, 5/21).

Angel told me that she aligns her assessments with her instruction practices. She exposes the students to problems similar to the ones on the test or quiz either in class or on the homework. If she assigns a problem that "requires them to use more brainpower" and has not discussed a problem similar to the one on the test or quiz, then she will make that problem a bonus question. Furthermore, she stated, "I make sure that I cover the material from the AKS, on the final and on the Benchmark. I go thru the information to help me learn what's important to the county" (Informal Interview 5, 3/13).

As evidenced from the comments above, Angel's assessment practices are influenced by the school curriculum. When asked about some influences on her assessment, she stated, "the Academic Knowledge and Skills (AKS) more so than the NCTM Standards. The AKS drives my practices more but I still try to keep in touch with the NCTM Standards" (Informal Interview 5, 3/13).

Angel's Enacted Model

When teaching, Angel focused on making and showing the students the mathematical connections in the lesson. During instruction, both she and the students completed problems on the board or overhead projector. Whether she was teaching new content or reviewing homework, she tried to engage her students into the activity. Both she and her students talked about the mathematics during class. Students felt comfortable answering questions and asking questions when they did not understand the mathematics.

On any given day, in all but one class, one would observe the students in front of the class explaining a mathematics problem to the class while angel was seated in a student's desk. During an observation on March 6th of her fifth period CoPS class, she explained, "This is a tough crowd. When I tried to get them to the board, with these big guys, if they are out of their seats, then they are all over each other."

Group work was encouraged in her class. For instance, during an observation on March 15th, after completing a lesson on solving trigonometric equations, she gave them their homework worksheet, told them to get a partner, choose three of the ten problems to complete and turn in for a grade and then to complete the remaining problems for homework. While doing mathematics in class and at home, she encouraged them to use calculators and the computer if the had access to one. She had a classroom set of calculators that she allowed the students to use.

To assess student learning, Angel used a mix of informal and formal assessments. The informal assessments were implemented daily and included teacher questioning, students presenting problem solutions to the class with an explanation, and teacher observations. The formal summative assessments were used periodically and included the tests, quizzes, homework, and Benchmark tests. She graduated from exclusively using her colleagues' tests and quizzes to creating her own assessments. Her assessments included a combination of curriculum-based problems plus those from other sources.

CHAPTER 5

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

Discussion

The purpose of this study was to examine the assessment practices and conceptions of first-year secondary mathematics teachers. The questions guiding this study were (1) What types of alternative assessments do first-year secondary mathematics implement? (2) What factors influences the assessment practices of beginning secondary mathematics? and (3) How do beginning secondary mathematics teachers conceptualize assessment in mathematics? Using the framework developed by Ernest describing the impact of teachers' beliefs on their practices, I analyzed the assessment conceptions and practices of three first-year secondary mathematics teachers. This section will highlight some major influences on the teachers' assessment practices.

Since the three teachers graduated from the same university, they received similar training in reform-based initiatives in mathematics education. They also taught in the same school district but in two different schools. They had the same curriculum and county requirements and guidelines for teaching and assessing mathematics. Yet the way they thought about and implemented assessment differed in many respects.

During data analysis, several major themes arose that influenced the teachers' conceptions and practices related to mathematics assessments: beliefs, perceived constraints and school culture, the level of teacher reflection. Similarly Sanchez (2001), found that the teachers' mathematics-related beliefs, the role of authority, and perceived constraints all impacted their use of open-ended assessment items. Unlike Sanchez (2001), my participants were all first-year teachers and more importantly, my analysis included the teachers' overall assessment practices, whereas, Sanchez (2001) limited her study to one aspect of assessment, the teachers' use of open-ended assessment items. Herrington, Herrington, and Glazer (2002) also found that the school culture influenced teachers' assessment practices like advice from colleagues and in this study, the shared practices of colleagues. Using Ernest's (1988) model for the impact of teachers' beliefs on their instructional practices, this study found that teachers' beliefs in conjunction with the constraints of the social context of teaching and teachers' level of thoughts processes and reflection provide a lens for understanding the mismatch or inconsistency between teachers' espoused and enacted models of teaching.

Ernest's Model

Ernest classified teachers based on their system of beliefs about mathematics and its teaching and learning, the teacher's role and intended outcome of instruction, the use of curricular materials, and the teacher's view of the process of learning. I have also included their espoused views about assessment since it too is an instructional practice as well as the focus of this study. Ernest suggested that when trying to understand the practice of teaching, one should also consider the social context of teaching and the teacher's level of reflection.

Jack's Espoused views

Using Ernest's (1988) model to analyze Jack's espoused views, I would classify him as having both instrumentalist and Platonist views about mathematics. Furthermore, Jack's espoused views about his role in the classroom were those of both an instructor who focused on the mastery of mathematical skills to correctly solve problems and an explainer who thought that conceptual understanding was important for his students. He discussed wanting to do more discovery learning and finding different ways to assess his students' learning including using alternative assessment methods. Yet, he described his teaching as being very teacher-centered.

He thought that his students should master the skills that he taught and also be engaged in learning process. He felt that he had no authority in making curricular decisions. Jack discussed the importance of both informal and formal assessments in determining students' knowledge of mathematics. Some of his purposes of assessment included preparing students for the end-of-course test, allowing students to demonstrate their knowledge, and allowing the teacher to reflect upon his/her teaching. For Jack, assessment should include a variety of methods including projects and discovery activities.

Jack's Enacted Model

Jack displayed the role of an instructor much more than that of an explainer. During a few observations, I saw him trying to help the students understand the concepts. Normally, he focused on mastery of skills with correct performance of procedures. He treated his students as receptors of his knowledge seldom engaging them in actively constructing their own mathematical knowledge. He asked questions during the lesson but he lectured while the students listened and took notes. Jack was in strict compliance with the curriculum and used it without deviations. For example, if the handout indicated that he should teach lesson 5.4 or give a quiz on a lesson on a particular day, then he taught that particular lesson or gave the quiz to his students.

Jack recognized that his assessment practices were very traditional and formal in nature and limited to those provided by the curriculum. Though he did use informal assessments like observations and teacher questioning during class to gauge student understanding.

Espoused-Enacted Distinction

One of the links described by Ernest (1988) closely aligned with Jack's beliefs and practices. Namely, Ernest stated that the "instrumental view of mathematics is likely to be associated with the instructor model of teaching, and with the strict following of a text or scheme. It is also likely to be associated with the child's compliant behavior and mastery of skills model of learning" (p. 3). Though Jack expressed both instrumentalist and Platonist views about mathematics, the instrumentalist dominated in his actual teaching practices. He also expressed views that were characteristic of both the instructor and the explainer, however the instructor traits dominated. He did strictly follow the curriculum and was concerned with skill mastery as well as some conceptual understanding.

A distinction does occur between Jack's espoused views about assessment and his actual assessment practices. Jack wanted to use more discovery learning activities and projects in his classes but instead only used traditional curriculum-based assessments. When I consider the social context and perceived constraints like school culture and the expectations of others and his level of reflection, then I have a better understanding of his assessment choices.

Similar to the beginning teachers in Herrington, Herrington, and Glazer's (2002) study, Jack stated that he lacked the time to find and do something different in the assessment of student learning. The time constraint was compounded by the demands of the school and the curriculum to stay on course with other teachers and cover the material before the administration of the Benchmark or other assessments. Jack's perceived lack of authority to make decisions concerning the curriculum may have played a role in his decision to strictly follow the curriculum. Also a new teacher, keeping pace with other more experienced teachers was a difficult task. Jack said that he "was trying to stay afloat."

Ernest (1988) stated that the teacher's level of consciousness of his or her beliefs and the extent to which the teacher reflected on his or her practice impacted the teaching of mathematics. According to Ernest, Jack was at the third level of reflection. Jack was aware of his views and assumptions about mathematics and its teaching and learning. He was also able to offer some explanation for his views and assumptions. His expressed desire to do some discovery activities let me know that he was aware of viable alternatives to his current practices. However, he did not reach the fourth level because he did not implement appropriate assessment strategies in accordance with his views of assessment. To assess for skill mastery, he used the traditional assessment methods designed to assess skills and procedures. However, he did not use the viable alternative to assess for conceptual understanding that he attempted on a few occasions and that he thought was important to learning mathematics. Thus, it was easier for Jack to follow the curriculum guides and focus on assessing the skills and procedures that he stressed in class. It was less time consuming and it allowed him to "stay afloat" and on track with his colleagues.

Karen's Espoused Views

Karen, like Jack would be classified as both a Platonist and an instrumentalist based on her espoused views. Karen stated that mathematics was partly a set of rules and truths but she recognized the connections in mathematics too. She also thought that mathematics occurred naturally but that it was discovered, not created. When she talked about her teaching, she described the traits of both an instructor and an explainer. She wanted her students to know skills and be able to correctly solve mathematics problems. She also discussed the importance of them have some conceptual understanding of the material. Her description of her use of the curriculum was similar to that of what I called a modifier, one who uses that textbook approach but enriches it with additional problems and activities. Karen described how she looked at the test bank and her colleagues' tests but also searched the internet for other problems and activities. Though she wanted her students master mathematical skills and engage in the learning process, she expressed doubts about the ability of some of her students to learn mathematics. She also thought that some of them lacked motivation to learn mathematics but simply wanted to pass the class. Similar to Jack, Karen also thought that assessment served several purposes like allowing a student to demonstrate knowledge and giving the teacher an indication of what and how well he or she is teaching. She believed that the assessment of student learning should include a variety of methods since students learn in different ways.

Karen's Enacted Model

Karen displayed the role of an instructor when teaching and focused on giving plenty of notes so that her students correctly mastered the mathematical skills and procedures. She imparted knowledge and the students were the receptors of the knowledge. She used a modified version of the textbook approach. Karen's thinking that mathematics was a set of facts and rules and consisted of computation problems was reflected in her assessments being primarily computational in nature (Cooney & Shealy, 1995). Even though she did experiment with some alternative assessments.

Based on Karen's espoused views, she did not align as closely as Jack did into one of Ernest's (1988) links between views and models. She had parts of an instrumentalist view of mathematics, implemented an instructor model of teaching, and was concerned with mastery of skills and the reception of knowledge but her use of the curriculum was uncharacteristic of teachers with similar beliefs.

Espoused-Enacted Distinction

Although Karen was also constrained by the lack of time, pressure to finish the curriculum, and the expectations of others to stay with the curriculum, she was the only first-year teacher to use any alternative assessments. Recall her one-shot approach. If she used an alternative activity and it was successful, then she tried another activity. On the other hand, if it was not successful, then she did not attempt other activities. She had more success with the Algebra II classes, therefore attempted more activities in those classes.

Consider her views about the students in the Concepts of Problem Solving (CoPS) class. She thought that many of them were not motivated to learn. More importantly, she thought that many of these students were not capable of learning mathematics. These views probably decreased her expectations of the CoPS students causing what is commonly termed the self-fulfilling prophecy or Pygmalion effect. She also said that she struggled with teaching this class and thought more experienced teachers should teach it. The combination of these factors along with her 'one-shot' approach hindered her from trying other alternative assessments or activities in the CoPS classes.

Now consider Karen's level of reflection. According to Ernest (1988), Karen reflected at the fourth level. At this level, Karen was able to choose and implement appropriate strategies in accordance with her views and models, dependent on the class. For the Algebra II classes, where she believed that many of the students were capable of learning and were motivated to learn, she implemented some appropriate alternative assessments, namely a project, a partner test, and eventually included some open-ended items on her test and quizzes. However, she did not reach what Ernest called reflectivity, the highest level of reflection. Karen was not concerned with reconciling her beliefs about the students in the CoPS classes to try any other alternative activities.

Angel's Espoused Views

Angel's expressed views were characteristic of both the Platonist and the problem solving view of mathematics. The importance of connections within mathematics was a clear and constant concern. She also talked about mathematics changing and being socially constructed. Her views of her role in the classroom were similar to those of an explainer and a facilitator. Like an explainer, she too discussed importance of having a conceptual understanding of mathematics. She also wanted to be more of a facilitator who assisted students by getting them to be problem posers as well as problem solvers. She described her transition from strictly following the curriculum to being a modifier, like Karen. Her goal for her students was for them to be active in the learning process as opposed to passive recipients of her knowledge.

Angel's Enacted Model

Angel displayed the role of an explainer when teaching by stressing connections and conceptual understanding. She engaged her students in the active construction of their own knowledge by encouraging discussions, allowing them opportunities to explain problem solutions to the class, and to play the role of the teacher. She began teaching as a strict follower but graduated to a modifier. Given her enacted model, Angel somewhat aligns with two of Ernest's (1988) links. According to Ernest, a teacher with a Platonist view of mathematics as a unified body of knowledge is likely to be associated with the explainer model of teaching, and with learning as the reception of knowledge model. The fact that Angel also expressed the views of mathematics as problem solving could explain why she viewed learning as active construction and not just the reception model. In another one of Ernest's links, he associated the problem solving view with learning as active construction.

Angel's assessment practices were traditional in nature. The homework problems from the practice booklet usually consisted of 10 problems that required knowledge of skills and procedures to solve. After asking her why she never assigned the one application problem, she changed that aspect of her assessment to include the one problem-solving questions. When she began creating her own tests, they were still traditional in nature. She did however, frequently assess her students through teacher questioning and by having them verbally explain their solutions to the class.

Espoused-Enacted Approach

Angel expressed views about using alternative assessments like projects and class presentations but did not attempt any of these activities. Like Jack and Karen, she too was constrained by the lack of time, the pressures of an institutionalized curriculum and pressures to stay on track with the other teachers. Similar to one of the first-year teachers from Zepeda and Mayers' (2001) study, Angel was also concerned about having to report the grades from alternative assessments and be accountable to parents or those in authority. She also thought that grading a test with open-ended assessment items would require too much of her time. However, some of her successful lessons were on the days that she did take her Algebra II classes to the computer laboratory during the semester. During these trips to the computer laboratory, she talked about being able to engage and reach students that she thought were average or that she had not been able to engage all semester.

Angel reached to the fourth level of reflection in Ernest's (1988) model. She was able to choose and implement appropriate teaching and learning strategies in accordance with her own views and models. For example, she believed that mathematical connections and having some conceptual understanding were important, thus she choose strategies like having engaging her students in discussions and role playing to help her students attain knowledge of the underlying concepts and notice the connections. When she changed the homework assignment to include the one application problem, she might have been reflecting at the highest level. She recognized that there was a conflict between her belief about the importance of connections and her practice of only assigning the skill-based problems. To reconcile the conflict between believing that mathematics is a connected body of knowledge with her practice of "giving them a detached view" of mathematics, she included the application problem because she thought that it was a way for them to see how to apply or connect the mathematics to a real-world context.

Summary & Conclusions

As this study found, the practice of teaching mathematics does depend on a number of elements (Ernest, 1988), most notably: teacher's system of beliefs about mathematics and its teaching and learning; the social context of teaching particularly the perceived constraints; and the teacher's level of reflection. Furthermore, as Herrington, Herrington, and Glazer (2002) found, a complex mix of these elements can impact teachers' use of assessment practices in their beginning years of teaching.

This study included a small sample of teachers but each teacher case study shed some light into the assessment decisions of the first-year mathematics teachers. The teachers' beliefs did not always translate to classroom practices. An initial examination of their espoused views and observations of the enacted models of teaching and learning revealed some mismatches between the two (Ernest, 1988). Ernest suggested two key causes for the mismatch, namely the powerful influence of the social context of teaching and the reflection level of the teacher. When discussing the social context, all of the teachers shared their perceptions of time constraints, curricular pressures, and meeting the expectations of others. To an extent, the three factors did impact their assessment practices. However, the three factors alone could not explain all of the mismatches. The additional consideration, the reflection level of the teachers, revealed a more complete picture of the influences on their assessment practices.

Jack's assessments were the most traditional and remained the same throughout the observation period. He was aware of assessment alternatives and wanted to implement them but never did. The data analysis revealed that his views and assumptions closely aligned with one of Ernest's (1988) links, he had the additional perceived constrained of lack of authority, and he only made it to the third level of reflection. According to Ernest, Jack's instrumental views and the associated models of teaching and learning require little self-consciousness and reflection or the awareness of the existence of viable alternatives. Though he was aware of some alternatives, Jack's perceived lack of authority and not reflecting at a higher level prohibited him from implementing or trying something different in his assessment of student learning.

Karen was proof that some beginning secondary mathematics teachers do implement alternative assessments in their first year of teaching. Though she stated that the curriculum was decided for her, she did exert control over how to assess student learning. However, these alternatives were limited to her Algebra II students. The project and partner quiz were successful assessments and encouraged her to try other activities. After discussions with the researcher about open-ended assessment items, she began including them on her assessments for the Algebra II classes.

Karen's belief that some of the technical level students were not capable of learning mathematics and her one-shot approach resulted in lowered expectations and hindered her from trying alternative assessments with these students. Even though she reflected at the fourth level, she was not able to reconcile her belief that assessment should be varied and include alternative methods to meet the different learning styles of the students.

Angel's assessment practices evolved during the observation period. After growing in confidence in her mathematical ability and becoming more familiar with the curriculum, she moved from a strict follower to a modifier of the curriculum. Her reflecting at the higher levels of Ernest's (1988) model allowed her to choose teaching and learning strategies aligned with her views. She was even able to reconcile conflicting espoused beliefs about teaching and learning mathematics with her enacted mathematics assessment practices.

Ernest's (1988) model was useful in illuminating some key causes to the mismatch between what teachers beliefs and their practices. His model included teachers' beliefs about mathematics and its teaching and learning, their use of the curriculum, the influence of the social context of teaching and their reflection levels. I focused on their assessment practices, which Ernest did mention in his model as being part of the institutionalized curriculum. Since it is part of a teacher's instructional practices, it would be impacted by some of the some influences as described in the literature (See e.g., Ensor, 2001; Herrington, Herrington, & Glazer, 2002).

Implications

This study raised questions for further study. Given that they were first-year teachers, how have their assessment practices changed over time? If not, why haven't they changed? If so, in what ways have they changed? How would constraint management or other professional development benefit these teachers? Would a replication of this study with different and possibly more first-year mathematics teachers reveal a different set of influences on their assessment practices?

This study highlighted the continued discrepancy between teacher beliefs and teacher assessment practices. It also revealed some potential causes of the mismatches. Given this knowledge, mathematics coaches and teacher educators could design focused professional development for beginning teachers. They could provide beginning mathematics teachers with support in constraint management, where they have an open forum via the Internet to voice and discuss their constraints, so that teachers can reach resolutions in a collegial manner (Herrington, Herrington, & Glazer, 2002). With the support, the teachers may learn techniques that allow them to reach the highest level of reflection where they would be concerned about reconciling their conflicting beliefs and their assessment practices. Since the first-year teachers recalled learning about various techniques during teacher training, coaches could also support and help them implement the techniques that they had previously learned and then help them to reflect on the implementation and effectiveness of the techniques. Coaches modeling different alternative assessments through demonstration lessons or co-planning alternative assessment activities can help teachers like Karen overcome her 'one-shot' approach. During preservice teacher education, teacher educators can design activities or include readings that allow the prospective teachers to become aware of and possibly challenge some existing beliefs. For example, the prospective mathematics teachers could read and discuss articles about teachers who implement various forms of assessments in their practices or that address the impact of beliefs on teachers' practices. Teacher educators could devote time to preparing future teachers who are assessment literate. Lastly, teaching reforms cannot occur unless teachers' deeply held beliefs about mathematics and its teaching and learning change (Ernest, 1988). Furthermore, Ernest stated that changes in beliefs are associated with increased levels of reflection. Thus, current and future mathematics teachers can benefit from learning to be reflective thinkers so that their pedagogical beliefs translate into effective classroom practices including assessment practices. Mathematics coaches and professional developers can help reform the teaching of mathematics by helping teachers become more reflective about their teaching and assessment practices.

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APPENDICES

APPENDIX A: INTERVIEW PROTOCOL FOR JACK

Informal Interviews #1

1. What do you like most about mathematics?
2. What do you like least about mathematics?
3. What made you want to teach mathematics rather than another subject?
4. Would you say that mathematics was discovered or invented?
5. Describe a good math student.
6. Describe a poor mathematics student.
7. How do you know when someone had learned mathematics?

Informal Interview #2

1. Do you differentiate between pure and applied mathematics? Why or why not? How?
2. What do high school students need to know about the Pythagorean Theorem?
3. Is mathematics a creative subject? What does it mean to be creative in mathematics?
4. What does it mean to know mathematics? When someone says "I know mathematics" what dos that mean to you?
5. When it comes to learning mathematics, would you argue more for nature or nurture?
6. Consider the following similes. Learning mathematics is like:

Working on an assembly line.	Watching a movie.
Cooking with a recipe.	Picking fruit from a tree.
Working a jigsaw puzzle.	Conducting an experiment.
Building a house.	Creating a clay sculpture.
Working as an apprentice.	Working on a corporate team project.

   Choose the simile that you believe best describes learning mathematics and explain your choice.

Informal Interview #3

1. How do you feel about cooperative learning in mathematics? Why?
   (individual endeavor or learned in interaction)

2. Describe the best environment for mathematical learning? Why?
   (What would students be doing? What would teacher be doing? What would room look like? What materials would be present in the room?)

3. If money were no a factor, what materials would you want your students to have at home to assist in their mathematical learning? (computers, calculators, manipulatives, tools)

4. Describe a particularly successful teaching episode that you remember. What made it successful?

5. What makes a mathematics lesson successful? If you could create the perfect teaching environment, what characteristics would it have?

6. Consider the following similes. A mathematics teachers is like:

News broadcaster	Entertainer
Doctor	Orchestra conductor
Gardener	Coach
Missionary	Social worker

   Choose the simile that you believe best describes a mathematics teacher and explain your choice.

Informal Interview #4

1. How do you know when learning has occurred?

2. What would it take for you to do something different?

3. \What makes a lesson unsuccessful?

4. How much information do you give during an assessment?

Informal Interview #5

1. Describe someone with a deep and thorough understanding of a concept or a given topic?

2. Describe someone with a minimal understanding of a concept or a given topic?
3. Consider the assessment items that you brought in from a test or quiz. What about the first item makes it assess a minimal understanding of the topic? What about the second

item makes it assess deep and through understanding of the topic? (Asked at a later date but related to questions 1 & 2.)

Informal Interview #6

1. Is it okay for students to feel uncomfortable during your mathematics class? When/under what circumstances? Elaborate.

2. Is it okay for you to feel uncomfortable during your mathematics class? When/under what circumstances? If so, can you think of an example? Do you avoid feeing uncomfortable? Elaborate.

3. What is your ultimate responsibility as a mathematics teacher?

4. Whose responsibility is it to decide what is taught in your mathematics classroom?

5. Consider the following continuum. As far as mathematical importance, put an X on the continuum where you believe the importance or emphasis should be in mathematics teaching.

|____|
skills concepts

Final Interview

1. Define assessment in math

2. How are assessment and grading related?

6. Aren't there some questions like that in the text, do you use those

7. Complete this sentence – Good assessment should …

8. Bad assessment …

9. How do you choose test items

10. How do you choose homework items?

11. Do the experienced mathematics teachers make the little schedule that you hand out?

12. Have you ever thought of using one of those like at the end of class? Oh but they don't bring their books so you would already have to have that like on the overhead or handout or something like that?

13. What are characteristics of a good assessment? Say more about that.

14. Suppose you grade a set of tests and the grades are much lower than you expected, how would you react?

15. Do you expect students to learn during a test?

APPENDIX B: INTERVIEW PROTOCOL FOR KAREN

Informal Interview #1

1. What do you like most about mathematics?
2. What do you like least about mathematics?
3. What made you want to teach mathematics rather than another subject?
4. Would you say that mathematics was discovered or invented?
5. Describe a good math student.
6. Describe a poor mathematics student.
7. How do you know when someone had learned mathematics?

Informal Interview #2

1. Do you differentiate between pure and applied mathematics? Why or why not? How?
2. What do high school students need to know about the Pythagorean Theorem?
3. Is mathematics a creative subject? What does it mean to be creative in mathematics?
4. What does it mean to know mathematics?
5. When it comes to learning mathematics, would you argue more for nature or nurture?
6. Consider the following similes. Learning mathematics is like:

Working on an assembly line.	Watching a movie.
Cooking with a recipe.	Picking fruit from a tree.
Working a jigsaw puzzle.	Conducting an experiment.
Building a house.	Creating a clay sculpture.
Working as an apprentice.	Working on a corporate team project.

   Choose the simile that you believe best describes learning mathematics and explain your choice.

Informal Interview #3

1. How do you feel about cooperative learning in mathematics? Why? (individual endeavor or learned in interaction)

2. Describe the best environment for mathematical learning? Why? (What would students be doing? What would teacher be doing? What would room look like? What materials would be present in the room?)

3. If money were no a factor, what materials would you want your students to have at home to assist in their mathematical learning? (computers, calculators, manipulatives, tools)

4. Describe a particularly successful teaching episode that you remember. What made it successful?

5. What makes a mathematics lesson successful? If you could create the perfect teaching environment, what characteristics would it have?

6. Consider the following similes. A mathematics teachers is like:

News broadcaster	Entertainer
Doctor	Orchestra conductor
Gardener	Coach
Missionary	Social worker

   Choose the simile that you believe best describes a mathematics teacher and explain your choice.

7. What makes a mathematical lesson unsuccessful?

8. Do you feel that you are able to be the best teacher you can be? Improve?

9. Who or what influenced you to pursue mathematics teaching? What about them influenced you?

Informal Interview #4

1. How do you define assessment in mathematics?

2. How are assessment and grading related?

3. Fill in the blanks: Good assessment should ____
   Bad assessment ____________________________

4. How do you choose test items?

5. How do you choose homework items?

6. What are characteristics of a good assessment?

Informal Interview #5

1. Consider the assessment items that you brought in from a test or quiz. What about the first item makes it assess a minimal understanding of the topic?
2. What about the second item makes it assess deep and through understanding of the topic?
3. Suppose you grade a set of tests and the grades were much lower than you expected. How would you react?
4. Would you say that your assessment is aligned with your instruction? In what ways is it aligned/misaligned?
5. Does the NCTM Standards affect your assessment practices? In what way?

Informal Interview #6

1. Is it okay for students to feel uncomfortable during your mathematics class? When/under what circumstances? Elaborate.

2. Is it okay for you to feel uncomfortable during your mathematics class? When/under what circumstances? If so, can you think of an example? Do you avoid feeing uncomfortable? Elaborate.

3. What is your ultimate responsibility as a mathematics teacher?

4. Whose responsibility is it to decide what is taught in your mathematics classroom?

5. Consider the following continuum. As far as mathematical importance, put an X on the continuum where you believe the importance or emphasis should be in mathematics teaching.

|____|
skills concepts

6. What is the best way to assess understanding of skills?

7. What is the best way to assess understanding of concepts?

8. Do your assessment instruments reflect where you fell on the continuum?

9. Have you or would you ever consider writing curriculum? Why or why not?

10. Two teachers were having a discussion in the teachers' lounge. With whom do you most agree? Why?

    Teacher A: We have a curriculum for a reason. It shouldn't matter which teacher a student has. Algebra I is Algebra I. Everyone should cover the same material. If a teacher doesn't finish the curriculum, she has really done her students a disservice. They won't be prepared for the next class. Even if you can't do everything in detail, you should at least expose the students to all the material in the curriculum. Our job is to teach the curriculum.

    Teacher B: Nobody can predict how long it will take a certain group of students to understand a given topic. It's okay to use the curriculum as a guide, but we have to honor the pace of our students. Developing mathematical understanding takes time. Getting students to make and test conjectures and draw conclusions takes time. I'm not willing to sacrifice understanding in order to finish the curriculum. Our job is to facilitate students' mathematical understanding.

11. The purpose of high school mathematics is to enable students to be able to:

    Function (or excel) I college mathematics courses
    Function in society
    Reason mathematically
    See mathematics as a connected whole
    See the beauty in mathematics
    Do well on standardized tests
    Solve mathematical problems

12. How do you decide how to teach a particular topic?

Final Interview

1. How do you define mathematics?

2. Which of the following best describes your view of mathematics:
    a. A set of rules and truths
    b. An unquestioned body of useful knowledge
    c. A body of structured, pure knowledge
    d. A personal experience
    e. A changing body of knowledge that is socially constructed

3. Do you write down your lesson plans? How far in advance do you plan?

4. What are your strengths as a mathematics teacher?

5. What about weaknesses?

6. If you were giving advice to a new teacher regarding assessment, what would you say? If they asked for help with assessment, what would you say?

7. What was your biggest dilemma as a math teacher?

8. Speaking of time, what part did coaching play? How did it affect your teaching?

9. Do you think there's anything you'll do differently next year to help them be more confident?

10. If tests were not required, how would you assess your students learning?

11. How important is it for mathematics teachers to be precise in their language?

12. What opportunities do you provide your students to discover mathematics on their own?

13. If you had to teach logarithms again how would you introduce it or do you recall how you introduced them?

14. How do you want your students to view you now that it is all over, when they think back to Mrs. C's class?

15. Think back to before you started the study, before, during and after, to what extent do you reflect on your teaching and your assessment practices? Or your teaching?

16. What are characteristics of a good assessment item?

17. Name some of the math classes you took in college.

18. What would have helped you had you learned it in your teacher education?

19. How well do you think you were prepared?

20. How would you define informal assessment?

21. Do you think some of your students are unmotivated to learn?

22. How capable do you think all of your students are at learning mathematics?

23. Is there a right way to teach mathematics or a wrong way?

24. What's the most important thing you can tell me about your beliefs about mathematics teaching and mathematics assessment?

25. Is there anything that happened since I was here last?

26. Now that you have finished a year of teaching, tell me something that have you learned about assessment, teaching, or mathematics this past year?

27. Do you think that you will use the same tests next year?

APPENDIX C – INTERVIEW PROTOCOL FOR ANGEL

Informal Interview #1

1. What do you like most about mathematics?

2. What do you like least about mathematics?

3. What made you want to teach mathematics rather than another subject?

4. Would you say that mathematics was discovered or invented?

5. Describe a good math student.

6. Describe a poor mathematics student.

7. How do you know when someone had learned mathematics?

Informal Interview #2

1. Do you differentiate between pure and applied mathematics? Why or why not? How?

2. What do high school students need to know about the Pythagorean Theorem

3. Is mathematics a creative subject? What does it mean to be creative in mathematics?

4. What does it mean to know mathematics?

5. When it comes to learning mathematics, would you argue more for nature or nurture?

6. Consider the following similes. Learning mathematics is like:

Working on an assembly line.	Watching a movie.
Cooking with a recipe.	Picking fruit from a tree.
Working a jigsaw puzzle.	Conducting an experiment.
Building a house.	Creating a clay sculpture.
Working as an apprentice.	Working on a corporate team project.

   Choose the simile that you believe best describes learning mathematics and explain your choice.

Informal Interview #3

1. How do you feel about cooperative learning in mathematics? Why? (*individual endeavor or learned in interaction)*

2. Describe the best environment for mathematical learning? Why? (*What would students be doing? What would teacher be doing? What would room look like? What materials would be present in the room*?

3. If money were no a factor, what materials would you want your students to have at home to assist in their mathematical learning? (*computers, calculators, manipulatives, tools)*

4. Describe a particularly successful teaching episode that you remember. What made it successful?

5. How do you know learning occurred?

6. Consider the following similes. A mathematics teachers is like:

News broadcaster	Entertainer
Doctor	Orchestra conductor
Gardener	Coach
Missionary	Social worker

   Choose the simile that you believe best describes a mathematics teacher and explain your choice.

Informal Interview #4

1. Would you say that your assessment is aligned with your instruction? In what ways is it aligned/misaligned?

2. Does the NCTM Standards affect your assessment practices? In what way?

3. Think of a mathematical task that you assigned recently that you particularly liked. What did you like about it?

4. Do you expect students to learn during a test? Elaborate.

5. When/where do you mostly use open-ended items?

Informal Interview #5

1. Is it okay for students to feel uncomfortable during your mathematics class? When/under what circumstances? Elaborate.

2. Is it okay for you to feel uncomfortable during your mathematics class? When/under what circumstances? If so, can you think of an example? Do you avoid feeing uncomfortable? Elaborate.

3. What is your ultimate responsibility as a mathematics teacher?

Final Interview

1. How do you define mathematics?

2. What are your strengths now that you have completed your first year as a mathematics teacher and go and tell me your weaknesses.

3. What is the most important thing you could tell me about your belief about mathematics teaching and mathematics assessment?

4. What is your biggest dilemma as a mathematics teacher?

5. Could you use that time to do the projects? You can tie several concepts together. You could think about that this summer.

6. If you were giving advice to a new teacher regarding assessment, what would you say?

7. Do you write your own lesson plan?

8. How far in advance would you plan your lesson?

9. Suppose you were not required to give any tests, how would you assess?

10. What opportunities do you give your students to discover mathematics?
    How important is it for math teachers to be precise in their language?

11. How important is it for math teachers to be precise in their language?

12. To what extent do you reflect on your teaching and your assessment practices and I want you to compare before you started what you were doing and then after.

13. How does that make you feel?

14. Which of the following best describes your view of mathematics? 1) A set of rules and truths 2) An unquestioned body of useful knowledge 3) A body of structured pure

knowledge 4) A personal experience 5) A changing body of knowledge that is socially constructed

15. If you had to teach Logarithms, how would you go about introducing the topic?

16. Is there a right way to teach mathematics?

17. How do you want your students to view you now that it's all over?

18. How do you define assessment in mathematics?

19. How is assessment and grading related?

20. I'm going to ask you to fill in the blanks. Good assessment should ___________?

21. Bad assessment…?

22. Based on what you said what kind of assessment do they have here, bad assessment or good assessment, based on your definition?

23. How about your homework problems how do you choose those.

24. What are characteristics of a good assessment?

25. Describe or name some of the math classes you took in college.