SECONDARY MATHEMATICS TEACHER EDUCATION:
A METHODS COURSE SYLLABUS

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Abstract

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The purpose of this study was to learn more about how secondary mathematics teachers are educated in reform-oriented methods courses and use the results to inform the creation of a methods' course syllabus. The research questions were: (1) What does research suggest should be the goals of preservice education for secondary mathematics teachers? (2) How does the content of secondary mathematics methods courses connect with those goals? (3) How do secondary mathematics methods instructors reflect on the effectiveness of their own course activities in meeting those goals? (4) How can the results of this study inform the creation of a secondary mathematics course syllabus? The literature concerned with enhancing pre-service teacher (PT) education indicated three goals: (1) challenging preservice teachers' beliefs about teaching and learning, (2) enhancing PTs' conceptual understanding of the mathematics, and (3) developing PTs' pedagogical content knowledge. These goals act as the conceptual framework for this study. The data consisted of eight methods instructor interviews, their course syllabi, and their institutions' demographic information. Within case results indicate that: field-based activities are more effective than classroom-based activities, learning math at a conceptual level is most effective when examining specific concepts drawn from PTs' immediate needs and interests, peer teaching and unit planning are the most prevalent activities mentioned by participants, and 20% of the activities mentioned by participants addressed all three goals. There was no consensus concerning a set canon of knowledge. The cross case findings revealed a structure for those activities considered effective by participants. This structure, an Effective Activity Cycle, contains three components. All three were present in activities considered effective, while components were missing in those considered not effective. The cycle provided a foundation for developing the secondary mathematics methods course syllabus.

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Dedication

To my husband, Jeffry A. Levy

Chapter 1. Introduction

For decades, teacher training programs have been challenged with helping their students apply effective teaching practices (Berliner, 2000; Darling-Hammond & Cobb, 1996; Feiman-Nemser & Remillard, 1996; Glatthorn & Fox, 1996; McDiarmid & Ball, 1988; Wilson, Floden, & Ferrini-Mundy, 2001). In an attempt to address this issue, many university and college programs adapt their methods courses' instruction to model recommendations made by organizations such as the National Council of Teachers of Mathematics (NCTM). The effectiveness of reform-based practice for improving student learning outcomes is based on a rationale well established in the research literature (Darling-Hammond, 2001; Horn, 2000; Wilson & Berne, 1999; Wilson et al., 2001).

Despite these efforts, disparities in achievement levels continue to persist within our culturally diverse student population (Delpit, 1995; Nasir & Cobb, 2003). This achievement gap coupled with the results of the Trends in International Mathematics and Science Study (TIMSS) (NCES, 1999), indicating that our students' math skills trail other industrialized nations, have caused what could be described as a ripple effect throughout the education community. Education policy makers, school administrators, teachers, and parents have reacted to this issue in different ways. Some responses have been made public, for example, policies have been enacted as evident on the national level by the controversial "No Child Left Behind Act" (*No Child Left Behind Act*, 2002), and on the state level by adoption of standards-based assessment tools like the WASL (OSPI, 2004b) in Washington state. Other examples include the push for charter schools and school vouchers, parents' groups pressuring school districts to "get back to basics;" and other responses which are relatively private, such as conversations within schools of education focusing on assessing their effectiveness in training qualified teachers.

Across all these conversations, the proverbial 'finger' appears to be pointing towards teachers' skills, or lack thereof, to effectively educate our children. It is, therefore, not surprising that increased scrutiny has been directed towards preservice teacher training programs. With standards-based assessment becoming the norm for K-12, the momentum seems to be towards creating a set of standards for evaluating the skills and knowledge of preservice teachers (OSPI, 2004a). This indicates an imperative for aligning secondary mathematics methods curriculum with reform-oriented teaching goals and assessing that curriculum to improve its effectiveness.

The purpose of this study is to learn more about how secondary mathematics teachers are educated in reform-oriented teacher training programs. The questions explored in this dissertation are: (1) What does research literature suggest should be the goals of preservice education for secondary mathematics teachers? (2) How does the content of secondary mathematics methods courses connect with those goals? (3) How do secondary mathematics methods instructors reflect on the effectiveness of their own course activities in meeting those goals? And (4) how can the results of this study inform the creation of a secondary mathematics methods course syllabus? To answer these questions, eight instructors were interviewed about their methods courses. The content of the courses was analyzed to determine the connection between course goals and those suggested by research on preservice education. The case and cross case analyses results were then used to inform the creation of a secondary mathematics methods' course syllabus and an activity assessment tool.

Reform-Oriented Teaching vs. Teacher-Directed Methods

Reform-oriented teaching is student-centered rather than teacher-directed, applying inquiry and constructivist principles rather than depending on memorization and rote drills to learn definitions and procedures. In mathematics education, student-centered teaching promotes conceptual understanding, where students actively engage in developing abstract representations, solving open-ended problems, and critiquing solution processes used by their peers. Teachers validate students' thinking process, using incorrect answers as opportunities to delve deeper into the concept. Although many studies indicate that students learn better through student-centered instruction, than by teacher-directed educational methods, many novice and experienced teachers find it difficult to put reform-oriented methods into practice (Darling-Hammond, 2001; Horn, 2000; Wilson & Berne, 1999; Wilson et al., 2001).

Overview of Supporting Literature

The literature concerned with preparation of secondary mathematics teachers indicates three goals that need to be addressed during preservice education: (1) challenging beliefs about teaching and learning, (2) enhancing conceptual mathematical knowledge, and (3) developing pedagogical content knowledge to support reform-oriented teaching practice. The overriding need to challenge preservice teachers' strongly held beliefs about teaching and learning is consistent across much of the research that frames this study. The literature indicates that many novice teachers' beliefs about teaching and learning are based on personal experiences as students, which for the most part have been in teacher-directed classrooms (Feiman-Nemser, 1983; McDiarmid, 1990; Zeichner & Tabachnick, 1981). For example, when introducing reform-oriented teaching practice, the research indicates that beliefs about what it means to teach and learn are developed long before preservice teachers (PTs) enter a teacher education program. Mathematics courses that PTs have experienced as students tend to be characterized by the expectation that children will memorize formulas and learn to manipulate abstract mathematical equations using standard procedures, thus emphasizing skills rather than understanding concepts. Their image of an effective classroom environment is one in which children quietly listen to the teacher's explanation and then practice the skills introduced until they gain proficiency. Preservice teachers' deeply held beliefs about teaching influence their ability to put newly learned theories into practice, even when convinced that student-centered learning is more effective than teacher-directed methods. These beliefs, when not identified and challenged, adversely affect learning outcomes (Kagan, 1992; Thompson, 1992).

The second goal, prevalent in the literature, is to enhance PTs' understanding of mathematics at a conceptual level. Most people interested in teaching secondary level mathematics have taken advanced courses in mathematics and are adept at using mathematical procedures; however, this knowledge base is not sufficient for reform-oriented practice which emphasizes understanding the 'big ideas' or concepts (Ball & Cohen, 1999; Monk, 1994). Research evidence indicates that novice mathematics teachers are able to teach algorithms, which consist of well-defined steps and procedures for manipulating abstract equations; however, they are not able to adequately answer questions about the underlying concepts, such as why a particular procedure works (Borko et al., 1992). For example, most of us were taught to multiply fractions by multiplying across (multiplying the numerators and then multiplying the denominators). Rarely discussed is the reasoning behind this procedure, which helps students to appreciate how and when it can be applied. Understanding this at a deeper level provides connections between arithmetic concepts and the higher level mathematics of multiplication of rational expressions in algebra. Reform-oriented learning experiences are designed to have students explore the underlying concept and develop procedures that make sense to them. They are then expected to explain their solution process, to justify their answers and to critique the procedures presented by their peers. The literature indicates that preservice teachers' lack of conceptual understanding affects their beliefs about what it means to know, understand, and 'do' mathematics (Eisenhart et al., 1993; Van Dooren, Verschaffel, & Onghena, 2002).

Finally, the third goal is to develop preservice teachers' repertoire of pedagogical methods to help them connect the mathematics with students' interests and needs and build on their students' knowledge. Since pedagogical skills for student-centered instruction differ from the instructional models familiar to preservice teachers as a result of their personal experiences, it is important to challenge their beliefs. This means introducing and modeling reform-oriented methods, and providing opportunities for testing, critiquing, and comparing theories of practice that they will be expected to use when teaching their students mathematical concepts, as described in the preceding paragraph. The literature review is detailed in Chapter 2 of this study.

Overview of Methodology

The intent of this dissertation is to create a secondary mathematics methods syllabus and an activity assessment tool. The three goals, as described in the overview of the literature review, provided a framework for analyzing the data and developing methods course objectives. However, it was difficult to find empirical evidence of the content or the effectiveness of the methods used for teaching the curriculum. To inform the creation of a secondary mathematics methods syllabus, the structure of eight secondary mathematics methods courses and reported activity effectiveness were analyzed.

Reform-oriented mathematics methods instructors were approached to participate in this research study. Information about what they used to prepare secondary mathematics teachers was collected and analyzed. The participants in this research were a select group of mathematics methods instructors at teacher education programs noted for their reform-oriented focus. These included institutions in Washington state and across the country. The participants supplied course syllabi and participated in a telephone interview describing the content and methods used in the mathematics methods course(s) they teach. Data examination included document analysis of the syllabi and qualitative analysis of the interview transcripts. The data collection process and analysis rationale are described in the methods section, Chapter 3, of this study.

The two methods used to analyze data were a within case analysis and a cross case analysis. The within case findings indicate that the participants consider field-based activities to be more effective than classroom-based activities for addressing all three goals, and learning mathematics at a conceptual level as most effective when examining specific concepts drawn from the PTs' immediate needs and interests. Also evident from the within case analysis was that peer teaching and unit planning were the most prevalent activities, with 20% of the activities described in the syllabi and interviews addressing all three goals derived from the literature review. The cross case results revealed an identifiable structure for activities considered effective by participants. This structure, an Effective Activity Cycle (EAC), contains three components: (1) identification of an issue or dilemma, (2) data collection and reflection, and (3) critical analysis and action. The EAC provided a foundation for evaluating the structure of the activities used in the secondary mathematics methods course curriculum.

The design of the methods course syllabus developed as a result of this study was based upon Wiggins and McTighe's (1998) performance-based curriculum model. The first of the three stages recommended in this model was to determine the course objectives based upon the desired learning outcomes. The second stage was to determine what constitutes acceptable evidence of those learning outcomes, followed by the third and final stage, which was to plan the learning experiences and instruction.

Organization of Dissertation

The format of this dissertation is as follows. Chapter 2 is a literature review of selected research indicating three goals for secondary mathematics teacher education: (1) challenging PTs' beliefs about teaching and learning, (2) enhancing PTs' conceptual understanding of mathematical concepts, and (3) developing reform-oriented pedagogical skills. These provided a framework for the case study analysis. Chapter 3 details the data collection method and analysis process. Secondary mathematics methods instructors were interviewed and copies of their syllabi were collected and examined to determine the ways in which the courses align with the three goals determined through the literature review. Chapter 4 presents a case study analysis of the data in response to the three goals. Chapter 5 is a cross case analysis which identifies a theme concerning the structure of activities designated by the participants as effective. Conclusions and implications determined through the within case and cross case analyses are the focus of Chapter 6, explicitly detailing links between the goals identified in the literature analysis and the claims developed through data analysis. Chapter 7 provides insight into the application of the research. It includes the general format of a methods course syllabus and a sample unit plan, as well as an activity assessment tool. Appendix A is the interview guide.

Chapter 2. Educating Preservice Secondary Mathematics Teachers

Existing research specific to educating preservice, reform-oriented mathematics teachers offers some insight into three important aspects of methods course instruction. In this chapter, the literature examined indicates three distinct goals that affect the application of reform-oriented practice: (1) challenging preservice teachers' (PTs') preconceived ideas about teaching and learning, (2) enhancing PTs' level of content knowledge, comparing their procedural and conceptual levels of understanding, and (3) developing PTs' repertoire of pedagogical content knowledge specific to teaching for conceptual understanding. The one recommendation that resounds across the literature is the importance of providing opportunities for preservice teachers to explicitly challenge their strongly held beliefs: whether comparing teacher-directed methods with student-centered learning, contrasting using mathematical procedures with understanding underlying concepts, or comparing alternative aspects of pedagogical content knowledge. In this chapter, the issue of challenging PTs' beliefs across each of the goals is discussed.

Preservice teachers' beliefs are byproducts of their primary and secondary education, as well as life experiences connected with education or interaction with children (Anderson, Smith, & Peasley, 2000; Ball & McDiarmid, 1989; Feiman-Nemser, 1983; Zeichner & Tabachnick, 1981). Research studies focused on educational and cultural biography indicate these social influences have a major impact on teachers' beliefs and skills (Kennedy, 1991). Educational biography develops "long before formal programs of teacher preparation. Its roots are personal experiences with parents and teachers and images and patterns of teaching shaped by the culture" (Feiman-Nemser, 1983, p. 166). Ball and McDiarmid (1989) describe everyday experiences and cultural traditions as often overlooked sources of subject-matter knowledge, asserting that teachers' conceptions of knowledge shape their practice. They suggest that this is evident in the kinds of questions teachers ask, the ideas they reinforce, and the sorts of tasks they assign. Therefore, biographical experiences affect PTs' understanding of what constitutes a disciplines' structure and inform their beliefs about teaching and learning long before formal training or actual teaching experiences commence.

The literature examined in this chapter indicates that methods classes are for the most part successful in presenting reform-oriented teaching theory at a cognitive level, which means students who have attended these courses are able to discuss reform-oriented theories using appropriate terminology. However, espousing reform oriented theory does not mean that PTs' strongly held beliefs have been altered or that these new theories will in fact affect the way they teach. What it does indicate is that intellectually, the PTs understand the reform theories at a level where they can discuss the issues and are able to identify aspects of teacher-directed instruction as compared with student-centered learning. Thus, a cognitive level of understanding indicates an intellectual awareness of reform-based methods.

Each of the articles discussed in this chapter emphasizes different aspects of what might be considered effective teacher training; together they provide a foundation for developing reform-based math methods course objectives. In this chapter, each of the three sections aligns with a particular goal: (1) challenging beliefs about teaching and learning; (2) enhancing conceptual understanding of mathematics; and (3) developing pedagogical content knowledge.

Challenging Beliefs about Teaching and Learning

Beliefs about teaching and learning are significantly influenced by experiences with schooling long before prospective teachers enter a formal teacher training program (Cooney, Shealy, & Arvold, 1998; Ensor, 2001; Frykholm, 1996). In this section, the research focuses on challenging prospective teachers' beliefs about teaching and learning mathematics. These beliefs developed as a result of their earlier experiences as students, influencing how they perceive the role of teachers, schools, and students. The literature provides evidence that most PTs' elementary, secondary, and post-secondary academic mathematics education experiences can be defined as teacher-directed, where students are expected to follow directions, memorize procedures, rules, and facts, work mostly independently and more or less within a passive/receptive schema. Wrong answers are considered failures, competition is encouraged, and the role of the teacher is as the knowledge-holder, lecturer, and final arbiter.

These teacher-directed experiences are very different from the reform-oriented teaching and learning theories that the participants in this study expect the PTs to put into practice. Reform-oriented methods require students to take an active role in the learning process, share their ideas about concepts and procedures, make conjectures and test them against different models, and work collaboratively. Conflicting answers are considered opportunities for in-depth examination of concepts, and the role of the teacher is that of a facilitator, guiding students through the discovery of patterns, proofs and conceptual understanding. Therefore, an important aspect of the syllabus developed for this study was to include curricula that challenge the preservice teachers' ways of thinking about teaching and learning.

Learning to teach using inquiry methods that encourage teachers to challenge their knowledge about teaching and learning is a "social enterprise. It can be done alone in some rare cases, but such cases require either special working conditions or almost heroic efforts on the part of the inquiring teachers, or both" (Ball & Cohen, 1999, p. 17). Beliefs need to be challenged, analyzed and critiqued within a community of learners, and expecting teachers to do this work in isolation is not a reasonable expectation. Deeply rooted beliefs are "not likely to change unless alternative experiences challenge their validity" (Feiman-Nemser & Remillard, 1996, p. 70).

This section of the literature review is divided into two subsections. To address PTs' needs, it is incumbent upon teacher educators to understand (a) the nature of reflective practice and its affect on the redevelopment of beliefs about teaching and learning, and (b) how novice teachers recontextualize new ideas to fit with their deeply help beliefs. The section concerned with the nature of reflective practice provides information to help teacher educators better appreciate various degrees of cognitive understanding that the PTs may exhibit. The section focused on how novice teacher recontextualize new ideas to fit their beliefs provides insight into a subconscious learning phenomenon that appears to exacerbate the theory to practice continuum. This information informed the content of the methods course syllabus as well as the activity assessment tool, as detailed in Chapter 7.

The Nature of Reflective Practice

One of the tenets of reform-oriented teaching is the use of reflection to enhance teaching skills. Reflective practice is an assessment process that is cyclical in nature (see **Figure 1.**) The teacher analyzes students' needs, the content of the curriculum, and curriculum objectives, and chooses activities, tasks and assessment measures to help students learn the concepts. These are all integral parts of the planning process. The result of the planning process is a lesson/action plan that includes the task students will perform, the teacher's role as facilitator, and the collection of evidence of student understanding (assessment). The reflecting happens when the teacher examines student work and the effectiveness of the task. This process of reflecting in turn informs the planning for the next time that particular lesson is presented. This cyclical process is called reflective practice (**Figure 1.**)

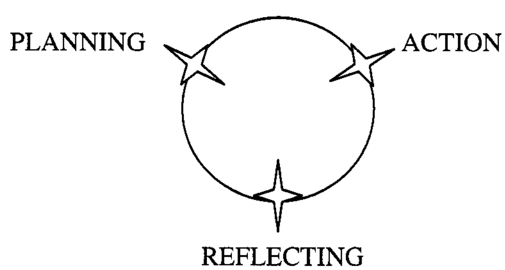

Figure 1. Reflective Practice Cycle

One of the aspects of reflective practice is to consider how teaching methods can be improved. The effectiveness depends upon the nature of reflection. Cooney, Shealy, and Arvold (1998) describe four patterns of reflection that they discovered through an analysis of novice teachers' practice. These patterns represent varying cognitive levels of reflection: (1) *naïve idealist*, (2) *isolationist*, (3) *naïve connectionist*, and (4) *reflective connectionist*. The *naïve idealist* is characterized by the pursuit for consensuality—uncritically accepting ideas that minimize differences in favor of agreement and making decisions that encourage harmony over controversy. Cooney et al. suggest that the *naïve idealist* is particularly vulnerable to the influence of the student teaching experience, especially if it is within a teacher-directed environment where contradictions with the theories learned in the methods class are not addressed. The second pattern described by Cooney et al. is the *isolationist*. (2) An *isolationist* is mostly interested in seeking confirmation, while not assimilating ideas perceived as different from their beliefs. This belief pattern is described as difficult to address as the *isolationist* tends to dismiss teaching methods that conflict with his/her strongly held beliefs.

The other two patterns of reflection are "more open to the idea of teaching as a problematic activity" (p. 331). (3) A *naïve connectionist* reflects on personal experiences in relation to reform methods of teaching but is not able to resolve contradictions with personal beliefs. This pattern of reflection manifests as indecisiveness. Within the methods classes and during the student teaching experience, opportunities to address these contradictions appear to be effective for helping the *naïve connectionist* link theory with practice. On the other hand, (4) a *reflective connectionist* uses reflection to integrate former beliefs about teaching and learning with reform-based ideas, analyzing the merits of different teaching concepts, and coming to terms with newly formed beliefs in a committed way. The *reflective connectionist* appears to be the most capable of connecting reform-oriented teaching theory with practice with minimal intervention.

These patterns of reflection can be used as a heuristic schema to help teacher educators develop deeper insights into their students' development as teachers. Teacher educators can use this schema to analyze their students' belief structures, paying particular attention to the intensity with which those beliefs are held and the nature of the evidence that supports those beliefs, to provide an effective structure that will move a student from being a *naïve idealist* or even an *isolationist* to being a *connectionist.* Accounting for "the structure of beliefs enables us to create activities that encourage teachers to wonder, to doubt, to consider what might be, to reflect, and most important, to be adaptive" (Cooney et al., 1998, p. 332).

These patterns of reflection are suggestive of varying degrees of cognitive levels of understanding. To move a PT from an appreciation of a teaching theory to a deep conceptual understanding from which they can base pedagogical decisions, teacher educators need to understand the process by which PTs respond to and interpret the theories presented through academic coursework. Opportunities to discuss the inconsistencies between strongly held beliefs, reform-oriented theories of practice, and observed teaching methods in public school classrooms are essential for helping PTs connect theory with practice.

Recontextualizing New Ideas to Fit with Beliefs

There is a negative impact on teacher training effectiveness when PTs' beliefs are not adequately challenged (Borko & Putnam, 1996; Ensor, 2001; Feiman-Nemser, 2001; Frykholm, 1996). One reason for this is that novice teachers (NT) tend to recontextualize new ideas about learning and teaching to align with personal experiences and beliefs when those experiences and beliefs are not adequately challenged. Ensor (2001) describes *recontextualizing* as "a process of embedding, reembedding, and change" (p. 297) that transforms beliefs about teaching and learning based on experience and reflection. The process of recontextualizing beliefs is influenced by the social context of the teacher education courses and in-school teaching experiences.

Many PTs, as they go through a teacher education program, are able to describe and evaluate what might be considered "best practice" as it applies to reform-based teaching. The ability to describe and evaluate teaching practices is a cognitive process whereby PTs learn vocabulary associated with teaching and develop analysis skills that allow them to discuss the merits of different teaching methods. Methods courses that (a) have students working in groups, (b) utilize tasks carefully chosen as exemplars for illustrating visualization of the mathematical concepts, and (c) apply inquiry style learning experiences whereby PTs discover rather than being told are modeling reform-oriented teaching practice. Also, methods instructors who offer "a range of exemplary mathematics tasks" and conduct "explicit discussion of issues emerging from them for mathematics teaching and learning" (Ensor, 2001, p. 302) are providing experiences that may be very different from those previously experienced by their students. However, even though modeling of reform-oriented practice and applying these exemplary tasks are important, they do not in and of themselves assist PTs to address deeply help beliefs that may conflict with newly acquired knowledge about teaching and learning.

In spite of instructors' attempts to model reform-based teaching and provide opportunities for reflection to challenge PTs' beliefs, Ensor found that many PTs draw mostly in two ways from the methods courses once they are in the field as first-year teachers. They reproduce a small number of discrete tasks and discuss their teaching practices using the professional jargon introduced in the methods courses. This indicates that they learned the material at a cognitive level; however, there is little evidence that they can put this learning into practice (Ensor, 2001). For example, Ensor compares what was taught in a methods course with observations of students' first-year teaching practice and interviews, stating that the language novice teachers use fits with what was taught during their training, but does not appear to align with observed teaching practice. In other words, the novice teachers express beliefs that align with reform-based teaching; however, their practice is more closely associated with traditional, teacher-directed methods. Ensor suggests that the first-year teachers *recontextualize* what is taught in the methods class to align with their strongly held beliefs about teaching and learning. Recontextualizing is shaped by prior beliefs about teaching and learning, but most particularly by the students' cognitive level of understanding. Strongly held beliefs about teaching and learning must be challenged by confronting inconsistencies to produce a deep level of understanding, called the metacognitive level. This is necessary to put theory into practice.

To help students develop an understanding of reform-oriented teaching practice at a deep level of understanding, the metacognitive level, whereby they can put newly formed beliefs into practice, teacher educators must challenge secondary mathematics PTs' beliefs about teaching and learning:

> Prospective teachers need opportunities to examine critically their taken for-granted, often deeply entrenched beliefs so that these beliefs can be developed or amended...Unless teacher educators engage prospective teachers in a critical

> examination of their entering beliefs in light of compelling alternatives and help them develop powerful images of good teaching and strong professional commitments, these entering beliefs will continue to shape their ideas and practices. (Feiman-Nemser, 2001, p. 1017)

In the next section, PTs' beliefs about mathematics and their conceptual level of understanding mathematics are examined.

Enhancing Conceptual Understanding of Mathematics

Many people believe that content knowledge is of primary importance for mathematics teachers to teach effectively; however, there is some disagreement as to what constitutes that knowledge (Borko et al., 1992). Monk (1994) indicates that the number of math classes, or degrees in mathematics that a person has, does not provide a clear indication of whether or not a person will be able to effectively teach mathematics using reform-based teaching methods. On the contrary, it is the level of deep and flexible content knowledge that is critical for being able to teach mathematical concepts. Depth of knowledge requires an understanding of central facts, concepts, theories, procedures, rules of evidence and proof, and relationships among problem types and solution strategies (Ball & Cohen, 1999; Borko et al., 1992; Eisenhart et al., 1993; Feiman-Nemser & Remillard, 1996; Nathan & Petrosino, 2003; Wilson, Floden, & Ferrini-Mundy, 2002).

In a report developed for the U.S. Department of Education, Wilson, Floden and Ferrini-Mundy (2002) concluded that "prospective teachers may have mastered basic skills but lack the deeper conceptual understanding necessary when responding to student questions and extending lessons beyond the basics" (p. 195). Developing PTs' conceptual understanding of mathematics needs to be addressed for training them to be effective reform-based practitioners.

As suggested in the previous section of this chapter, PTs' prior experiences have a profound affect upon their deeply held beliefs about teaching and learning. Strongly held beliefs about mathematics as a discipline can affect what mathematics teachers consider important for students to know and learn (Ball & McDiarmid, 2000). This section is divided into three subsections focusing on aspects of PTs' level of conceptual understanding about mathematics and their beliefs about what constitutes knowledge of mathematics that affect their teaching practice: (1) how preservice teachers' beliefs affect their perceptions about students' levels of understanding, (2) the relationship between PTs' level of content knowledge and their ability to teach for conceptual understanding, and (3) the correlation between PTs' level of content knowledge and their beliefs about what it means to know and do mathematics. The information provided indicates an imperative to enhance PTs' conceptual understanding of the mathematics they will be teaching.

Levels of Understanding

For many PTs, content knowledge is defined as *content level* understanding of standard procedures called algorithms, vocabulary facts, and rote skills. This type of content knowledge; however, only describes a superficial level of understanding. Kinach (2002) cites Schwab in describing four distinct types of content knowledge that go "beyond the *content-level* … that are usually taught in schools" (2002, p. 55):

> (1) *concept-level understanding* … (2) *problem-solving level understanding* ... (3) *epistemic-level understanding* which refers to the warrants for evidence in a discipline, and (4) *inquiry-level understanding* which refers to the generation of

> new knowledge that advances thinking in the field...At the content level, what is known (i.e., algorithms, facts, and skills) is learned passively and accepted without questions. At the deeper levels of knowing, what is known is learned actively through reasoning within a problem context. This is possible because it is context which makes critical thinking, the finding of relationships, and the making of judgments possible (Schwab, 1978). (Kinach, 2002, pp. 55-56)

Reform-oriented teaching practices encourage teachers to go beyond the *content-level*, to help their students understand the mathematics at a deeper, more conceptual level. The ultimate goal is the *inquiry-level* of understanding of concepts that are central to mathematics. The dilemma for teacher educators is that the majority of PTs entering teacher education programs have only attained a *content-level* understanding even though they may hold bachelor's degrees in mathematics. This level of content knowledge has a profound affect upon PTs' abilities to teach for conceptual understanding.

Relationship between level of content knowledge and ability to teach for conceptual understanding

To illustrate this difficulty, Borko et al. (1992) conducted a case study of a PT's difficulty in teaching for conceptual knowledge, even though the PT expressed strong beliefs about the importance of students' learning mathematics at a conceptual level. During an interview, the participant expressed her belief that effective teaching requires making the math relevant and meaningful for students. To do this, she said she needs to apply the math to students' everyday lives and to what students might consider useful, and the activities need to be enjoyable. She expressed that for the lesson to be meaningful, students should be encouraged to "understand the math, not just know the process, but to understand the reasoning behind it and the logic of it" (p. 204). As for her conceptual understanding of the mathematics she was teaching, in interviews at the beginning of the student teaching experience, Borko et al. were unable to get her to talk about the division of fractions in a meaningful way:

> When asked how she might try to explain division of fractions to a sixth-grade student, she responded after a long pause, "Every time I've had trouble with fractions, I make the little pie thing. I mean pictures are about the only way you can show someone how fractions work. (pp. 206-207)

In spite of her qualifications, having completed three years as a college math major, this PT developed only a rote understanding of the mathematics and appears to have "no knowledge of representations that might enable her to teach the topic except by demonstration of the algorithm. These limitations would clearly make it difficult for her to implement her ideas about good mathematics teaching" (p. 207). From the statements the PT made concerning her pedagogical choices, it can be assumed that this PT intended to use reform-oriented teaching methods; however, the researchers found that despite attempts at such, she was not successful due to her dependence upon procedural knowledge of the mathematics.

Correlation between level of content knowledge and beliefs about what it means to know and do mathematics

As suggested in the previous section, there is a correlation between content knowledge and beliefs about what it means to know and do mathematics (Van Dooren et al., 2002). Van Dooren et al. found in their study comparing secondary and primary level teachers in Belgium that secondary level teachers tend to have a strong preference for using algebraic procedures to solve word problems, even when those problems would be more efficiently solved using simple arithmetic procedures. This is in contrast with primary level teachers who seemed to prefer arithmetic solutions with a wide diversity of solution processes for the algebra problems. Van Dooren et al. discovered that secondary level teachers tended to favor algebraic or abstract manipulation of the mathematics. This was demonstrated by their giving students high scores for these types of procedures as compared with their primary counterparts who justify their highest scores by taking into account the complexity of the problem, considering whether it is arithmetic or algebraic, and giving lower scores if the solution process seems too complex or abstract. This research indicates a direct relationship between teachers' content knowledge level and their perceptions concerning what constitutes effective mathematical processes. The secondary teachers in this study had more extensive experience with higher level math courses than had the primary teachers. Therefore, the secondary teachers had more exposure to mathematics being taught in strongly procedurally-based coursework. The results of this study indicate that the secondary level participants valued procedural over conceptual knowledge. Beliefs about what constitutes a high level of understanding appear to be reliant upon the teachers' beliefs about what it means to know and do mathematics.

Another example of the relationship between PTs' deeply held beliefs about the nature of mathematical knowledge and their level of subject-matter expertise is illustrated by Nathan and Petrosino (2003), who studied the relationship between PTs' subject-matter expertise in mathematics and their judgments concerning students' algebra problem-solving difficulties. All of the PTs in this study were enrolled in "reform-oriented teacher education programs that emphasized constructivist views of learning and student-centered instruction" (p. 915), the researchers expected the participants to be more likely to "reject views that emphasize getting the correct answer (product) over the specific solution methods used (process) and views that disregard the importance of students' invented methods as a basis for subsequent learning" (p. 915). The results of their study, however, indicate that this was not the case. Although PTs' stated beliefs align with current reform-based ideas as evident in their responses to the survey questions, there was a significant difference in how they responded to the math problems. The data indicated that the more advanced mathematics training the teachers had during their formal education, the more likely they were to consider algebraic procedures as the most effective solution methods and the less likely to believe that teachers can effectively build on students' invented methods. This indicates that the level of mathematical training effects PTs' beliefs about the nature of mathematics which in turn affects how they judge students' knowledge levels. These deeply held beliefs affect PTs understanding of mathematics and what it means to do mathematics.

This section of the literature review provides evidence that PTs have developed a *content-level* understanding of mathematics that has a profound affect upon their ability to teach mathematics for understanding. However, since the studies analyzed in this section do not analyze the pedagogy used in the methods classes that their participants had taken, it is not possible to hypothesize as to the effectiveness or ineffectiveness of specific teacher education training methods. What can be concluded is that secondary level PTs have strong procedural knowledge but overall lack the conceptual levels of understanding that are necessary to teach for understanding. As described in Ensor's study (2001) from the previous section, these beliefs about what constitutes mathematical knowledge are not only affected by the PTs' cognitive level understanding about teaching but by their content-level understanding of mathematics. This information provides a clear imperative to enhance PTs' level of understanding of the mathematics they will be expected to teach. For methods courses to successfully address this issue, instructors must help PTs deepen their conceptual knowledge by critically challenging their deeply held beliefs about what it means to know and do mathematics.

Developing Pedagogical Content Knowledge

The third goal addressed in the literature is developing preservice teachers' pedagogical content knowledge, which is deeply inter-connected with beliefs about teaching and learning as described in the first section of this chapter and with beliefs about mathematical knowledge as detailed in the second section. Shulman (1986) suggests that pedagogical content knowledge includes knowledge of "the ways of representing and formulating the subject that make it comprehensible to others…[and] an understanding of what makes the learning of specific topics easy or difficult" (p. 9). Pedagogical content knowledge, therefore, is a synthesis of knowledge about teaching and learning, about content, and about students' interests, needs and cultural influences.

The studies in this section examine the pedagogical issues related to teaching mathematics for understanding. The first topic discussed in this section focuses on the pedagogical factors that affect student engagement in high-level mathematical thinking. This includes: (a) the process of task selection and implementation, (b) aspects of task implementation that promote mathematical discourse, and (c) contextualizing a mathematical task to enhance teaching for understanding. The second topic focuses on the tensions and pressures that affect pedagogical decisions, such as influences during the field experience that may encourage following a particular textbook or timetable vs. considerations about student needs and levels of understanding.

Taken together, these two topics represent the complexity of teaching for understanding. Reform-oriented teaching practice is not a matter of show and tell but rather a complex orchestration of tasks, reflection, and probing for understanding. Pedagogical content knowledge is a content area that needs persistent attention, as the methods and tasks used for one group of students may be very different from those chosen for another group.

Pedagogical Factors that Affect Student Engagement in High-Level Mathematical Thinking

There are distinct classroom factors that either hinder or support students' engagement in high-level mathematical thinking and reasoning (Henningsen & Stein, 1997). These factors are defined by the pedagogical decisions teachers make concerning the implementation of tasks. Tasks flow through a series of three phases: The first is the representation of the task as provided by the curricular materials. The second is the selection of a task from the curriculum materials and its development into a format to present to students. The final phase is the interpretation and enacting of the task by the students. The level of a teachers' pedagogical content knowledge, it is presumed, plays a decisive role in these three phases, starting with an understanding of the content, scope, and sequencing of the curriculum materials available. This curriculum knowledge effects the choice of tasks, continuing through the analysis of the task which provides a context and structure around which the students will become engaged and finally in their responses to students' interpretations of the tasks.

Henningsen and Stein (1997) distinguish between pedagogical factors that maintain and reduce levels of thinking. There are five factors that effect the structure of the tasks for maintaining high levels of mathematical thinking: (1) building on students' prior knowledge, (2) scaffolding to maintain student engagement and move the task along, (3) allotting an appropriate amount of time for full competition of the task, (4) modeling high-level performance, and (5) consistently maintaining pressure for explanation and meaning. There are also six factors suggested that produce a decline in students' mathematical thinking: (1) removing the challenging aspects of the task, (2) using a task inappropriately for a variety of reasons (e.g., lack of interest, motivation, knowledge, or unclear task expectations), (3) allotting too little time for completion of the task, (4) not holding students accountable for explaining their reasoning, (5) presenting problem-solving strategies in discrete steps to be followed, and (6) shifting the focus of an activity from understanding the mathematics to merely finding the correct answer. To summarize, teachers not only need to "select and appropriately set up worthwhile mathematical tasks, but must also proactively and consistently support student's high level mathematical thinking and reasoning" (Henningsen & Stein, 1997, p. 546).

Process of task selection and implementation

Pedagogical content knowledge (PCK) is made evident by particular activities that teachers perform when planning and implementing lessons, such as: "figuring out what students know; choosing and managing representations of mathematical ideas; appraising, selecting, and modifying textbooks; deciding among alternative courses of action; steering a productive discussion" (Ball & Bass, 2000, p. 89). Teachers go through a process by which they select a task and make decisions concerning how to deal with the discussion of the mathematics based on students' numerous ways of solving the problem. As suggested by Ball and Bass, prior to presenting a problem teachers should (1) think about whether the task is a good problem for that particular group of students, considering their grade level and mathematical level, (2) figure out what is involved in determining patterns and nuances, (3) determine what is worthwhile in terms of what the children will learn and how it relates to other aspects of the curriculum and unit goals. "When teachers hold class discussions, they make decisions about which (and whose) ideas to pick up and pursue and which (and whose) to suspend or let drop. The teacher formulates probes, pushes students, offers hints, and provides explanations" (Ball & Bass, 2000, pp. 93-94). The decisions that teachers make about the appropriateness of mathematical tasks for a particular group of students, the depth of understanding concerning the different aspects of the mathematical connections, and the decisions made during the discussion phase of the task are important pedagogical decisions/activities that teachers of mathematics at all levels need to make.

Task implementation that promotes mathematical discourse

Another important aspect of reform-oriented practice is teaching students how to communicate with one another. This includes having students share their thinking with others, supporting their beliefs, and convincing others of the validity of their solution processes. This requires making pedagogical decisions such as: choosing tasks that elicit student thinking, monitoring the discussion so that the relevant mathematics is brought forward for examination, and communicating with one another in such a way as to respect alternate ways of knowing. Flexibility, the amount of time allotted to the task, the choice of the task, and the decisions concerning who will be part of the conversation are all pedagogical issues that must be weighed daily when teaching mathematics for understanding (Lampert, 1992).

Contextualizing a mathematical task to enhance teaching for understanding

Reflective practice is an important aspect of reform-oriented teaching practice as it allows the teacher to analyze how to improve mathematics instruction, dealing with issues concerned with curriculum, pedagogy, and classroom norms that support reform-based teaching practices. With an emphasis on conceptual understanding, teachers are confronted with dealing with curricular materials that may not support this method of teaching and learning. Therefore, PTs need to learn how to confront their beliefs to utilize curriculum that may be "deeply flawed and must be challenged" (Chazan, 1996, p. 458). If a teacher believes that "algebra is a subject to be understood," the methods used to teach, based on this philosophy, may run counter to the symbolic manipulation emphasized in the curriculum materials and textbook (Chazan, 1996, p. 463). This dilemma implies an imperative for teacher educators to provide PTs with activities that help them develop the skill to construct tasks that will make math more accessible to their students. However, when tasks are presented, issues concerning students' interpretation of the context may arise that are not expected. Even for highly skilled reform-oriented practitioners, this is a dilemma, as exemplified by Chazan's (1996) description of one of the exercises he gave to his students and their responses:

> Many of the students treated this problem as a real problem involving the business of a particular individual...One student went farther; she felt that the problem as written did not model the situation appropriately. She brought to bear considerations that were not represented in the problem...Her focus on

> these contextually important issues made it hard for her to work successfully toward finding a break-even point for the problem as posed (p. 466).

Chazan realized that his best intensions to present the mathematics in a realistic manner opened up issues of interpretation by students that did not lead them to the mathematical concept he hoped to have them explore. Pedagogical content knowledge is the ability to take knowledge concerning students, the mathematics and contextual relationships and developing a task that helps the student better understand the mathematics. However, what Chazan discovered is that sometimes the context can actually make the mathematics less accessible for some students.

There are many factors that come into play in the classroom that teachers need to take into consideration when developing effective lessons. In this excerpt, Chazan talks about his beliefs, sharing some of the dilemmas that teachers face:

> I see an attempt to teach algebra as a subject to be understood; I see students who would like to study the mathematics before the class and those who would not; I see students' social categories and experiences outside of school shaping our interactions around mathematical content; and I see combinations of sophisticated understandings of the need for and purpose of mathematical conventions alongside a desire simply to be told what is correct. (p. 470)

Teaching for understanding is a complex process which compounds best intentions for putting theory into practice as it involves not only conceptual understanding of the mathematics being taught but also a deep level of knowledge about students' motivation expectations and students' ways of learning, communicating, and understanding.

Tensions and Pressures that Affect Pedagogical Decisions

As described in the previous section, *content-level* understanding can be considered procedural knowledge of mathematics, whereas the *conceptual-levels* of understanding are those emphasized in reform-oriented teaching practices. *Procedural* and *conceptual knowledge* are essential to the study of mathematics, and both need to be taught to help students understand math; however, if only one is taught to the exclusion of the other, there are many issues that arise in students' abilities to do mathematics. The dilemma is how to balance the two so that students understand the "big ideas" and can apply reasonable procedures to solve complex, multi-level problems. Since mathematics courses taken at the university and public school levels by PTs prior to their formal teacher training are the "major sources of external influence on the process of learning to teach" (Henningsen & Stein, 1997, p. 11), it is important to understand "some of the tensions and pressures that face novice teachers and teacher educators who attempt to teach for conceptual knowledge and that make it difficult for them to move beyond procedural knowledge to conceptual knowledge in their classrooms" (Henningsen & Stein, 1997, p. 10).

The research reviewed in the first two sections of this chapter indicate that although PTs recognize the importance of helping their students understand mathematical concepts, and many are able to articulate ideas about how to teach mathematical concepts, they still have difficulty enacting those newly acquired understandings. Their procedural knowledge of mathematics and mathematics teaching is stronger than their conceptual knowledge. This claim is supported by Henningsen and Stein (1997) who discovered that although PTs have a reasonable level of conceptual understanding for a particular topic and are inclined to make an effort to teach for conceptual understanding, they still have difficulty executing that directive. As discussed previously, although methods instruction demonstrates or models teaching for conceptual knowledge, unless strongly held beliefs are critically analyzed and contradictions based on strongly held beliefs are explicitly addressed, PTs will interpret the information in "procedural terms, as routines for, or lists of, pedagogical strategies" (Henningsen & Stein, 1997, p. 36).

Pedagogical decisions based on textbook and timetables vs. student needs and levels of understanding

There are patterns that predict pedagogical decisions made by PTs. For example, Borko et al. (1988) discovered that many PTs during their student teaching experience rely almost exclusively on the textbook and standard curricular materials for basing their pedagogical decisions concerning what and how to teach. These PTs tended to model their daily planning primarily by selecting mathematics problems and examples from the standard textbook supplied by the school or district. Borko et al. found that when teaching the same topic to different classes, the PTs in their study tended to discuss differences between the classes at a superficial level, such as (1) describing one class as more restless than the other, (2) stating their main concern as trying to keep the classes together so that students will be "adequately prepared for the test" (p. 76) which is especially difficult during snow days or when classes were cancelled, (3) saying that when one class falls behind the other, some PTs use exercise sheets supplied by their cooperating teacher to give to the class that is ahead until the other class catches up (1988). These examples indicate the main concern is sticking to a timetable rather than whether students understand the mathematics or are challenged. The researchers also discovered that some PTs talk about how an earlier class provides a form of dress rehearsal "in terms of transitions" before teaching the later class (1988,

p. 77). This indicates a concern more about classroom management issues than the pedagogical issues concerning actual math tasks.

Another pedagogical issue is when PTs have difficulty keeping their students engaged. Borko et al. found differences in PTs' training align with ways they perceive this pedagogical dilemma—those who had gone through a teacher education master's degree program less frequently attribute students' lack of engagement to external elements that were outside of their control. For example, a participant in their study who had not completed a master's program said, "Some kids just don't like learning. They really don't like being here and there's nothing you can do. You know, you try everything to draw them into the learning scene, but this is not what they are interested in" (p. 78). While participants who had completed a master's level program were observed more frequently using a problem-solving approach to actively modify their pedagogical strategies based on self-evaluation and their cooperating teachers' suggestions. The master's level PTs appeared to have had more training in effective reflective practice (as illustrated in **Figure 1** at the beginning of the chapter.)

Conclusion

Appreciating the effectiveness of reform-oriented teaching practice, enhancing mathematical content knowledge to elevate it to a conceptual level of understanding, and developing pedagogical content knowledge is not enough to ensure that PTs can put teaching theories into practice. Although these are important goals for a reform-oriented methods course, there is a pedagogical component critical for helping PTs put theory into practice. As Ensor (2001) suggests, PTs deeply held beliefs must be addressed through opportunities to discuss and resolve inconsistencies. When conflicts surface they need to be recognized and addressed formally during educational training. Reflection should be situated within a group activity that encourages diverse ways of thinking to be brought forward and discussed. Evidence from Ensor's study suggests that attainment of professional language allows people to communicate with one another; however, vocabulary does not hold a fixed meaning. Vocabulary is understood based upon how it has been contextualized, therefore deeply held beliefs need to be addressed to better align PTs' vocabulary with the intended interpretation.

Ensor found that even if PTs state an intention to use reform-oriented practice, if they are not given opportunities to develop that understanding at a deeper level, they will recontextualize the vocabulary to align with their beliefs. The vocabulary therefore is understood at a cognitive level, rather than at a conceptual understanding of the teaching practice. Ensor clearly demonstrated this misalignment by comparing novice teachers' explanations with their observed teaching practices.

Kinach (2002) seems to have taken this into consideration when she developed a new pedagogical method for helping PTs develop their pedagogical content knowledge (PCK) so that it would more closely align with teaching mathematics for understanding. Kinach used a cognitive strategy to guide the PCK development of her students, using "Perkins and Simmons' levels of understanding framework as developed in the Teaching for Understanding Project at the Harvard Graduate School of Education (Perkins & Simmons, 1988; Wiske, 1998)" (p. 55). Her strategy is composed of five levels: (1) identify the PTs' PCK for a specific topic by asking them to describe how they would explain a math problem to someone learning it for the first time; (2) assess the adequacy of the PTs' instructions using Perkins and Simmons' levels of understanding; (3) challenge, using Socratic dialogue, the conceptions concerning a "good" explanation; (4) transform PCK into those that lead to learning for understanding by introducing a manipulative representation "not likely to lend itself to easy representation of the mathematical concept of process" (p. 55). Through the class discussion Kinach creates and maintains cognitive conflict to allow the PTs to work through the paradox at a deeper level and (5) resolves confusion by asking PTs to explain, choosing a visual representation that lends itself to a clear and precise explanation. Kinach has PTs use this "5-element cognitive strategy as a heuristic tool to redirect their habitual ways of thinking about subject-matter and subject-matter teaching toward a teaching-for-understanding philosophy" (p. 55).

Kinach found that using this five step approach, the results of her study indicated a significant shift in the PTs' use of PCK for promoting student understanding of mathematics. She found that, after working through this process of examining their PCK, "their core beliefs about teaching "simple" topics were challenged by the levels of understanding framework. When pressed to teach for understanding and not just information or skills, teacher candidates began to see the conceptual intricacies of so-called simple topics like adding and subtracting integers" (p. 63). Kinach's method appears to effectively challenge the PTs' beliefs about teaching and learning, presses them to interpret the mathematics at a conceptual level and models pedagogical methods that align with reform-oriented teaching practice. It also includes a critical analysis component that the other research studies allude to but do not have recommendations for how to accomplish.

This literature study indicates that the three goals initially identified need to be further clarified if they are to be used as a foundation for reform-oriented mathematics methods course objectives: (1) challenge PTs' beliefs about teaching and learning (2) enhance PTs conceptual level of understanding of the mathematics they will be expected to teach by challenging what they know and how they 'do math', and (3) develop their pedagogical content knowledge so that they are able to choose and develop tasks that will address their students' needs, develop students' mathematical discourse skills, and encourage problem solving while maintaining a high cognitive level of understanding of the mathematics.

The literature has provided a strong foundation for the course objectives and a framework for the case analysis; however, as discussed in the book, *Understanding by Design* (Wiggins & McTighe, 1998), there are four important aspects of syllabus design: (1) course objectives, (2) content, (3) pedagogy, and (4) assessment. The literature review addresses the first aspect, course objectives. In the following chapters, the data collected from interviews with reform-oriented teacher educators and their course syllabi provide other essential components. Although the literature suggests the importance of using inquiry, there is little detail, other than Kinach's approach, concerning how to go about doing this. The literature suggests the importance of having preservice teachers critically address their strongly held beliefs about learning and teaching mathematics but does not provide details for constructing those experiences. These types of detail will be addressed through case and cross case analyses of the interview data and syllabi. The data collection and analysis process are detailed in the methodology section, Chapter 3, of this study.

Chapter 3. Data Collection and Analysis Methodology

The goal of this dissertation was to develop a secondary mathematics methods' syllabus and an activity assessment tool that are grounded in reform-oriented objectives, methodology, and content. The intent was that the findings of this study would inform the methods course syllabus design and enhance the effectiveness of lessons, units and activities. A key assumption was that insight from practicing instructors can inform syllabus and activity design. The research was qualitative in nature, using purposeful sampling and case study analysis. Content and thematic analyses were performed to determine patterns within and across cases. This was accomplished by conducting case studies of the individual participants and a cross case analysis of the data. Data were collected during the month of April 2005; instructors were asked to provide their most current syllabi and discuss the course they taught that used that particular syllabus. The three sections in this chapter provide details concerning: (1) participants, (2) data collection, and (3) data analysis.

Participants

The sample consisted of eight nominated participants. The instructors who participated in this study were identified as using reform-oriented practice within teacher education programs in Washington state and across the country. The participants and/or the programs in which they teach were recognized for their emphasis on reform-oriented instruction educating secondary level preservice mathematics teachers. These were the criteria for nomination as this was a selected sampling. Potential participants were those instructors who had been nominated by my colleagues in the American Educational Research Association (AERA), the Washington Education Research Association (WERA), and the Washington Teachers of Teachers of Mathematics (WaToToM), or by members of my dissertation committee. Other potential participants were nominated by the initial group contacted to take part in this study. Therefore, each participant was nominated by a personal reference or through a personal reference. In total, there were eight participants, representing diverse programs with a broad range of course goals and objectives for secondary level math methods. The demographics of the programs included in the study were:

Carnegie Foundation Classification 2000

*http://www.carnegiefoundation.org/Classification/CIHE2000/defNotes/Definitions.htm

3 of the 8 programs

Doctoral/Research Universities—Extensive (D/RU-E): These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded 50 or more doctoral degrees per year across at least 15 disciplines.*

1 of the 8 programs

Doctoral/Research Universities—Intensive (D/RU-I): These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded at least ten doctoral degrees per year across three or more disciplines, or at least 20 doctoral degrees per year overall.*

4 of the 8 programs

Master's Colleges and Universities I (MC&UI): These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the master's degree. During the period studied, they awarded 40 or more master's degrees per year across three or more disciplines.*

Field experience integration into methods course/series

4 of the 8 programs:

PTs were in their student teaching experience during all of or part of the methods course/series.

6 of the 8 programs:

PTs were involved in formal field experiences that were integrated into the methods course/series.

2 of the 8 programs:

PTs' field experiences were not formally integrated into the methods course/series.

Table 1 provides a brief description of the program type, course objectives and field experience integration for each program. Please note that all names used in this study are pseudonyms, which have been listed in alphabetical order.

Table 1. Participant Background Information (all names are pseudonyms)

Name	Program Type	Main Course Objectives	Field & Course Integration
Bob	MC&UI, Certificate program, sec. math methods, 1 semester	Teaching for social justice, teaching as research, listening & curriculum creation	No formal field experience integrated into program
Jackie	D/RU-E, Certificate program, sec. math methods, 3 quarters (full yr.)	Challenge PTs' assumptions about teaching & learning, role of listening to inform teaching, promote a value of self-authority	Field experience, each qtr., student teaching last qtr—meet 2 mornings/wk for math education, and 1 afternoon/wk team meeting
Kim	D/RU-E, Certificate program, sec. math methods, 2 semesters	Curriculum, equity, conceptual math – focus on 'Now & Future'—time to discuss PTs' issues, share and analyze PTs' experiences	1st semester: Prior to student teaching, focus on inquiry skills. 2nd semester: Meets one day/week, with student teaching 4 days/week
Lilly	MC&UI, Certificate program, Math Dept., sec. math methods, 1 quarter	Enhance PTs' conceptual understanding of the math to inform their teaching and ability to assess student knowledge	Meets daily, no formal field experiences linked to the methods class (field experience linked with education department courses)
Mary	D/RU-E, Certificate program, sec. math methods, 2 semesters	Understanding: students' thinking, learning environments, math concepts	Meets daily, in the field 1-2 hours per week during 1st semester. Meets for 2 hrs, 2 days/week during 2nd sem. while student teaching
Matt	MC&UI, Certificate program, Math Dept., sec. math methods, 2 qtrs.	Focus on student learning and curriculum alignment between instruction and assessment	Field experience is extensive during the second quarter
Pam	MC&UI, Master's degree program, middle school science/math methods, 1 quarter	Focus on what student know and are able to do	Methods class meets daily for ½ day with ½ day in student teaching
Rick	D/RU-I, Certificate program, sec. math methods, 1 quarter	Develop connection with students—really getting to know how they learn, what motivates them, what they know and understand	Methods class meets one afternoon/week. Some are student teaching full time, others may not be teaching (career changers-working in other professions)

Data Collection

Each eligible participant was contacted by e-mail to ask if they were interested in taking part in this study. Those who agreed submitted an informed consent form and course syllabus. An appointment was made for each participant to be interviewed by telephone. All participants agreed to allow the interview to be audio recorded and transcribed.

Systematic data collection was from three documents: (1) internet web sites and information from the second section of the interview provided general background information about the institution, instructor, and teacher training program; (2) the course syllabi; and (3) the first section of the interview contained guiding and probing questions which asked the instructors to share their course goals, content focus, what they thought their PTs have learned, and their assessment and planning methods. The general interview protocol designed for this study had two distinct sections; the first was a guide for the topics and issues, the second section contained background or demographic questions. The protocol was sent to participants as a general question guide to prepare for the interview. The advantages of the interview guide section was that it maintained the overall focus across participants yet was flexible enough to be adjusted to particular issues that arose through the syllabus analysis. Probing and clarifying questions were developed based on an analysis of the instructor's syllabi, and follow-up questions were asked during the interview to clarify issues introduced by the interviewee. The disadvantages to the guide were that participants were not necessarily asked the same questions. Omissions and responses should be considered within this context of question variability as it may reduce the comparability of the data across cases (Patton, 2002). The general interview protocol is included in this dissertation as Appendix A. This was the guide used for sorting the probing questions that were individualized for each interviewee. The interview responses were collected, transcribed, and analyzed through the framework of the three goals determined from the literature review in Chapter 2 of this study.

Data Analysis

As described in Chapter 2 of this dissertation, the three goals identified through the literature review provide a framework for analyzing the data. These goals were to: (1) challenge PTs' beliefs about teaching and learning, (2) enhance PTs' conceptual level of understanding of the mathematics that they will be expected to teach, and (3) develop PTs' pedagogical content knowledge (PCK) so that they are able to choose and develop tasks that will address their students' needs, develop students' mathematical discourse skills, and encourage problem solving while maintaining a high cognitive level of understanding of the mathematics.

The data provided three types of information:

(1) Background and demographic information about the individual instructors, their methods courses within the context of their institution, and the teacher education programs.

(2) Pedagogical methods, activities and projects, and course objectives included in the syllabi.

(3) Instructors' perceptions of the effectiveness of the projects, lessons and activities; issues or frustrations they experience in teaching the course; and overall insights concerning their students.

The intent of the data analysis was to organize and analyze the content and pedagogical methods used by reform-oriented methods instructors to determine how these align with the three goals as defined through the literature review in Chapter 2 of this study. To accomplish this, the data from the syllabi and interviews were divided by case and aligned with the three goals. This provided a basis for analyzing the individual cases, as described in Chapter 4. The second half of the process was a cross case analysis which determined patterns common to all of the cases studied here. A theme concerning the structure of activities designated as effective by the participants emerged from the cross case analysis. This theme is described in detail in Chapter 5. In Chapter 6, the data from the literature review, individual case studies, and cross case analysis are synthesized and summarized to provide the criteria for formulating a reform-based secondary mathematics methods course syllabus. The final chapter of this dissertation, Chapter 7, applies what has been learned through this study. The secondary mathematics course syllabus and activity assessment tool were designed to meet the criteria specified in Chapter 6.

Chapter 4. Examining What is Taught in Secondary Math Methods Courses

In Chapter 2 of this study, the literature indicated three distinct goals that are important to consider when educating preservice secondary mathematics teachers: (1) challenging preservice teachers' (PTs') beliefs, (2) enhancing PTs' conceptual understanding of mathematics, and (3) developing PTs' pedagogical content knowledge (PCK). These goals provided a framework for analyzing the case data. The purpose of the case analysis was to answer two of the dissertation research questions: How does the content of secondary mathematics methods courses connect with those goals? How do secondary mathematics methods instructors reflect on the effectiveness of their own course activities in meeting those goals? Each case is a collection of data from several sources consisting of: (1) background and demographic information concerning each participant, defining the teacher education program and affiliated institution, (2) methods course syllabi, and (3) instructor interviews.

This chapter is divided into five sections. The first provides an overview of the findings. The next three sections correspond with the three literature-derived goals, opening with claims and concluding with a brief summary. The last section summarizes the findings.

Overview of Findings

Table 2 displays and summarizes the data by case. The activities mentioned in the interviews and described in the syllabi are listed for each case. The term *activities* used in this dissertation is considered to be a category title that includes projects, lessons, units, and classroom-based and field-based activities.

Table 2. Case Data Aligned with Literature Review Goals [1]

Name (syllabi date) & **Demographics**	**Activities** Description	**Self-reported Effectiveness** Rating	**Goals**		
			Beliefs	Math	PCK
Bob (2000) 1 semester, no formal field experience	Treatise on Mathematical Thinking		Yes		yes
	Big Year Curriculum: 1 math concept	mixed success	yes	yes	yes
	Unit Plan			yes	yes
	Mega teaching				yes
	Interviews		yes	yes	
	Class Readings		yes	yes	yes
	Problems of practice				yes
Jackie (1997) Full year course, 3rd semester student teaching	Summative Paper: school placement				
	Listening to people who don't buy into school math – observation & interview		yes		yes
	Field placement assignments	mixed	yes		yes
	Encyclopedia: [working definitions]				
	Personal Philosophy for Learning Math	not effective	yes	yes	yes
	Class Activities: a PT takes notes	not effective	yes	yes	
	Readings: summary, 3 questions	not effective	yes	yes	
Kim (2003) 2 semesters, 2nd semester meets 1 day/week, student teaching--4 days/wk	Focus class binder, Units, Cool Stuff	effective	yes	yes	yes
	Micro-teaching Lab: 1st sem, field lab	effective			yes
	Field instructors	effective			yes
	Researchable question: math idea proj.		yes		yes
	Assignment of Choice				yes
	Focus on doing math	effective	yes	yes	
	Portfolio/philosophy of math education		yes		yes
Lilly (2005) Math Dept. 1 quarter No formal field experience	Qs from classroom—some observation		yes		yes
	Curriculum material review	effective	....	....	yes
	2 Exams: readings, text, class activities	not effective		yes	yes
	TIMSS Video 1995		yes		yes
	Lesson plan	not effective			yes
	Vignettes: misconceptions/ fns		yes	yes	yes
	Reflections: written assignment	not effective	yes		yes
Mary (2005) 2 semesters; 1-2 hrs/wk in field	Journals & lessons	effective		yes	yes
	Analyze student understanding -- interview	effective	yes		yes
	Readings/Videos	mixed	yes		yes
	Microteaching			yes	yes
	Analysis of teaching		yes		yes
	Forced choice: Which do you agree?	effective	yes		
Matt (2005) 2 quarters, Math Dept., 2nd quarter student teaching	Electronic Portfolio: 2nd qtr	fairly good		yes	yes
	Lesson/unit plan		yes	yes	yes
	Outcomes with evidence notebook		yes		yes
Pam (2003) 1 quarter., half day student teaching, half day on campus	Field experiences -- observation	reflection better	yes		yes
	Lesson Plans/Unit Plan	not effective	yes	yes	yes
	Written work				yes
	Journal & Readings	not effective	yes	yes	yes
	Electronic Portfolio				yes
	Mini lesson [micro-teaching]	not effective			yes
Rick (2005) 1 semester; 4 days/wk student teaching, 1 day/wk on campus	Sharing a Lesson Plan or Idea		yes		yes
	Presentation to Parents--interviews		yes		yes
	Analyze assessment -- interviews	effective	yes	yes	yes
	Showing students you care--interview	effective	yes		
	Unit Plan	not effective			yes
	Grab bag			yes	
	Good ideas file				yes
	Peer teaching lesson				yes
	Homework/class activities: TIMSS video		yes	yes	yes
	Informal presentation			yes	yes
	Readings/Reflections w/questions	mixed	yes	yes	yes

The activities mentioned during the interviews and/or described in the syllabi were sorted into two categories: field-based and classroom-based. Field-based activities (**Table 2**, column 2, top of each section) have some aspect integrated with work in the public schools, with adolescents, or with some component of the broader education community (i.e. parents and administrators). Classroom-based activities (**Table 2**, column 2, lower portion of each section) are academically structured and situated within the higher-education institution.

During the interviews, participants were asked to identify and describe any course activity that they considered particularly *effective* or *not effective* in addressing PTs' beliefs, as illustrated by the sixth question on the interview protocol:

> In a previous question I asked you about student teachers' preconceived ideas about teaching and learning. This can include preconceived ideas about mathematics, about pedagogy and about teaching and learning in general. How do you see these needs being addressed in your methods course and in other aspects of the teacher education program? (Appendix A, Question 6)

This question encouraged participants to elaborate on their understanding of how well particular lessons and activities addressed the literature-derived goals of

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[1]Explanation of **Table 2**

- **Column 1** ***Name & Demographics***. This column identifies each of the eight cases by participant's name (all names used are pseudonyms: Bob, Jackie, Kim, Lilly, Mary, Matt, Pam, and Rick) and includes a brief summary of their demographic information. Highlighted are participants who are faculty in a mathematics department (Lilly & Matt), as opposed to an education department, and those with no formal field experiences integrated into their programs (Bob & Lilly).
- **Column 2** ***Activities*** lists and briefly describes activities predominant in the syllabi and interviews. For each case, the section is split with *field-based* activities listed at the top of the section and *classroom-based* activities in the lower part of the section.
- **Column 3** Participants were asked to describe any activity they thought was *effective* or *not effective* for challenging PTs' beliefs. A blank space indicates the activity was not mentioned in response to this question.

The last three columns are the literature-derived *Goals*:

- **Column 4** ***Beliefs***—challenging beliefs
- **Column 5** ***Math***—enhancing conceptual understanding
- **Column 6** ***PCK***—developing pedagogical content knowledge

A designation of *yes* in one of these last three columns indicates some degree of alignment with the goal, while a blank space means that there was insufficient evidence to determine alignment. This is a subjective evaluation by the researcher.

challenging PTs' beliefs about teaching and learning, mathematics, and pedagogy. Since this was an open-ended question, there was no basis given for how they might interpret the term *effective*. Therefore in this study, the term *effective* is used as a category indicating that the participants "self-reported" particular activities as successful at challenging preconceived ideas; whereas the terms *somewhat effective* and *not effective* are used to indicate that participants considered the activity as somewhat successful or unsuccessful in achieving this goal. Therefore, it can be assumed that what one participant might consider effective, would not be considered this way by another participant. This limitation needs to be taken into account when evaluating the data results.

Twelve of the twenty-four field-based activities (50%) were mentioned by participants as *effective* or *somewhat effective*, as compared with only four of the thirty (<14%) classroom-based activities. In fact, only two field-based activities, as compared with eight classroom-based activities, were mentioned as *ineffective*. This indicates that field-based activities tend to be perceived by participants as more effective overall for challenging preservice secondary mathematics teachers' beliefs about teaching and learning. Of the field-based activities, the most commonly used by participants were the unit/lesson plans and secondary level student interviews. Of the classroom-based activities, the most common were readings, some type of portfolio or philosophy statement, and case studies. The TIMSS report and video were the most frequently mentioned case study. Peer-teaching, another activity used by a majority of the participants, was almost evenly split between those who use it as a field-based or classroom-based activity.

In the following three sections, the activities are examined to determine whether and how they align with the three goals determined through the literature study chapter.

Challenging PTs' Beliefs about Teaching and Learning

Alignment with this goal was satisfied if an aspect of an activity challenged in some respect PTs' beliefs or experiences concerning teaching and learning, adolescent development, multicultural issues, or what it means to know and 'do' mathematics. The activities aligned with this goal address this broad range of beliefs. Some were designed to challenge PTs' thinking about what it means to understand and 'do' mathematics, e.g. Jackie's "Personal Philosophy for Learning Math" activity, Kim's "Focus Class Binder" project, and Lilly's vignettes that she used to uncover her students' "misconceptions about functions." Others were focused on challenging PTs' beliefs about teaching and learning, such as Pam's readings and case studies, Mary's "Forced Choice" activity, and Rick's assessment analysis project. Also challenged were PTs' beliefs about issues of equity, as exemplified by Jackie's activity where PTs were asked to "listen to students who do not buy into school math" (Jackie, 2005, interview), and Rick's activity where PTs were expected to spend 15 minutes with students to get to know them better (see **Table 2**). Both of these activities challenged the PTs' beliefs about stereotypes. Jackie's activity helped PTs understand students' motivation, while Rick's activity offered them insight into a classroom management technique that breaks down barriers between teachers and students who tend to be marginalized. There did not appear to be any consensus amongst the participants as to what activities should be used to address PTs' beliefs, or what activities are most effective for this purpose. However, there were some patterns that emerged when examining the activities within the two categories of field-based and classroom-based. **Table 3** provides a summary of the data for this section.

Table 3. Summary of Alignment with Challenging Beliefs about Teaching and Learning

Name and Field Integration	Activities	Goals		
		Beliefs	% of alignment	Self-Reported Effectiveness Rating of activities aligned w/goal
Jackie—full yr, extensive fld experience, student teaching 3rd sem.	3 field 4 classrm	2 yes 3 yes	71%	1 somewhat 3 **not** effective
Mary—2 semesters, 1-2 hrs/wk in the field during 1st semester	2 field 4 classrm	1 yes 3 yes	67%	1 effective 1 effective, 1 somewhat
Matt—2 quarters, 2nd qtr student teaching (math dept)	2 field 1 classrm	1 yes 1 yes	67%	
Bob—1 sem. no formal field exper. included with methods course	5 field 2 classrm	3 yes *1 yes*	57%	1 somewhat
Kim—2 semesters, 2nd semester has full time student teaching 4 days/week	3 field 4 classrm	1 yes 3 yes	57%	1 effective 1 effective
Lilly—1 qtr, no formal fld experience included with methods (math dept)	2 field 5 classrm	1 yes 3 yes	57%	 1 **not** effective
Rick—1 semester, 4 days/week student teaching	5 field 6 classrm	4 yes 2 yes	54%	2 effective 1 somewhat
Pam—1 quarter, half day student teaching	2 field 4 classrm	2 yes 1 yes	50%	1 somewhat, 1 **not** effective 1 **not** effective
Totals	24 field 30 classrm	15 yes 17 yes	63% 57%	4 effective, 3 somewhat, 1 **not** 2 effective, 1 somewhat, 5 **not**
	54 total	**32 yes**	**59%**	6 effective, 4 somewhat, 6 **not**

The first column on the left describes the PTs' program experience.
The second column sorts the data into either *field-* or *classroom-based* activities.
The last three columns define alignment with the goal.
The third column indicates the number of activities that align with the goal.
The fourth column indicates the % of alignment, with the cases sorted in descending order based on their percent of alignment with the goal.
The last column indicates the number of activities indicated as effective, somewhat effective, or **not** effective.
(During the interview, participants were asked to describe the activities they thought were *effective* or *not effective* for challenging PTs' beliefs about teaching, learning, math, and pedagogy. A blank space indicates the activity was either not mentioned in the interview or its *effectiveness* was not discussed.)

The data indicate that although classroom-based activities have a slight edge over the number of field-based activities that challenge PTs' beliefs, a higher percentage of field-based activities address this goal. Also of interest is that 7 of the 15 or 47% of the field-based activities that align with this goal are considered *effective* or *somewhat effective* by the participants; while only 3 of the 17, which is approximately 18% of the classroom-based activities that align with the goal are designated as such.

The data also indicate that 7% of the field-based as compared with 29% of the classroom-based activities were singled out by the survey participants as *not effective*. This supports the claim that the participants in this study consider field-based activities as more effective than classroom-based activities for challenging PTs' beliefs.

Field-Based Activities

Six of the eight participants in this study had students involved in formal field work concurrently with their methods courses. All eight participants incorporated some form of field-based activities in their curriculum. There was a wide variability in the focus or goals addressed by these activities. For example, Rick considered two of his field-based activities as highly *effective* for challenging PTs' beliefs. One of them appears to challenge PTs' thinking about issues of equity, while the other seems to challenge their thinking about what it means to know and 'do' math.

Rick's students were assigned to a particular cooperating teacher. During student teaching, the PTs were responsible for teaching all of their CT's classes during the school day. While involved in student teaching, after teaching a full day of classes, Rick's students came to campus one day per week for their methods course. Rick indicated that one of the PT field assignments, called "Showing Your Students You Care," was specifically designed to challenge PTs' beliefs about issues of equity. Here is the syllabus description of this assignment:

> I know that student teachers care deeply about their students, but all too often student teachers are unable to show their concern due to the many issues surrounding management of the classroom and instructional decisions. I would like to provide you an incentive to spend at least 15 minutes with one of your students in the next week. The purpose is for you to interact in a more personal, caring environment. One way to satisfy this assignment would be to schedule one 15-minute interview with a student sometime during the school day.

> Another way might be to play basketball with a student, or go visit a student during a track meet and be sure you talk to him or her, or have a raffle and let a student win a lunch with you. (Rick, 2005, syllabus)

Rick said that he models this value for his students by taking one or two of them, during each course meeting, out for coffee to get to know them better. Rick said that he feels very strongly about the importance of getting to know students in order to be an effective teacher for everyone. In the interview, Rick said that at the end of each quarter he asks his students to share what they think was the most useful activity. He said, "You'll never guess what … they [PTs] said was most useful—*Showing Your Students You Care*." In the syllabus, Rick tells the PTs to "Remember to share something that you consider personal but appropriate with your student. You cannot expect another person to open up if you are not willing to be open." In the interview, Rick described the assignment, explaining why he thought it was so powerful for his students:

> I asked them to try to talk to someone who might be problematic in the class, and the experience often changes the student's relationship with the teacher significantly enough that the teacher is affected by the experience. (Rick, 2005, interview)

This assignment appears to have challenged PTs' beliefs about students, especially those who are labeled "problematic."

When asked how he challenged PTs' beliefs, Rick shared other ways in which he uses field-based assignments:

> My approach to changing beliefs is to provide evidence that might be used to challenge existing beliefs and then provide opportunities to reflect upon that. So for example, if they think that they don't need to think about teaching rational numbers, let them go out and gather some data on what kids know about rational numbers. And they'll come back and say, "Holy mackerel my kids don't understand what a fraction is, and they're in tenth grade." So then we talk about

> not only whether rational numbers are important to teach, but what does it mean to learn it with meaning? … I think it is very helpful for them to see how that plays out in the classroom with their children. (Rick, 2005, interview)

In this assignment, Rick utilized PTs' field experience by having them collect data about what their students know and are able to do concerning specific mathematical concepts. As illustrated in this quote, just because the PTs' students covered rational numbers in elementary or middle school does not mean that they necessarily understand the concept of fractions. From the PTs' responses, Rick indicated that he believes that this activity was very *effective* for challenging PTs' beliefs about what it means to learn, communicate, and "do" mathematics.

Mary also used a field-based assignment to challenge her PTs' beliefs; however, her activity appears to be focused on challenging their beliefs about teaching and learning. Although Mary's students were only in the public schools a couple of hours each week, Mary said that she considers this assignment to be very *effective*:

> Student assessment assignment … they find pretty powerful because … it lets them interview students one-on-one and their goal is not to teach the student but to understand what the student knows. And they have been sitting in these classes and have seen the instruction and they follow the kids on a test. And so again this is sort of an eye-opener for them and they start to realize that there's a lot more to unpack there … getting them to really start thinking about students' thinking and raising their awareness of the way students learn, how complex math can be for the students and how to organize effective instruction for the students. (Mary, 2005 interview)

Mary's PTs observed instruction and assessment, and then interviewed their students afterwards to determine what they had learned from the lesson or unit. They compared the students' test results with the interview data. This comparison helped them identify what the test questions actually assessed, and how that may be very different from what students could articulate or demonstrate in an interview. The "Student Assessment

Assignment," therefore, appears to have challenged PTs' beliefs about traditional testing, teaching and assessment practices. Mary said that she believes that what PTs see "in classrooms and the feedback they get from cooperating teachers… [and] supervisors is unbelievably important" (2005, interview).

The two participants with no formal field work associated with their courses were Lilly and Bob. Lilly taught as part of her university's math department which does not assign field-based activities; however, her students were concurrently involved in formal field work through their education department courses. Lilly incorporated the students' education department field experiences, although she did not assign specific field activities in her course. Here is an example from Lilly's interview where she talked about sample student responses to questions that she integrated with her students' formal field work:

> I have a book called *Questions From the Classroom* that are based on real life things, so I choose the ones that I think apply … We work a lot on ... *Questions from the Classroom.* I give the student response and then, what the preservice teacher has to do is write if that happens in their classroom, what kind of dialogue? If it was in a perfect setting [what] would they have...a student...do? (Lilly, 2005, interview)

As suggested here, Lilly encouraged her students to connect what they were learning in this math lesson with their formal education department field experiences. Lilly also mentioned that at times her students voluntarily brought questions from their own classrooms along with samples of their students' responses. Lilly had the class discuss these questions and added them to her collection to enhance the material from the text. From Lilly's description, I concluded that this activity challenged the PTs' thinking about how math is taught.

This is very different from how Bob incorporated field work into his course. Bob expected his students to make contact with local area schools through their own initiative to complete four field-based activities for his course. Many of Bob's students already were teaching under "emergency certification" whereas others were undergraduates. Since those who were already working as teachers could interview their own students, the onus was on the undergraduates to locate adolescents they could interview to comply with the assignment requirements since formal field work was not integrated into the program. Interpreting the syllabus and Bob's interview responses, it appeared that three of the five field-based activities that Bob assigned were designed to challenge PTs' beliefs. Two were specific to what it means to know and do math, while the third involved student interviewing which seemed to challenge their thinking about teaching and learning (see **Table 2** for details).

The field-based activities appeared to be an important aspect of all the participants' curriculum for challenging PTs' beliefs about teaching and learning. Whether through fulltime student teaching, periodic field visits, or personally initiated connections with adolescents, the experiences influenced, in variable degrees, PTs' strongly held beliefs about student motivation and what it means to teach and learn secondary level mathematics. The most prevalent field-based activity was student interviewing and/or observations, which accounted for seven of the 15 field-based activities and three of the four that were mentioned by the participants as effective for challenging PTs' beliefs. Overall 63% of the field-based activities used by the participants in this study are considered to be aligned with the goal of challenging PTs' beliefs about teaching and learning.

Classroom-Based Activities

Other than field experiences, the participants in this study talked about particular classroom-based activities that challenged PTs' beliefs. For example, Mary described the "little activity called *Forced Choice*" where students were asked to choose between statements that may be somewhat "provocative," such as, "The teacher strongly influences the norms in the classroom. Or, some students just don't want to learn so there's nothing you can do" (2005, interview). The PTs were asked to stand in different parts of the room to indicate the statement choice that most closely articulated their personal beliefs. Mary then called on people to defend or explain their choice:

> They have to defend their response... Sometimes it gets a little heated. But I think that's good because the awareness that someone holds a very different position from you ... especially one of your peers, can help you to at least be a little more open to rethinking things. (Mary, 2005 interview)

For this activity, Mary said that her students developed an awareness that others hold very different beliefs about teaching and learning, and teachers' roles. Mary said that this appeared to be a powerful experience where listening to their peers' justification for choosing a position quite different from their own seemed to influence them by either confirming or forcing them to re-evaluate their personal beliefs. Mary said this was evident during the discussion when PTs would, during the discussion, physically move to another location in the room indicating that they had changed their thinking about the topic.

A number of participants mentioned the use of the TIMSS report and video (NCES, 1999). Although used for a variety of purposes, the main focus appeared to be to challenge PTs' beliefs. For example, Lilly said that she used the TIMSS video to provide a model of a reform-based classroom. Here is how she talks about this in the interview:

> When they look at the U.S. Geometry lesson it's a very traditional lesson, where the teacher's doing all the questions, all the talk. He asks very factual questions, sometimes answers them himself. And basically it's … what we'd term a traditional classroom with the students kind of working along on some lower level worksheet exercise activity, as compared to the Japanese lessons; which … starts off with an engaging problem at the beginning and then the students do some group work and come up with some interesting relationships. And it's just to show them [PTs] that, when they read the NCTM document, they think, "Oh, there is no classroom that can look like this, this is really unrealistic." And by looking at the Japanese classroom, they see, "wait a minute, it can, that can happen." It's just to give them something that it can look like that. (Lilly, 2005, interview)

The manner in which Lilly used the TIMSS materials appears to challenge PTs' beliefs about teaching and learning by having them compare the norms of a "traditional lesson" with a model of reform-based teaching.

Rick, however, said that he used the TIMSS report along with segments of the book called the "Learning Gap" (Stevenson & Stigler, 1992) to challenge PTs' thinking about the cultural basis for the way we teach in the U.S. Here is how he described the lesson:

> I had them read a couple of papers from the TIMSS and also [selections] from *The Learning Gap*, where they talked about the difference between ability and so forth. So they [PTs] start to recognize international kinds of issues, and be able to put the United States' educational system into slightly broader context. (Rick, 2005, interview)

This activity seems to challenge PTs' beliefs by having them think about the teaching and learning they were accustomed to as a product of our U.S. culture. This activity provided a broader lens for thinking about education than just relating it to their personal experiences.

The classroom-based activities used by the participants in this study indicated a 57% alignment with the goal to challenge PTs' beliefs about teaching and learning. However, only 18% of the classroom-based activities that aligned with this goal were designated as *effective* or somewhat *effective* by the participants, while 29% are mentioned as *ineffective*. The classroom-based activity most often considered *not effective* by the participants was the readings and reflections which accounted for four of the five *not effective* designations.

The data analyzed in this section of Chapter 4 illustrate how participants used activities, both field-based and classroom-based, to challenge PTs' beliefs about teaching and learning. The analysis provided evidence that the field-based activities were perceived to be much more *effective* for challenging PTs' beliefs about teaching and learning then classroom-based activities. Interviews were mostly considered by participants as *effective*, whereas readings and reflections were overwhelmingly considered to be *ineffective*.

In the following sections, the projects, lessons, and activities participants used to enhance PTs' conceptual understanding of mathematics (Math) and develop their pedagogical content knowledge (PCK) are discussed.

Enhancing Conceptual Understanding of Mathematics

Alignment with this goal was determined if specific aspects of a mathematics activity focused on enhancing PTs' conceptual understanding of mathematics to some degree. The degree to which this took place is variable and the types of activities and frequency also differed by case and within each case. As described in the previous section, some of the activities used by the participants were field-based while others are classroom-based. Only 41% of the activities aligned with the goal to enhance PTs' conceptual understanding of mathematics (Math). In fact, two of the eight participants (Jackie and Lilly) did not indicate any use of their field-based activities to enhance PTs' conceptual understanding of mathematics, and, surprisingly, Matt, who is associated with a mathematics department, provides no indication that this goal was a focus for any of his classroom-based activities. Also, only 27% of the activities that addressed this goal were considered by participants as *effective* or *somewhat effective* while 27% are considered to be *ineffective*.

Two of the eight participants (Lilly and Matt) were mathematics faculty as compared with the other six who were specifically in teacher education. An assumption might be that the mathematics professors would lean more heavily on the conceptual level of understanding mathematics than professors of education; however, at least from the results of this study, this did not appear to be true. Matt's courses had approximately a 67% alignment, which was the highest of all participants; however, Lilly had one of the lowest alignments at less than 29%. **Table 4** provides a brief summary of these claims, with cases displayed in descending order based on their percent of alignment.

The data in this section of the case analysis indicated that participants agreed that PTs came to their methods courses with strong procedural level understanding yet need to improve their conceptual understanding of the mathematics they would be responsible for teaching. There was little agreement concerning mathematics content; however, half of the participants stated that the math focus should come from the PTs rather than being dictated by the instructor. Three quarters of the participants mentioned algebra as an important mathematics strand although there was little agreement as to the specific algebraic concepts that should be addressed in their courses. These claims are detailed in this section.

Table 4. Summary of Alignment with Enhancing Conceptual Understanding of Mathematics

Name and Field Integration	Activities	Goals		
		Math	% of alignment	Effectiveness Rating of those activities that align w/goal
Matt—2 quarters, 2nd qtr student teaching (math dept)	2 field 1 classrm	2 yes	67%	1 somewhat
Bob—1 sem. no formal field exper. included with methods course	5 field 2 classrm	3 yes 1 yes	57%	1 somewhat
Rick—1 semester, 4 days/week student teaching	5 field 6 classrm	1 yes 4 yes	45%	1 effective 1 somewhat
Jackie—full yr, extensive fld experience, student teaching 3rd sem.	3 field 4 classrm	3 yes	43%	3 **not** effective
Pam—1 quarter, half day student teaching	2 field 4 classrm	1 yes 1 yes	33%	1 **not** effective 1 **not** effective
Mary—2 semesters, 1-2 hrs/wk in the field during 1st semester	2 field 4 classrm	1 yes 1 yes	33%	1 effective
Kim—2 semesters, 2nd semester has full time student teaching 4 days/week	3 field 4 classrm	1 yes 1 yes	29%	1 effective 1 effective
Lilly—1 qtr, no formal fld experience included with methods (math dept)	2 field 5 classrm	2 yes	29%	1 **not** effective
Totals	24 field 30 classrm	9 yes 13 yes	38% 43%	2 effective, 2 somewhat, 1 **not** 1 effective, 1 somewhat, 5 **not**
	54 total	**22 yes**	**41%**	3 effective, 3 somewhat, 6 **not**

The first column on the left describes the PTs' program experience.
The second column sorts the data into either *field-* or *classroom-based* activities.
The last three columns define alignment with the goal.
The third column indicates the number of activities that align with the goal.
The fourth column indicates the % of alignment, with the cases sorted in descending order based on their percent of alignment with the goal.
The last column indicates the number of activities indicated as effective, somewhat effective, or **not** effective.
(During the interview, participants were asked to describe the activities they thought were *effective* or *not effective* for challenging PTs' beliefs about teaching, learning, math, and pedagogy. A blank space indicates the activity was either not mentioned in the interview or its *effectiveness* was not discussed.)

A number of the participants described activities that enhance the PTs' conceptual knowledge of mathematics. Here are a few examples: Mary indicated that her micro-teaching activity (peer teaching) was designed to enhance PTs' conceptual understanding of mathematics. Mary had the PTs develop a lesson plan to use with their students where the focus "has to be either a construct, a concept, or discover a relationship and that's pressing on … higher order thinking" (Mary, 2005 interview). By having the PTs draw an activity from this lesson plan to use for their micro-teaching activity, Mary integrated the PTs' development of understanding of a math concept with having to present it to their own students. Here is how Mary described the activity:

> Micro-teaching does not have to be done this way, but I use it as a way to get them to think about making a strong … lesson. How are you going to grab students' interest and pull them in and I require them to have us working within something like 3-5 minutes. Often, they use real world data or ... some sort of ... problem solving activity, or something beyond standard textbook stuff. So that's the other requirement of it. And then I also give them written feedback after. I try to not say much during the debrief time and then I give them written feedback. (Mary, 2005, interview)

The written feedback dealt with the level of content knowledge as well as suggestions for improving the overall development and delivery of the lesson. Mary also used micro-teaching to enhance the conceptual understanding of the PTs who were acting as the students in the activity. Mary suggested, in the interview, that she uses the content, that the PTs use in their micro-teaching assignment, to develop the PTs' conceptual understanding of mathematics.

Another participant, Rick said he tried something new this year rather than his choosing a math topic. Here is how he described the activity:

> Each student would share something they were thinking about teaching and lay out how they might teach it, but before they taught it… They all brought something in and shared it. And then we analyzed what the mathematics is embedded in what they brought. So somebody came in one day and said, "I'm going to teach scientific notation." And then we started talking, and I led the discussion and helped them think about "What is scientific notation, and why does it matter and what's significant there?" And that ended up being a mathematical conversation. (Rick, 2005, interview)

Although "scientific notation" is a convention, Rick tried to deepen the PTs' understanding by using probing questions such as "Why it matter?" Rick said in the interview that he felt that these math conversations had mixed results, and that he will use it again after making some revisions. He did not share what those revisions would be. Rick also said that he gave his students math problems for homework and sometimes used a "grab bag" – a collection of about 25 math problems. Rick said his goal was to affect PTs' beliefs about teaching and learning, "but more importantly, I want them to come to look at mathematics from a more conceptual perspective" (2005, interview.

Kim was also concerned about her students' conceptual understanding of the mathematics they would be teaching. Here she explained the goals of the course:

> One of the things that we do try quite a bit is doing mathematics with students. Like I mentioned, the focus early on … in the internship year course [is] on algebra. Solving equations on the surface seemed sort of like [a] quintessential algebra task. They feel like… that's one of the things they know quite a bit about. And so through the various tasks that we have them work on, in the first half of that course, we try to help them see to what extent they may be taking some of that for granted. And to what extent things like using a graphing calculator or some other kind of technological support might obscure some things, might reveal some things about the underlying mathematics. So that is an example of something that I think worked pretty well in the past. (Kim, 2005, interview)

Another participant, Jackie mentioned in her interview how she introduced "relational" understanding (relational is another term for conceptual) of a math concept, as compared with procedural understanding. Jackie said her students appeared to like the idea but thought that it would only work for certain topics or concepts. She said that the PTs decided amongst themselves that students need calculus to really understand pi at a relational level. To challenge their thinking, Jackie had them develop a lesson to teach pi at a relational level to 9th graders and actually brought in two 9th grade students (one was Jackie's daughter) on which they could test out their lesson. Here is how Jackie described what happened:

> The students measure the outside of a bunch of round items, then measure the radius and then build a table and they divide them and look at them. And when these girls were doing this they [the PTs] would say, "What do you see?" ... And it was like an incredible discovery after maybe 15 minutes where my daughter jumped up and said, "I see it, every time!" and she would recognize that it was a constant and she would use the items and then draw her finger around, like the cookie and the rim of a bicycle wheel and a camera lens. "It's this around, and it's divided by this! And it's the same thing every time!" It was so exciting. It was just an awesome experience. (Jackie, 2005, interview)

Jackie found when she used the math the PTs brought up in conversation, as was the case with pi, or incorporated what they were working with in their field experience, that there was greater motivation than when she imposed math content on the group:

> One thing that we tried [that] wasn't very successful was ... to impose on them the idea that we would pick the content. And it was a content area that we thought they should come to know more deeply. But I never felt that they were really buying in... So we were sort of doing the very thing that we didn't want to do and that was trying to force them to think about something. And it was statistics, because we knew from the research, that [it] was becoming more and more important in high school mathematics ... but it didn't appear that any of them ... or maybe only just a handful, were actually working with statistics with their students in the field. ... So it was much more effective when we had them work in content that they were actually teaching or watching being taught, either one. (Jackie, 2005, interview)

This was a pattern in how math content was approached within each case. For example, Bob also said that he had mixed success with imposing math content on his students, but he was always prepared to do so, in the event that the timing was right, or the class conversation appeared to support it:

> I tried with mixed success just to bring in mathematics that I thought was interesting and to have them work on it. So I would always be prepared for that. Sometimes we wouldn't have time to do it, sometimes they were just at another place and I decided not to bring it in. But if it was right, then ... we would do some mathematics. (Bob, 2005, interview)

Bob also mentioned that the big project he assigned was somewhat successful for those students who felt they needed to go a bit deeper on a particular math topic, and was less successful for those who did not come into the project with the same mind-set.

Lilly and Matt were both mathematics professors; however, their programs had very different structures. For example, Matt's students were engaged in full-time student teaching whereas Lilly's students did not have formal field experience integrated with the methods course. Yet, one of Lilly's main objectives for her course was to have PTs focus on student learning. To accomplish this goal, Lilly said that she had her students use manipulatives to demonstrate their understanding of mathematics, which is a different way of illustrating the concepts than the PTs would normally think about mathematics education at a secondary level. And she provided vignettes that represented common misconceptions students have when studying particular concepts. Here is Lilly's description of the vignettes:

> These are little stories that highlight the different misconceptions on functions. And so it's just a six-page packet ... students answered, "You're studying inverses in your class and one student says that "dadadada." [There are] several responses and then there was a set of questions... "As the teacher, what is this person thinking? What misconceptions do you think? How would you illustrate? Can you clarify the concept of inverse for these students?" So that's the way those are used. Those are ... not real life cases. They're based on the common misconceptions that we have seen over and over. (Lilly, 2005, interview)

Lilly said, "I liked the vignettes because it highlights the misconceptions with functions, which is such a central idea in mathematics" (2005, interview). Lilly said that she also helped her students deepen their understanding of the math concepts through the use of examples of student responses to problems. For example, Lilly provided a math problem with a sample student response and the PTs then were asked to "decide if the student is right or wrong in their response and how we could lead the student toward a conceptual and procedural understanding" (2005, interview).

Matt, who, like Lilly, taught the methods course through the school of mathematics at his university, had the benefit of knowing that his students were in their student teaching experience at the same time that they were enrolled in his class. This allowed Matt to integrate enhancement of PTs' conceptual understanding of mathematics along with their awareness of adolescent development of understanding mathematics. Matt said that he talked a lot with PTs about integrating mathematics both "from outside math and inside math, vertically within math and horizontally among disciplines. We talked about all of those and they planned lessons using all of those" (Matt, 2005, interview). Therefore, the conceptual aspects of the mathematics were interwoven within the discussion of how to use these ideas to develop lessons. Matt was very aware of keeping the course focused on the PTs' needs to apply whatever they were learning immediately to their main focus which was teaching students at their placement schools. To assess his students' conceptual understanding of the mathematics, Matt assigned an electronic portfolio, which he considered to be a fairly effective tool. This portfolio covered all the content strands, although it did not focus on a particular one. In the interview, Matt described the use of the electronic portfolio to assess how the PTs' conceptual mathematics understanding related to the process standards:

> They have to write an artifact [for the portfolio] in which they are able to go and show that they understand … NCTM standards … for problem solving, communicating mathematically, reasoning mathematically and making connections… there isn't any specific mathematics content … The focus is all on the 4 process standards. (Matt, 2005, interview)

It was difficult from Matt's interview and syllabus to distinguish conceptual understanding of mathematics from the pedagogical content knowledge as they were woven very closely together in his lessons and activities. The intent, as Matt suggested, was to make the coursework immediately relevant and applicable to the PTs' student teaching experiences.

Overall, the participants agreed that PTs' conceptual understanding of mathematics was weak, although their procedural knowledge was strong. They integrated the math with pedagogical methods, used constructivist or inquiry style methods to discuss math topics, and stated that imposing specific concepts was less successful than incorporating the math from the PTs' field experience or issues brought up by the PTs during class discussions. Four of the eight participants specifically said that they discussed math topics brought up by their students; six of them also mentioned algebra as an important topic for which most of the PTs would be teaching at some point in the next couple of years.

Other than algebra, there appeared to be little agreement. Jackie talked about historical context of mathematics concepts, infinity, real numbers and geometry. Lilly emphasized inverse functions, and both Lilly and Matt said they focused on process strands as described in the NCTM *Principles and Standards for School Mathematics* (Ferrini-Mundy, Joyner, Reys, Silver, & Schoenfeld, 2000). Pam, whose students will be middle-school teachers, focused on multiplying fractions with "snippets" on number sense, geometry and statistics. Rick mentioned dividing fractions, algebra as generalized arithmetic, Euclidean geometry, rational numbers and proofs. Therefore, other than algebra, and working on math that connects to their field experience, there seemed to be little agreement as to the mathematics content that should be included in a methods course, and even less agreement as to how or to what extent to allot time to specifically address the enhancement of PTs' conceptual knowledge of mathematics as evident by the broad range of percentages of alignment (67% to 29%) with this goal.

Developing Pedagogical Content Knowledge (PCK)

The final goal identified through the literature review was developing PTs' pedagogical content knowledge (PCK). It was this goal that was addressed most completely by the participants, although some of the lessons, projects and activities noted by the participants were less *effective* than others. Participants' activities were most closely aligned with this goal with 100% alignment for Lilly, Matt and Pam (**Table 5**). At the other end of the range, Jackie's alignment of activities with this goal at 43% appeared to be an outlier as compared with the other participants; however, this was because much of the activities listed on her syllabus were assessment tools for which the syllabus descriptions and interview data did not provide enough information to suggest alignment. Six of the eight participants had 100% alignment with this goal for their field-based assignments. **Table 5** provides a brief summary of these claims with cases sorted in descending order based upon their percent of alignment. This section is divided into two subsections, dealing with field- and classroom-based activities separately.

Table 5. Summary of Alignment with Developing Pedagogical Content Knowledge

Name and Field Integration	Activities	Goals		
		PCK	% of alignment	Self-Reported Effectiveness Rating activities aligned w/goal
Matt—2 quarters, 2nd qtr student teaching (math dept)	2 field 1 classrm	2 yes 1 yes	100%	1 somewhat
Pam—1 quarter, half day student teaching	2 field 4 classrm	2 yes 4 yes	100%	1 somewhat, 1 **not** effective 2 **not** effective
Lilly—1 qtr, no formal fld experience included with methods (math dept)	2 field 5 classrm	2 yes 5 yes	100%	1 effective 3 **not** effective
Bob—1 sem. no formal field exper. included with methods course	5 field 2 classrm	4 yes 2 yes	86%	1 somewhat
Kim—2 semesters, 2nd semester has full time student teaching 4 days/week	3 field 4 classrm	3 yes 3 yes	86%	3 effective 1 effective
Mary—2 semesters, 1-2 hrs/wk in the field during 1st semester	2 field 4 classrm	2 yes 3 yes	83%	2 effective 1 effective, 1 somewhat
Rick—1 semester, 4 days/week student teaching	5 field 6 classrm	4 yes 5 yes	82%	2 effective, 1 **not** effective 1 somewhat
Jackie—full yr, extensive fld experience, student teaching 3rd sem.	3 field 4 classrm	2 yes 1 yes	43%	1 somewhat 1 **not** effective
Totals	24 field 30 classrm	21 yes 24 yes	88% 80%	8 effective, 4 somewhat, 2 **not** 2 effective, 2 somewhat, 6 **not**
	54 total	**45 yes**	**83%**	10 effective, 6 somewhat, 8 **not**

The first column on the left describes the PTs' program experience.
The second column sorts the data into either *field-* or *classroom-based* activities.
The last three columns define alignment with the goal.
The third column indicates the number of activities that align with the goal.
The fourth column indicates the % of alignment, with the cases sorted in descending order based on their percent of alignment with the goal.
The last column indicates the number of activities indicated as effective, somewhat effective, or **not** effective.
(During the interview, participants were asked to describe the activities they thought were *effective* or *not effective* for challenging PTs' beliefs about teaching, learning, math, and pedagogy. A blank space indicates the activity was either not mentioned in the interview or its *effectiveness* was not discussed.)

Field-Based Activities

Kim's students, in the semester prior to full time student teaching, were assigned to teams to work on unit planning. What was unique about this is that they were grouped by the subject matter they would be teaching although they were assigned to different schools for their student teaching experience. When designing a unit plan, the PTs were instructed to "give these plans to your mentor teacher and field instructor for feedback and suggestions before beginning [to use them with students]" (2003, syllabus). As Kim suggested, another aspect of the field experience that made the field experience an effective aspect of the program was that each PT was placed with a mentor teacher "who is going to give students [PTs] the opportunity to try things out regardless of whatever the established curriculum is in the placement" (2005, interview). The PTs chose one of their mentor's classes to focus on. In the interview, Kim explained the unit plan grouping criteria and process:

> They have something we call a focus class, where they pick one section of the schedule that their mentor teacher has. And then we organize them ..., because that is the only course that they teach continuously through the fall, in smaller groups in which we do a variety of things. One of the things that they do is ... planning for a unit and then looking at that unit to try to understand whether the student met that goal. So we put people together based on what their subject matter is, they look at state and national standards related to that, they look at a variety of ways that that is being taught in different schools, different curricula that are being used, etc. (Kim, 2005, interview)

Therefore, Kim's unit plan was a collaborative field activity, where the PTs brought together the curricular materials used at their respective placement schools to plan the unit together. This unit was then used during their student teaching experience, the following semester. An important part of the process included feedback from the mentor teacher and the university field instructors. Kim said that the field instructors were an important aspect of the second semester methods course as they worked with the PTs while they were in the field, extending and personalizing field assignments as an important aspect of methods instruction:

> We have people called field instructors who ... see them [PTs] once every other week or whatever. ... And field instructors meet once a month. ... We encourage them to do a wide variety of things in the field ... they video tape and watch the video tape together and sometimes they co-plan with the intern, or the intern and the mentor. Sometimes the field instructor and the intern watch the mentor teach and the three of them talk about that. So we encourage them to be very flexible with the different kinds of tasks that they do. (Kim, 2005, interview)

This description of a field instructor was unique to Kim's program, as the other participants in this study did not indicate the use of field instructors as part of their programs. Also unique was that student teachers did not take on the full course load of their mentor teacher but rather choose a focus class which they taught full time during their student teaching period. This gave them time to continue teaching lessons in other teachers' classes and plenty of time to do planning and to reflect upon what they taught.

Unlike Kim, Rick said that he was never satisfied with the unit plans his students produced, so he does not include that in his methods course anymore. Here is what he said about unit plans:

> I was always frustrated with my unit plan assignment, cause they would turn in really traditional looking things, and they thought they were great. And then I came to realize, okay that's what they need to do, that's where they are. But I didn't feel like that's what I wanted ... that wasn't so satisfying, so I let that go. (Rick, 2005, interview)

The data did not indicate if the unit planning was field-based or classroom-based. Although dissatisfied with the unit plan assignment, Rick said that he had success with another field-based project that helped his students develop PCK. This assignment had three distinct stages where students selected a mathematics concept and assessed student understanding using whole class assessment and two different types of interview, analyzed the data, and planned math instruction based on the analysis. Here is how Rick explained this project:

> I have a three-part assessment assignment. So they select some mathematical content domain ... I have my students conduct a whole-class, very short, paper and pencil, assessment, maybe ten minutes. They analyze those data and write up what surprised them, what they learned. Then they go out and interview 1 student for a lengthy interview. Then they interviewed 3 students for very short interviews to show that they could get information in a short amount of time. And then they analyze all of that. So what happens in the course of this is they are thinking about the content differently because they're not only focusing on the student's procedural knowledge, but also the student's conceptual knowledge. And their own knowledge ... plays out because some of the content that they're thinking about is content that they themselves either had struggled with or are just now coming to grapple with. (Rick, 2005, interview)

Rick found that this project was effective in helping his students appreciate three different forms of assessment and the type of information a teacher can get from each concerning their students' understanding of a math concept.

Lilly also found connecting information the PTs brought back from the field as an effective tool for developing their PCK. However, rather than a large project, Lilly used a far more informal method that seemed to develop almost as serendipity. Lilly's methods course was through the mathematics department and had no formal field experience integrated into the coursework. However, her students were involved in field experiences through their other education courses. Here is how Lilly described the changes that occurred within her course once her students were concurrently working in the field:

> But when I first ... came here, students weren't in a field experience during methods. I have really noticed a tremendous difference from when they're out in the field because it's great, because they bring problems, they say, "Oh, this is what's happening, this is what my teacher did, what do you think about this?" Or, "I have these students that don't know their multiplication facts" and "is that right? Is that okay to be in 7th grade and not know that?" They bring all sorts of things. So we open it up to the class and we brainstorm on things that they can try. (Lilly, 2005, interview)

From what Lilly shared during the interview, it appears that this format for reflection was very effective. The content was coming from the PTs and the issues were those the PTs were dealing with in the field rather than being introduced through readings. Lilly found that reflections based on course readings were not effective, as she explained in the interview:

> I actually quit the [reading] reflections towards the end of the quarter, because they were getting redundant. And they [PTs] gave me several suggestions. I think they said that ... those are probably the least worthwhile because ... after the first couple ... it was hard to reflect. (Lilly, 2005, interview)

Lilly found that the curriculum review and lesson planning were assignments that her students "really liked doing … because they were culminating activities … pulling everything together" (Lilly, 2005, interview). Since the PTs were in the field concurrently through their education course, they had access to textbooks used in their cooperating teachers' classrooms. For the curriculum review, the PTs brought copies to class and analyzed the problems that students were usually assigned from those texts:

> Looking at a regular textbook … what kind of questions are asked, are there any that are procedures with connections, are there any doing mathematics here? How could you change this question from procedural to procedural with connection? (Lilly, 2005, interview)

The PTs used this information to develop lesson plans that addressed students' conceptual understanding of mathematics, by incorporating the changes made to problems from the curriculum review assignment.

Of all the participants, Kim was the only one who mentioned peer-teaching as a field-based activity. Kim said that the *Micro-teaching Lab* enhanced PTs' lesson planning skills during their first semester classes, prior to student teaching. During the first semester of the program, the PTs visited the schools twice a week in pairs, teaching five to six times, including a day lesson series that was connected with the lab. The teaching pairs decided upon a math topic and developed a three-day lesson plan. From that lesson plan, they extracted an activity to teach to their peers in the lab. The purpose of the micro-teaching lab was to collect peer feedback on the activities to re-evaluate and make adjustments before actually teaching students in the field.

Some of the field-based activities were not considered effective by the participants. For example, Pam mentioned a problem with interviewing middle school students:

> Some … small group or individual interviews, that turns out to be difficult at the middle school level, but I want them to have at least an understanding of how to construct interview questions, getting at student understanding not just social interview kinds of questions. (Pam, 2005, interview)

And there were a few assignments that were not *field-based* that had mixed results, such as Rick's readings and reflections, as described here in his syllabus:

> Write one paragraph and one question about each reading. Your paragraph should highlight something that stood out for you … draw connections between the reading and something in your professional life. … If you would like to be critical of a reading… be specific in your critique so that you convey that you have thought deeply about the ideas … tell me what you did or did not like, and why.
>
> The question you write should reflect your understanding of some important idea or ideas … Some questions might be more theoretical … Some … might relate to issues of teaching and learning … Some … might be mathematical … vary the type of question you pose so that, over the semester, you will push yourself to apply different lenses to the readings. (Rick, 2005, syllabus)

The questions were used in the class discussion and also for delving into mathematics about which the PTs presented questions. Unfortunately, Rick said that he had mixed results with this assignment format, saying, "Some of my students do very well; some … do a really lousy job. It's like they just skimmed it and wrote something quickly before they came in" (Rick, 2005, interview).

Of the field-based assignments, the prevalent goal across the activities designed to develop PCK was for PTs to learn how to assess student understanding of the mathematics, with six of the participants including some sort of student interview. The other two, Matt and Lilly, who both taught through mathematics departments, used either analysis of field-based assessments or vignettes using sample student work to achieve the same goal.

Classroom-Based Activities

Although only field-based activities that align with PCK were designated by the participants as *effective*, as compared with the *classroom-based* activities for which none were ranked as such, this does not suggest cause and effect, as there were a few field-based assignments that were not considered *effective*. There also were a couple of participants whose classroom-based activities might be considered *somewhat effective*. For example, Mary talked about using video cases. Here were two pieces of data, one from her syllabus and the other from the interview, which indicate Mary's perceptions and degree of alignment with PCK:

> We will consider a particular problem, look at students' thinking with respect to that work, and watch an experienced teacher as she implements the activity and extends it over several days. You will be analyzing the teaching and learning, and evaluating/generating a rubric to score the particular task. (Mary, 2005, syllabus)

> We also watch videos which are important for helping them see … students' thinking in action… It starts... where they have to look at ... two different versions of one task … They do the problem and then ... compare the two tasks... basically, one is much more structured to leading the student through it... Then we look at a piece of student work ... and talk about the student's response. What the student knows, what the student doesn't know, and so on. And then with that same task ... we look at the video and start asking questions. "What can students learn by looking at this task?" And there is a shift there that has to happen. Students often think ... "I have to teach the students something and then they can do this problem," and so we're shaping that as, instead, "okay here's a problem, what can students learn by doing the problem? What does this problem help you teach students?" (Mary, 2005, interview)

Mary considered the use of video cases important for helping PTs see "students' thinking in action;" however, she did not mention this activity when asked which activities were most or least *effective*. Therefore it was listed as *somewhat effective* as the descriptions imply that it was helpful in challenging PTs' beliefs about pedagogy.

Other activities that align with PCK had mixed interpretation by the participants. Some were considered *not effective* while others were not designated as most or least effective. For example, readings and reflections were designated *not effective* by Jackie, Lilly, and Pam, and *mixed* by Mary and Rick. Another activity, unit planning was noted as *not effective* by Pam and Rick. As for peer teaching, Pam singles it out as *not effective* since her students have difficulty providing constructive peer criticism:

> If they did a little mini-lesson to each other, they were expected to give some feedback, and I tried to have them give some specific praise, something specific that they did well and then something that they might want to be working on. And I had them do it again when they did the science labs. One of the things that I have been a little disappointed with the peer feedback is that they all want to cheer each other up and say how wonderful they are, but they really don't want to give constructive criticism. I don't know whether if it's because they don't personally want to get criticism, or they feel like their peers aren't up to it, or what. I'm not really sure of the reasons for that, but that's another area that I think could be strengthened, I think it could be valuable, but it's just hard for them to do anything but to say "that's really nice" and "I like how you did this" and "I like how you did that." (Pam, 2005, interview)

Other participants (Bob, Mary, and Rick) also used peer teaching, but did not single it out as either *effective* or *not effective*. Over all, pedagogical content knowledge development appeared to be most effectively addressed through field-based activities.

Conclusion

The final results indicate that the three goals derived from the literature were addressed to varying degrees in the methods courses examined for this study. Eighty-three percent of the activities mentioned in interviews and prominent in the syllabi aligned with development of PTs' PCK, while 59% with challenging PTs' beliefs.

Although only 41% focused on enhancing PTs' conceptual understanding of the mathematics they will be teaching at the secondary level, this makes sense since the instructors indicated that they allow the math to arise from other tasks. The final results discussed here are displayed in **Table 6**.

Table 6. Summary of Alignment with Goals

Name and Field Integration	# Field- & Classroom-based Activities / Effectiveness Rating	Objectives			
		Beliefs	Math	PCK	%
Matt—2 quarters, 2nd qtr student teaching (math dept.)	2 field (1 somewhat) 1 classroom	1 yes 1 yes	2 yes	2 yes 1 yes	83% 67% **78%**
Bob—1 semester with no formal field exper. included with methods course	5 field (1 somewhat) 2 classroom	3 yes 1 yes	3 yes 1 yes	4 yes 2 yes	67% 67% **67%**
Lilly—1 qtr, no formal fld experience included with methods (math dept)	2 field (1 effective) 5 classroom (3 **not** effective)	1 yes 3 yes	 2 yes	2 yes 5 yes	50% 67% **62%**
Pam—1 quarter, half day student teaching	2 field (1 somewhat, 1 **not** effective) 4 classroom (2 **not** effective)	2 yes 1 yes	1 yes 1 yes	2 yes 4 yes	83% 50% **61%**
Mary—2 semesters, 1-2 hrs/wk in the field during 1st semester	2 field (2 effective) 4 classrm (1 effective, 1 somewhat)	1 yes 3 yes	1 yes 1 yes	2 yes 3 yes	67% 58% **61%**
Rick—1 semester, 4 days/week student teaching	5 field (2 effective, 1 **not** effective) 6 classroom (1 somewhat)	4 yes 2 yes	1 yes 4 yes	4 yes 5 yes	60% 61% **61%**
Kim—2 semesters, 2nd semester has full time student teaching 4 days/week	3 field (3 effective) 4 classroom (1 effective)	1 yes 3 yes	1 yes 1 yes	3 yes 3 yes	56% 58% **57%**
Jackie—full yr, extensive fld experience, student teaching 3rd semester	3 field (1 somewhat) 4 classroom (3 **not** effective)	2 yes 3 yes	 3 yes	2 yes 1 yes	44% 58% **52%**
Totals	24 field (8 effective, 4 somewhat, 2 **not**) 30 classrm (2 eff., 2 somewhat, 8 **not**)	15 yes 17 yes	9 yes 13 yes	21 yes 24 yes	63% 60%
	54 total (10 eff., 6 somewhat, 10 **not**)	**59%**	**41%**	**83%**	**61%**

The first column on the left describes the PTs' program experience.
The second column sorts the data into either *field-* or *classroom-based* activities, indicating the number of activities self-reported by participants as effective, somewhat effective, or **not** effective. (During the interview, participants were asked to describe the activities they thought were *effective* or *not effective* for challenging PTs' beliefs about teaching, learning, math, and pedagogy. A blank space indicates the activity was either not mentioned in the interview or its *effectiveness* was not discussed.)
The third, fourth, & fifth columns define alignment with the goal.
The last column calculates the % of alignment, with the cases sorted in descending order based on their percent of alignment with all the goals.

The shaded items refer to field-based activities. Those without shading are classroom-based activities, and the bold numbers are the combined percentages. The participants are listed in descending order based on the percentage of their activities which align with the goals.

What is interesting is that the two participants (Bob and Lilly) whose students were not formally involved in field experiences through their methods course and the two math department instructors (Matt and Lilly) had the highest alignment percentages. Also curious was that the depth of field experience integrated into the methods courses appeared to have an inverse relationship with percentage of alignment. This pattern can be seen by examining the participants, with the exception of Matt, which indicate alignment percentages going from 67% to 52% while their students' field experiences ranged from no formal field experience to a few hours per week in the field, ending with full time student teaching. The only case that did not fit this pattern was Matt (first on the list) with an overall alignment of 78%. Of interest is that Matt, like Lilly, worked through a mathematics department; however, unlike Lilly's, Matt's students were full-time student teaching. Although there were only 8 participants in this study, the pattern appeared to be interesting and might suggest further research at a quantitative level with a larger group of participants to determine if there is a correlation between PTs' depth of field experience through their methods courses and the alignment of activities with the literature-based goals.

Looking at the goals individually does not seem to support this pattern but rather appears to be more random. For example, challenging preservice teachers' beliefs about teaching and learning had a 63% of field-based and 57% of classroom-based activities aligned with this goal, with Bob and Lilly at 57% and those cases where PTs were in full-time student teaching were dispersed throughout the range. For this goal, there appeared to be no correlation between level of field experience and activity alignment with the goal. However, when comparing the types of activities, the data revealed that 47% of the field-based activities were indicated by participants as *effective* or *somewhat effective* as compared with less than 18% of the classroom-based activities. A designation of *ineffective* was given to only one of the *field-based* while 29% of the *classroom-based* activities were considered ineffective by the methods instructors. Overall there was 59% alignment with the Beliefs goal (see **Table 6**.)

Activities used by the participants in this study indicated that enhancing conceptual understanding of mathematics had the lowest level of alignment, with only 38% of the field-based and 43% of the classroom-based activities indicating alignment. Thus, less then 41% of the activities aligned with enhancing conceptual understanding. This is consistent with the findings from Floden, McDiarmid and Jennings (1996) who found that methods teachers do not see the teaching of math concepts as their responsibility. There was also little agreement about the mathematics concepts to focus on. This goal had the widest range of alignment (67% to 29%). Overall there was 41% alignment with the Math goal (see **Table 6**.)

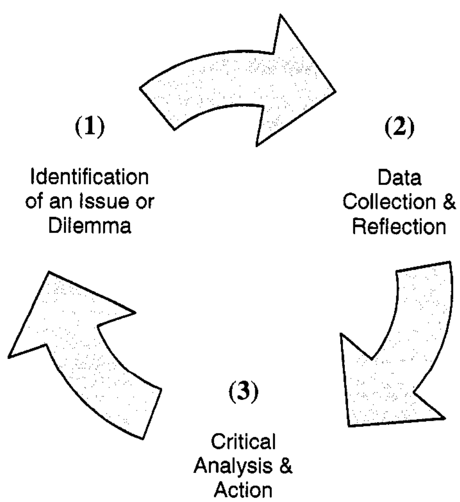
The final goal, developing pedagogical content knowledge (PCK) had the highest percentage: 83% of the activities used by the participants indicated alignment with this goal. There were three participants for whom 100% of their activities addressed this goal. The range was between 100% and 82% with one outlier at 43%. However, close examination of the outlier's data indicated that 57% of the activities mentioned in the syllabus and interview for this participant were designed as assessments of what the PTs know rather than activities to teach or present new material. Therefore they were not indicated as developing PCK although they may assess those skills. Overall there was 83% alignment (89% alignment if the outlier is excluded from the data) with the PCK goal.

There were four general conclusions derived from the case study analysis. *Field-based* activities were perceived by participants as most *effective* for addressing all three goals. Algebra was considered to be a very important mathematics strand to focus on during methods course work at a conceptual level, although emphasis on specific concepts should be drawn from the students' immediate needs and interests. Microteaching and unit planning were the most prevalent activities used by the participants in this study. There were 54 activities described in the syllabi and interviews, with 20% of them addressing all three goals derived from the literature review. The effectiveness of the activities is looked at more closely in the following chapter through a cross case analysis.

Chapter 5. Effective Activity Cycle Framework

In the previous chapter, analysis of individual case studies provided an overview of the alignment between the projects, assignments, and activities (all grouped under the category called *activities*) used by the methods instructors and the literature-derived goals and the participants' perceptions concerning the effectiveness of the activities for challenging PTs' beliefs about teaching, learning, mathematics, and pedagogy. The three goals that affected the application of reform-oriented practice were described as: (1) challenging preservice teachers'(PTs') beliefs about teaching and learning (beliefs); (2) enhancing PTs' conceptual understanding of the mathematics they will be expected to teach (math); and (3) developing PTs' pedagogical content knowledge (PCK). These served as a framework for analyzing the syllabi and interview data as detailed in Chapter 4 of this study. The analysis revealed that PCK most closely aligned with the participants' activities, followed by beliefs and math. The degree of alignment was variable. Effectiveness of the activities was determined by participants' responses to how well their activities challenged PTs' beliefs about teaching and learning mathematics.

Although the three goals developed in Chapter 2 were addressed in each of the methods courses examined for this study, the perceived effectiveness of the activities appeared to depend upon the structure or framework of the activities. Close examination of the instructors' perceptions and their syllabi descriptions provided evidence of this framework. This chapter summarizes a cross case analysis through which an activity framework emerged. Heibert et al. (1997), in their book *Making Sense*, talk about three important task features: (1) "make the subject problematic for students," (2) "the tasks must connect with where students are," and (3) "tasks must engage students in thinking about important mathematics" (p. 8). The framework determined through the cross case analysis is an adaptation of these three features as they pertain to educating preservice secondary mathematics teachers. The framework, described here as an Effective Activity Cycle (EAC) as depicted in **Figure 2**, relates to the perceived effectiveness of the activities for challenging PTs' preconceived ideas about teaching and learning mathematics. Whether designed to challenge PTs' beliefs, enhance their understanding of mathematics, or develop their PCK, the activities identified by the methods instructors as effective, had three pedagogical components: (1) identification of an issue or dilemma; (2) data collection and reflection; and (3) critical analysis and action (**Figure 2**.) It appears that when one of these components was missing or weak, the activity was identified by the instructor as frustrating or ineffective. The activities designated by instructors as most effective for challenging PTs' beliefs contained all



three components of the cycle.

Figure 2. Effective Activity Cycle (EAC) for Challenging PTs' Beliefs

This cycle is associated with reform-oriented teaching practice as it depicts an inquiry process that was prevalent throughout the literature. For example, the National Council of Teachers of Mathematics (NCTM) used a similar set of stages to define their *Data Analysis and Probability Standard*: “Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them” (Ferrini-Mundy et al., 2000, p.249). *Formulate questions* relates to the first stage of the EAC, *collect* and *organize* refer to stage 2, and *display relevant data to answer them* aligns with stage 3.

Similarly, Moses and Cobb (2001, p. 120) describe “crucial steps in the Algebra Project curriculum process.” Moses and Cobb claim the development of these steps is based on experiential learning theory:

> Experiential learning theory is grounded in the countless cyclical experiences in which people try something, then think about what they did, then make improvements, then practice their improvements. It seems that we learn most of what we know, from language to cooking to building shelters to live in, by applications of this process. One model for experiential learning is often presented as shown below:

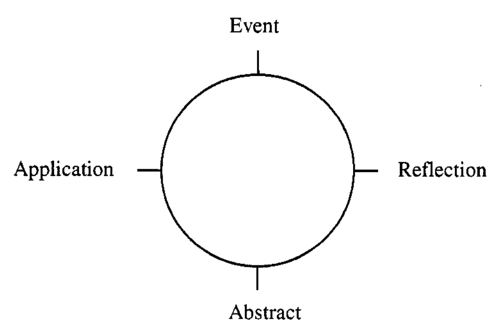


Figure 3. Experiential Learning Theory (Moses & Cobb, 2001, p. 198)

The *event* stage of the experiential learning model is similar to the first component of the EAC, *identify an issue or dilemma*. In traditional mathematics courses, issues or dilemmas are defined as problems and are primarily de-contextualized and presented to the students as abstract entities, whereas in reform-oriented courses, such as those described by Moses and Cobb, the issues or dilemmas students examine are usually deeply embedded in context where the students must wrestle with developing and identifying the problem in their own words. The second stage of the experiential learning model, *reflection*, is very similar to the second component of the EAC, *data collection and reflection*. For example, in the Algebra Project, Moses' students *reflect* on their own understanding of an issue or dilemma, examining and sharing their ideas about multiple problem-solving methods. This means of reflection and sharing is in essence a form of *data collection and reflection* as defined in the EAC. The last two experiential learning stages, *abstract* and *application*, are combined in the third stage of the EAC, *critical analysis and action*. Abstraction requires *critical analysis* to connect what is known and understood into a generalized format that can be applied to context that is different from the original problem scenario, and *application* is just another way of talking about action.

The EAC, therefore, is not a new idea, but rather an adaptation of an already broadly accepted reform-oriented teaching pedagogy. The basis for this modification is to clarify how this pedagogy aligns with preservice teacher education as compared with the more thoroughly developed application for adolescent mathematics education. The EAC stages are further clarified in this chapter and evidence from the data is provided to demonstrate how the EAC stages apply to methods instruction for secondary mathematics preservice teachers.

This chapter is divided into four sections. In the first three sections, the components of the EAC are clarified and claims are made concerning why each appears to affect the efficiency of activities for challenging PTs' beliefs as perceived by the participants in this study—(1) identification of an issue or dilemma; (2) data collection and reflection; and (3) critical analysis and action. Evidence is provided to substantiate the claims and show how activities identified as *effective* align with components of the cycle, and how other activities described as *ineffective* do not indicate alignment. When a project, lesson, or activity designated as *ineffective* is presented, it is compared with examples of alternatives that align with the EAC. In the concluding section of this chapter, the claims and evidence provided in each of the other three sections are summarized.

Identify Issue or Dilemma

All activities, lessons, and units are devised to address a certain need. Whether explicitly revealed or not, the intent of a lesson is in essence to address an issue or dilemma. Outside of school, people identify issues, collect the information they need to address the issue and then take action, which is described by Moses and Cobb (2001) as experiential learning. This also applies to the Effective Activity Cycle (EAC) (**Figure 2**), with the first stage being *identify an issue or dilemma*. When identification of the issue comes from the person taking action, the motivation to pursue a solution is intrinsic (Lave, 1988). As Lave suggests, this power or control over what one learns tends not to be applied within traditional school settings where the issue or dilemma an activity addresses is presented by the instructor. Involvement in identifying personal needs, issues or dilemmas is the first step required to take control of ones life, as Moses and Cobb (2001) suggest, "History demonstrates that taking responsibility for one's own life, one's own learning, can change a person" (p. 188). This first stage of the EAC, in essence provides a means by which the PTs can exercise some control over their own learning, by providing them with a means to address issues they identify as important or critical to their development as effective secondary mathematics teachers.

The idea of having students actively involved in identifying an issue or dilemma that will frame their learning experience is directly related to reform-oriented goals as suggested by Dewey (1944) who states:

> That education is not an affair of 'telling' and being told, but an active and constructive process…it is intrinsic to the disposition of the person, not external and coercive. To achieve this internal control through identity of interest and understanding is the business of education. (pp. 38-40)

Dewey is describing how students learn through intrinsic motivation and that this should be the "business of education" (pp. 39-40). If one of the goals of an activity is to build upon intrinsic motivation, then the questions PTs are expected to investigate and form opinions about should be developed as a joint process and integrated into the learning experience.

It is not surprising, then, that a cross case pattern was identified indicating that when the objectives for an activity are not validated by the students, the instructor reports PTs' lack of motivation to complete the task, or the task is completed with minimal effort. However, when PTs are involved in identifying an issue or dilemma, the instructors indicate that there appears to be strong, intrinsic motivation to be involved in the activity. In this section, the examples provide evidence of PTs' involvement or lack of involvement in the process of identifying issues and dilemmas that frame the objectives for specific activities. PTs' level of involvement appears to be directly related to how the instructors perceive the *effectiveness* of the activity, with active involvement associated with *effectiveness* and lack of PTs' involvement indicating *ineffectiveness*.

One means of involving PTs is to have them identify issues and dilemmas that they feel need to be resolved for them to become effective teachers. This means being open to challenging their beliefs and ideas by questioning theories presented to them through readings and case studies and exploring options presented by their peers and instructors. In this sense, Jackie's syllabus describes the questioning mind-set that she expects her students to develop:

> As for questioning, we encourage you ALWAYS to be skeptical about the knowledge and truth claims made by both `the authorities' – including us – and you yourself. Whenever you read a prescription for the reform of mathematics education, ask questions such as `What assumptions are built into this?'; whenever you listen to our ideas about the way things should be, pester us with the likes of `Have you thought of _____ or _________?'; when you hear yourself say, `I believe that ...,' come back with `Why do I believe that ...?' and `What has led me to believe that ...?' And so on.... (Jackie, syllabus, 1997)

Please note the phrase "we encourage you" which implies that the questioning is an expectation; however, through analysis of Jackie's syllabus and interview responses, this skill does not appear to be explicitly developed throughout the course. Jackie had set questions about learning and teaching that she expected her students to examine closely, and in only one assignment were the PTs asked to actually formulate their own questions about their practice or about issues they might have concerning teaching and learning. The syllabus described a project called *Personal Philosophy of Learning Mathematics (PPLM).* The PTs handed in three versions of their philosophy over the course of the semester. The syllabus stated that each version must end with questions that the PTs believe they need to think about further. These types of questions are important for a professional as they form the basis for improving practice. However, the questions were personally formed and were not publicly shared or collaboratively developed with the instructor or peers. Therefore, they do not align with the first stage of the EAC, *identify issues and dilemmas*. Jackie stated that it was the instructors who "ask a lot of those theory questions." For example, when using the TIMSS videos, Jackie said that it provided data from which they discussed the theoretical idea of content depth versus breadth. Jackie said,

> We talked about, "Is it easier to go deeper when you know more content or to go wider when you know less content in a more complete way or deeper way?" And we all agreed, the latter. So that was also our theory in teaching the course. That it wasn't important for us to cover all content, but whatever content that we did try to uncover we wanted to go very deep in it, basically so the students could continue to ask themselves those sorts of questions and investigate their understanding. (Jackie, 2005, interview)

The key phrase here is "so the students could continue to ask themselves those sorts of questions." The inference is that the questions were presented to the PTs to provide a model or an incentive for them to continue to think about and formulate like questions, but there was no evidence from the description of the assignment that this was explicitly asked for other than as a means to reflect. Action did not appear to be connected with the questioning.

Jackie explained in the interview that she was concerned with the lack of "self-authority that she sees in her students," citing Herbert Kohl's book, *I won't learn from you* (1994). In the following quotation, Jackie shared some of her frustration concerning the PTs reluctance to embrace the idea of inquiry which required students to be actively involved in the process of identifying issues and dilemmas:

> The research shows that people act out, like Herbert Kohl's book, *I won't learn from you,* and they experience so many oppressive situations throughout their schooling where they had no say, that pretty soon they just gave it up ... the major barrier is that not having the authority, not owning your understanding, not having, not knowing that even though…, many of the things that people expect you to do in school are ridiculous and are hoop jumping, you can decide to do that … in order for it to be a stepping stone for the goals that you had for your life, and so ... you don't have to give up your authority... that was sort of our goal. How do you build that into these preservice teachers so they can recognize the need to build it into their students? (Jackie, 2005, interview)

Jackie appeared to be suggesting that if the PTs could change their ways of thinking to accept the "hoops" as "stepping stones" then they could take back their self-authority to achieve their goals. Her question at the end of her statement indicated that although this was a major goal of the course and an integral part of her personal philosophy of teaching, she appeared to be at a loss to know how to "build that into these preservice teachers so they can recognize the need to build it into their students."

The answer to Jackie's question appears in Kohl's book. Kohl does not suggest that the problem of self-authority lies in students' lack of goals or lack of insight to know that hoops are stepping stones. Rather, he appears to be saying that to promote self-authority it is the responsibility of the teacher not just to provide a safe, nurturing environment where students can realize their personal goals, but rather to actively and explicitly incorporate into the activities means to develop students' questioning abilities. For example, Kohl shares a story about Akmir's defiant statement of "That's white man's psychology" (p. 17) when the class was discussing Sigmund Freud. Kohl said, "I told him that his questions and challenges were just what the class needed and invited him to join us" (p. 18). Kohl talks about how he learned from Akmir "to unlearn habits of mind that let such racism in books pass unexamined. Before knowing him I was not attuned to many nuances of racist implication because I was not the victim of racism" (p.20). Kohl indicates that when students are encouraged to ask questions, to challenge authority and formally presented interpretation of issues, then the instructor also learns from the experience. This presupposes that the instructor cannot truly understand or know what questions students have about a topic, as each individual has had different experiences. The responsibility of the instructor, as suggested by Kohl, is not only to provide a safe environment, but to push the students to develop their own questions and share them within the social context of the classroom.

Another participant, Kim seemed to address this issue of motivating students to identify issues and dilemmas with which Jackie was still struggling. For example, Kim incorporated students' identification of issues and questions about teaching dilemmas into the process by which she evaluated and modified her lessons and activities. In the syllabus, Kim mentioned that activities and assignments had been designed to be useful to the students and that they had a responsibility to negotiate to assure that this goal was met. Like Jackie, Kim also stated in her syllabus that everything in the course was negotiable:

> Although we will continue to eat up a chunk of your already small non-teaching time, we're trying to do so with things that will be extremely relevant and helpful. We would certainly appreciate it if you would tell us when this is not the case… All of the assignments ... are negotiable. We want the assignments to serve you well, so if changes ... will help you learn more and get more from your placements, then we would be happy to modify our plans. (Kim, 2003, syllabus)

In this way, Kim was setting up the norms of the course where students' opinions, challenges, and needs were validated, similar to what Kohl did with Akmir; Kim was ready and willing to adjust the focus of a lesson or activity to meet individual students' needs. As described by Kim, this encouraged her students to be involved in identifying the issues and dilemmas that they wanted to address.

Kim's approach was focused on using choice as a means to motive her students to learn critical reasoning and questioning skills that would enhance their teaching practice. This was exemplified by the semester project called an *Assignment of Choice* for which the PTs identified a teaching dilemma or issue they wanted to pursue. The overall goal was to help them apply the questioning and research methods they had learned to issues they felt were important for their growth as mathematics teachers. They could choose to delve into a mathematics topic to deepen their understanding of a concept, or another aspect of teaching such as issues of equity, or questioning and communication methods to improve their PCK skills. Although this activity was not singled out for discussion by Kim in the interview, the syllabus description provided an illustration of Kim's overall philosophy concerning inquiry and the importance of the PTs' learning to identify and question issues concerning their own growth as professionals.

Bob, another participant in this study, also included in his syllabus an invitation for students to negotiate anything and everything:

> No teaching method is more undervalued and underutilized than negotiation. In our class, everything ... is negotiable. This means that assignments, class activities, class processes, the pace of the course, due times, requirements are flexible, malleable, up for discussion, open to mediation, amenable to change. Don't presume that I'm automatically aware of your concerns... please be up front with your suggestions, criticisms, and discontents. If you choose not to, then an unhappy or dissatisfying situation may continue to make you unhappy or dissatisfied. (Bob, 2000, syllabus)

Like Kim, Bob encouraged PTs to take control over their learning experience. In the interview, Bob revealed that he was willing to put this statement of intent into action by adjusting the course format to address the needs of a large portion of his students. Although making adjustments to validate his students' needs, Bob maintained control of the overall objectives of the course by focusing the discussions on "particular problems of mathematical practice." For example, he talked about not realizing how many practicing teachers would be in his class and described how he dealt with this unexpected issue:

> I had no choice but to turn a good deal of the classes over to … a "problems of practice" session where they would come in with particular ... issues, and we would try to take them up. It's always a challenge to make that productive, to not just let it turn into a venting session, even though some venting is needed… So I structured it so that ... a good deal of class time would be for that, and I tried to... gear it towards ... particular problems of mathematical practice rather than classroom management. (Bob, 2005, interview)

Although Bob encouraged the PTs to be actively involved in the content of the course, he still had his own agenda and tried to manage the situation so that their needs were validated and addressed while still maintaining a direction and focus that he felt was important. Bob did not identify any of his lessons as more or less *effective* in challenging PTs' beliefs; however, this example provides evidence of how he adjusted his planning to validate and address the issues and dilemmas identified by his students.

The data indicated that encouraging the PTs to question what they read as well as their own assumptions is a skill that not only provides intrinsic motivation but also develops their ability to examine their own teaching practice. This is a skill that needs to be taught and appears to be an important aspect of the EAC to effectively challenge PTs' beliefs about teaching and learning.

Data Collection and Reflection

The second component in the cycle, once an issue or dilemma has been identified, is *data collection and reflection*. It is important to distinguish how the word reflection is used here, as it has many connotations. For the purposes of this dissertation, *reflection* refers to an immersion in the data to clarify and communicate understanding about an issue or dilemma.

Data can be collected from a number of sources, such as (a) personal beliefs and experiences, (b) articles and books, (c) video cases or vignettes, (d) student interviews, (e) student work, (f) opinions from cooperating teachers (CTs), field supervisors, instructors, and/or peers, and (g) solution strategies. The findings indicate that activities, in which *data collection and reflection* was isolated from the other EAC components, the instructors reported that PTs' exhibited low cognitive level of understanding as demonstrated by superficial levels of performance and a lack of motivation to provide constructive criticism to peers and to complete the assignments. Participants indicated that when fully integrated *data collection and reflection* provide alternative perspectives that can be effectively used to challenge PTs' beliefs.

One source of data shared by participants was to have PTs share their insights about teaching or learning theories that were introduced through research articles and books that they read as part of their coursework. This can be considered as a form of reflection, as the PTs were asked to read the material (collected data) and then articulate their understanding of that data. Some of the participants said that in the class discussion that followed this process, PTs' reflections were incorporated into the whole class discussion of the articles. This is an example of *data collection and reflection* done in isolation of the other parts of the EAC when reading the articles is not tied to the identification of an issue by the PTs and the results of the discussion are not used as a catalyst for action to improve or enhance their teaching practice.

In Pam's syllabus, journals were mentioned as a reflective tool for collecting PTs' perceptions concerning the readings they were assigned to help them identify the big ideas. Pam's intent or goal for this assignment was to incorporate the PTs reflections as a means of enhancing the class discussions and motivating their involvement. However, the information they collected through these discussions did not appear to be used in any format outside the class discussion. Pam mentioned in the interview that she probably will not use journals again. She said that unless she went "around and check[ed] off that they have written reading notes," the PTs would not do the reflections. Pam said that "it almost feels like being a policeman" (2005, interview).

Pam also talked about a different means of collecting data that appeared to be a more effective form of reflection, which was separate from the journal writing -- "after they [PTs] have taught a lesson we ask them to reflect on that and turn it in with their lesson plan" (2005, interview). Although Pam noticed stronger motivation for this form of reflection, she appeared to be unaware of why they were more motivated to do the lesson reflection as compared with the reading reflection. Both forms of reflection were means of summarizing what they had learned and both were done in isolation of the other stages of the EAC. The reading reflections and lesson reflections were viewed by the PTs and the instructor as evidence that the PTs had completed the homework assignment. The differences in motivation that Pam noticed could be related to what Lave (1988) calls *everyday activity* as compared with *intentional pedagogy* (p. 14).

Reflection on a lesson that they had just taught appears to have a greater level of intrinsic motivation as it is an *everyday activity* for a teacher who is interested in improving on a lesson to make it more effective for the next time it is used. This means that PTs think about the lesson reflection as a data collection strategy that informs the action of improving the lesson. In comparison, reflection on a reading assignment is often perceived as *intentional pedagogy* which is a contrived form of reflection assigned by a teacher to provide evidence that the students have indeed completed the reading assignment.

In Pam's course, PTs participated in math activities to collect information about how they understood the math concepts, they read articles and were supposed to "take notes on the readings to help … [them] think about big ideas of each piece before class," and they were asked to "always include student work or copies of student work when requested" (2003, syllabus). These were all data collection strategies; however, there was little to indicate that the data were used beyond the initial purpose of collection and personal reflection. These examples indicate that data collection from multiple sources was strongly emphasized; however, the other two components of the cycle were difficult to discern.

Pam mentioned that PTs "are supposed to do an analysis of the textbook program used in their practicum school." Pam said that she asks them to consider the class activities "from both the student perspective … and the teacher perspective" with a suggestion that they think about, "What modifications would I have to provide for children to participate in a similar activity?" They also experience "culture shock" when they are placed in "a very urban, widely diverse school" (2005, interview). It appeared that none of these potentially rich data sources were taken to the *critical analysis and action* level of the EAC, and *issues and dilemmas* were either provided by the instructor or not explicitly stated. Critical analysis did not appear to be integrated into the learning process, as further exemplified by this segment of the syllabus:

> It is possible that you may feel some tensions between your own experiences in school, the observations you make in your practicum, what you feel is "ideal" instruction, and what happens in our class. You may also feel tension between what you thought a methods class would be like, and what happens in our class. Hopefully you will have opportunities to sort through some of these issues in class, but if you find yourself frustrated or have problems with the format or content of the class, please make an appointment to talk to the instructor outside of class. (Pam, 2003, syllabus)

The impression from this statement is that these frustrations or problems were not issues discussed with the whole group, but were to be dealt with on an individual basis. Analysis of Pam's syllabus and interview responses indicated a strong emphasis on data collection with very little consideration for the other two components of the EAC.

In contrast to Pam's goals for data collection, Kim focused on encouraging her students to challenge their own beliefs by providing evidence from a variety of opinions as a whole group exercise. Comparing the quotation above from Pam's syllabus with the quotation here from Kim's which dealt with similar issues, the difference in course objectives is apparent:

> There is no taken-for-granted consensus at the moment about how mathematics should be taught. Here and there you can find pockets of people with similar ideas. You can also find commonalities among people who initially seem quite different. But, as a teacher, you will need to be ready to justify what you do, because other people will not automatically hold similar opinions. (Kim, 2003, syllabus)

Kim encouraged her students to use data collection as a means to examine different opinions so that they had a rich source of ideas and evidence to help them challenge what may be strongly held beliefs. This segment from the syllabus appeared to validate alternative opinions, thus helping the PTs challenge their beliefs without feeling defensive or apprehensive that their beliefs were flawed, thus providing them with an opportunity to re-evaluate their ideas.

Pam said that she had been "a little disappointed with peer feedback… They [PTs] all want to cheer each other up and say how wonderful they are, but they really don't want to give constructive criticism" (2005, interview). In contrast, Kim challenged her students to defend their ideas and beliefs and learn from their peers:

> The opportunity to share your thinking and have your ideas challenged by others is a critical part of developing as a teacher, and an experience that is often hard to come by in the normal course of the school day. This year, we will help you develop the skills for learning from your colleagues, and, perhaps more importantly, the disposition to do so, so that you can seek out or create these kinds of opportunities throughout your career. (Kim, 2003, syllabus)

This segment of the Kim's syllabus implied that sharing opinions and ideas was an integral part of the learning process and placed the PTs in the role of knowledge provider so that they could learn from each other. This was a form of data collection where they elicited opinions and beliefs from their peers and used that information to improve their practice, thus situating the data collection in the midst of an EAC.

Another way that Kim used data collection was exemplified by the way she explained the unit-planning process that spanned two semesters:

> In the unit planning, rather than giving them a prescribed template … we say, "Here is what some people have done … You tinker with it a little bit and then you talk to me at the end of the semester about what you think you've learned about unit planning from that process. And the rubric is set up such that they do not have to have learned any particular thing, but they have to be very clear about what they think they have learned and how the various plans that they've written across the year, how they can draw

> evidence from what they've put into those plans that would illustrate that they have learned thus and such. (Kim, 2005, interview)

Here Kim used data collection as a means of having the PTs analyze different ways to develop a unit plan. As suggested in the first section of this chapter, taking responsibility for ones learning is an important aspect of intrinsic motivation (Moses & Cobb, 2001). This can be called self-authority. Kim used data collection as a tool to enhance her students' self-authority, by providing them with the opportunity to design their own unit plan process after having examined different models. This validated their deductive reasoning abilities and taught them how to use data from different sources to improve their practice.

Jackie, another participant in this study, also placed a strong emphasis on data collection in her syllabus. Unlike Pam's and Kim's syllabi, Jackie's syllabus presented the data collection process as a tool to challenge beliefs about equity issues that affect student learning:

> Another bedrock belief of ours is that every mathematics teacher on the doorstep of her/his career needs to learn as much as humanly possible about the entire profession s/he has chosen to enter. Hence our `many-dimensional exploration of secondary-school mathematics education' will extend beyond mathematics learning and teaching to embrace the larger domains in which mathematics is taught and learned. The purposes that mathematics education serves with respect (and disrespect) to our society; which special-interest groups whose special interests are well-met by mathematics education; the different values that different approaches to mathematics teaching tend to transmit: all these professional issues and more like them will be on our plentiful plate during the year to come. (Jackie, 1997, syllabus)

Like Pam, Jackie used literature as a source of data. However, they differed in one very important way. Since Pam's students were asked to identify and reflect on the "big ideas" in the readings, the implication is that there was one prevalent view point, the author's, to be considered. This may be a misreading of the Pam's syllabus since only one text was listed and a reading list was not included. However, there was no mention of tensions surfacing within the readings themselves but rather only in relation to the PTs' beliefs and experiences. In contrast, Jackie was very explicit about controversy, suggesting that these conflicts stem from the literature which supported multiple viewpoints. This was exemplified by the following excerpt from the Jackie's syllabus:

> The desire for reform and controversy have generated a rich literature relevant to mathematics teaching. During this semester, our readings will focus on students, their learning, and how mathematics teaching does and does not support such learning. We will use these readings to learn to think about students' understandings of particular mathematical topics and about their motivations for learning or not learning mathematics. (Jackie, 1997, syllabus)

Although the *issues and dilemmas* were explicitly identified in the syllabus descriptions of the reading activities, this brief excerpt from another part of the syllabus suggested that the data came from a variety of sources relevant to mathematics teaching, implying multiple viewpoints concerning big ideas.

Data collection appeared to be an important aspect of all the courses examined in this study. None of them neglected this aspect of the EAC; although there was variation as to how the data were used. The following section examines critical analysis and action, which tend to be the component of the EAC that was missing or de-emphasized in many of the cases and strongly emphasized in a few of the others.

Critical Analysis and Action

Critical analysis connotes reflection based on broad issues, challenging strongly held beliefs, while action suggests adjustments made to a lesson, unit, or activity, or re-evaluation and articulation of a teaching and learning philosophy in light of the newly acquired understanding or knowledge.

As described in Chapter 2 of this study, when methods courses modeled reform-oriented teaching practices, introduced PTs to reform-based theories and encouraged reflection, the PTs developed a cognitive level of understanding. However, *critical analysis and action* appear to be an aspect of the EAC that elevates PTs' learning to a metacognitive level. In this context, critical analysis challenges the process by which PTs recontextualize the theories and practices they have learned in the methods courses by having them confront the tensions that arise between their beliefs and experiences and the information they are introduced to through multiple sources or data input (Ensor, 2001). The pattern across the cases indicated that it was this aspect of the EAC that was most commonly minimized or missing from the activities suggested as *ineffective* by the instructors.

An important aspect of this component of the cycle is that *critical analysis and action* need to connect data findings with the PTs' teaching practice or beliefs about teaching and learning. This means the PTs need to discuss or indicate how their thinking about teaching, learning, mathematics, etc. has changed and how these changes will affect their teaching practice. This is a critical aspect of the cycle to enhance the PTs' metacognitive understanding. As described by Ensor in the literature review, without this component the PTs develop recognition rules which are indicative of cognitive levels of understanding such that the PTs can discuss the concept. However, to put theory into practice the PTs must reach the realization level—metacognitive understanding. The critical analysis and action component of the cycle has the PTs closely examining the data they have collected to expose tensions with their personal beliefs, and then put that newly formed knowledge into action. For example, they might adjust their lesson and unit plans, assessment protocols, and/or curriculum they plan to use with students based on this new information or change in beliefs. This is the application step that tended to be missing or weak in activities that instructors claimed were *ineffective* and to be identified as strongly prevalent or emphasized within activities that the instructors claimed to be the most *effective*. In this section of the chapter, evidence is presented to support this claim.

Mary talked about an activity, as described in the previous section, which she felt was effective at challenging PTs' beliefs. She called it 'Forced Choice' in which she presented a scenario and offered a number of options for dealing with the issue. Mary said that one of the scenarios she introduced dealt with students' learning and offered (amongst others) these two options: "The teacher strongly influences the norms in the classroom. Or, some students just don't want to learn so there is nothing you can do." Mary said she used statements like these as they tended to be "very provocative" (2005, interview). The PTs committed to one of the statements by physically moving to a part of the room designated for that option. This commitment aligns with the first component of the cycle. Here is how Mary described what happened next once PTs committed to an option:

> I call on different ones to defend their stance. And sometimes it gets a little heated. But I think that's good because the awareness that someone holds a very different position from you...especially one of your peers, can help you at least be a little more open to re-thinking things. (Mary, 2005 interview)

This can be considered the data collection aspect of the activity; however, it involves a level of critical analysis that was not evident in some of the other activities designed for sharing ideas that were used by other instructors. Mary said, "It gets a little heated" which indicated that the exercise had touched on deeply held beliefs; identifying those beliefs and challenging them is an important aspect of critical analysis. As suggested by Mary, the fact that peers held very strong beliefs that were different added another dimension to the analysis. It was not some distant theorist or researcher but rather a colleague who might end up teaching at the same school, so how they reconciled these differences was an important aspect of the activity. Mary said that this helped the PTs to re-think things. The re-thinking part happened during the class discussion as the PTs defended their positions and challenged one another to defend other choices. This activity aligns with the action component of the cycle and makes this a powerful exercise for challenging PTs beliefs.

Mary also talked about another activity where the PTs collected a number of different forms of data to analyze students' understanding of a concept: "whole class data for one assessment, and three forms of data on two focal students: a traditional test, observations on their work and a clinical interview" (2005, interview). Although the goal of this project was to "produce an analysis of … a particular concept … as demonstrated by a variety of assessment means" (2005, syllabus) the action component seemed to be missing. The assignment gave them information about what the children know and understand about a particular concept, and, implicitly, they had learned what types of information can be derived from different assessment methods, but how to apply this to their own teaching was left to the individual PT to figure out. Mary did not mention this activity as either most or least *effective* as it appears to meet the goals set forth for it; however, to affect PTs' strongly help beliefs about teaching and learning, it appears to need a critical analysis and action component.

In contrast, Rick also had the PTs do a large project that entailed student interviews, and he said that his students considered this to be the assignment that made the biggest difference in the way they think about teaching and learning. This was a multi-staged project, with specific parts due over the span of the quarter. Rick started off by having the students "buy-in" to the math concept that he wanted them to focus on for this project. He did this by having the PTs, early in the quarter, read articles about rational numbers and then go to their schools to collect data on what students know about the concept. The response he received was: "Holy mackerel, my kids don't understand what a fraction is and they're in tenth grade" (Rick, 2005, interview). Once he had this "buy-in", he then introduced the project. In the first part of the project, PTs administered a "10 minute whole-class assessment on rational number understanding" (Rick, 2005, syllabus). The PTs used what they learned from the article they read earlier in the quarter about rational numbers to discuss the tasks in class before they went out to their schools to administer the assessment. Afterwards, they used the article again to help them analyze the assessment results. Already in this project there are aspects of critical analysis and action. PTs are applying what they have learned in an article to help them formulate assessment questions and analyze the results.

The second stage of the project was a follow-up interview with one student to help the PT "better understand the student's thinking and to assess his/her mathematical understanding" (Rick, 2005, syllabus). This was followed by brief interviews, which tended to be a more practical format for practicing teachers. The PTs conducted "three one-minute interviews during class" (Rick, 2005, syllabus) to help them understand students' thinking. All of these data were analyzed and compared.

This last part of the project challenged PTs' beliefs and was called "Using Assessment to Plan Instruction." The PTs responded to these prompts:

> What did you learn about children's thinking and how might this information influence subsequent instruction? Be specific about how your analysis of the results could inform your instruction. You need not actually construct items or a lesson plan that you would use. However, it would be helpful to specify the types of items and lesson that you believe they need. (Rick, 2005, syllabus)

The prompts pushed for critical analysis and suggestions for application or action. Looking back at Mary's project, which was described earlier, up until this last part, the two projects look very similar. However, it was this last part, where PTs apply what they learned about different forms of assessment into an action plan that aligns Rick's project with the third component of the cycle.

Rick also talked about a much smaller activity that also received high ratings from his students, called "Showing your students you care." This activity was designed to challenge their beliefs about classroom norms and student motivation. Here was how Rick described the activity:

> I asked them to try to talk to someone who might be problematic in the class, and the experience often changes the student's relationship with the teacher significantly enough that the teacher is affected by the experience. (Rick, 2005, interview)

This was a rather simple activity, but the action component was immediate and dramatic. The process of collecting data, which Rick suggested could take as little as 15 minutes, was where the PT shared something about themselves with the student and tried to make a personal connection and get the student to open up and share something back. Although this does not appear to have a critical analysis component, the action was in the interview, while the analysis was based upon the perceived results. Rick said that the PTs reported back that some of the behavioral issues in the classroom dissolved after meeting with the student. Rick reported that this simple activity was evaluated by many of the PTs as a solution to a classroom management issue that had not been considered before.

Critical analysis and action are important parts of inquiry as they answer the question of "How do I use all this information?" The data in this section indicate that when this component is missing, PTs are left with having to apply theory to practice without any experiences to fall back on to help them understand how to do this. When it was integrated into the course and activity expectations, instructors reported that PTs seemed able to apply the skill. This indicates that this component may help move the PT from a cognitive level of understanding to a metacognitive level. When it is missing, the instructors described PTs' units and lessons as being very traditional even though the instructors had emphasized throughout the course reform-oriented teaching methods.

Conclusion

What does it mean to build methods course activities around the framework of the Effective Activity Cycle? When the cycle is applied, what is the perceived effect of PTs' ability to put theory into practice?

When this cycle was reflected in the teaching philosophy of the methods instructors, it permeated many of the course assignments. As an example of this, here is Kim's description of the portfolio assignment and how the PT's Philosophy of Education affected the assignment goals:

> They start off thinking about a portfolio sort of a scrapbook of their work. So they stick things in it but through the assignment called the Philosophy of Mathematics Education... we try to get them thinking about ... the 3 or 4 big things ... to represent about what's important ... in your teaching? And how do these documents, how do the artifacts that you are collecting represent that? And how would you describe or point to various aspects of these things in order to make that clear to someone who was paging through this informally? Or how would you make that clear by using this task that you've included in this scrapbook? How would you talk about that in the context of an interview? So I do talk with students about how they use those things directly. (Kim, 2005, interview)

Kim started off by describing the portfolio as a "sort of a scrapbook of their work" which indicated that the PTs were, over a period of time, collecting data. The intent or purpose of that data collection seemed to be somewhat random and with little focus or coherency. However, the assignment called the "Philosophy of Mathematics Education" provided a framework to formulate essential questions that the PT believed defined what is important to them concerning their teaching. This meant that the PT was actively involved in the first step of the cycle, which is to formulate a question or issue. Since the materials or data were already collected over the course of the PT's teacher training experience, step two of the cycle was already satisfied. Kim provided the catalyst for the PTs to delve into the third component of the cycle, which required critical analysis. Kim asked the PTs to use their collection of artifacts—data—to substantiate their teaching philosophy by providing evidence in a coherent manner. Kim made this activity relevant to the PTs' by suggesting through her line of questioning that the evidence should be clear enough to substantiate their philosophy to a prospective employer. All three components of the cycle were deeply embedded in the portfolio assignment.

When a majority of students do not meet the expectations of an activity, it is a fairly good indication that something may be missing from the structure of the assignment rather than an overall failing of the students. By examining the structure of the assignment against the cycle described in this chapter, there appears to be some correlation between the alignment of, or lack of alignment with, different aspects of the cycle. In **Table 7**, the data analysis evidence and cycle components are summarized.

The findings indicate that a cyclical activity process effectively challenges PTs' beliefs about teaching and learning mathematics. This cycle includes three components: identification of an issue or dilemma, data collection and reflection, and critical analysis and action. For the first component to be effective, not only must PTs be encouraged to identify issues, but those issues need to be incorporated into the learning process to ensure that the students are intrinsically motivated, and that they learn the important skill of developing essential questions that will guide their lesson and unit planning and assessment of their own teaching skills. The second component needs to include multiple sources and opinions so that PTs can identify with tensions in the data. PTs' ideas and beliefs should be included in the data mix and tensions brought to the surface and shared within the learning community. The final component raises the level of understanding of teaching and learning concepts to a metacognitive level. This happens when PTs defend their views and re-evaluate their practice based on newly formed ideas and understanding.

Table 7. Alignment with Effective Activity Cycle

Cycle Componen t	Important aspect of the component	Impact not integrated into activity	Impact when integrated in activity
Identify Issue or Dilemma	PTs' involved in developing the essential questions for an activity A means to develop PTs 'buy-in' to lesson objectives PTs' questions and concerns validated and addressed	Lack of motivation is evident Lack of self authority Struggle to develop essential questions	Provides source of intrinsic motivation Enhances skills in developing essential questions
Collect & Summarize Data	Multiple sources and opinions PTs involved in data collection process	Students perform at a superficial level Students' lack motivation to provide constructive criticism of peers	Provides alternative perspectives that can be used to validate or challenge beliefs Enhances skills at collecting data that can be used to assess student learning, teaching practice, etc.
Critical Analysis & Action	Knowledge is applied to real teaching tasks to improve practice Data analyzed with respect to larger societal issues and applied to teaching practice	Theory is not applied in practice Concepts learned at a cognitive level as opposed to a metacognitive level Misconceptions not addressed	Metacognitive level of understanding is achieved Tensions with personal beliefs are exposed What is learned is applied to re-evaluate teaching practice

Chapter 6 is a summary of the findings of this study which connects the literature derived goals as described in Chapter 2, the case analysis results from Chapter 4, and the cross case analysis framework as described in this chapter. Chapter 6 also includes implications for future research and suggestions for application in developing secondary mathematics methods syllabi. The final chapter of this dissertation, Chapter 7, applies the findings of this study by describing the formulation of a sample secondary methods course syllabus and an activity assessment protocol.

Chapter 6. Conclusion, Summary and Implications

As suggested in the introduction to this dissertation, U.S. teacher education programs are more focused on reform-oriented teaching practices and curriculum than in past decades. In the past few years, with our students' performance in mathematics trailing that of other industrialized nations (NCES, 1999), there have been a number of responses to this issue, such as the *No Child Left Behind Act* (2002) at the national level and state-level adoption of standards-based preservice teacher assessment tools (OSPI, 2004a). Less visible segments of society have also responded, such as the attention being paid towards the education of preservice teachers (PTs). This is evident in educational research where researchers are now focusing attention on the design of *educative curriculum materials*, which are concerned with teacher training and development (Davis & Krajcik, 2005).

The goal of this dissertation is to develop a secondary mathematics methods syllabus and an activity assessment tool that can enhance PTs' reform-oriented teaching practices. The questions explored in this dissertation are: (1) What does research literature suggest should be the goals of preservice education for secondary mathematics teachers? (2) How does the content of secondary mathematics methods courses connect with those goals? (3) How do secondary mathematics methods instructors reflect on the effectiveness of their own course activities in meeting those goals? And (4) how can the results of this study inform the creation of a secondary mathematics methods course syllabus? Analysis of the literature concerned with these issues indicated three goals that were used as a framework for analyzing the data in this study. The goals were: challenging PTs' beliefs about teaching and learning, enhancing PTs' conceptual understanding of the mathematics they will be responsible for teaching, and developing PTs' pedagogical content knowledge (PCK).

The first of the goals is to challenge PTs' beliefs about teaching and learning. Teaching is one of the few professions in which PTs have had years of exposure through their personal education experiences. A majority of PTs in the U.S.A. have spent nine years in primary school, four years attending secondary school, and for many another four years in undergraduate studies. From the research, we can conclude that a large portion of these years were spent in what would be considered traditional teaching environments—teachers lecture and demonstrate procedures, students sit quietly practicing what has been introduced to the class (NCES, 1999; Stevenson & Stigler, 1992). This is a very different teaching environment compared with the reform-oriented practices that many teacher education programs expect PTs to apply during their teaching careers. Because of this exposure since early childhood, beliefs about teaching and learning are deeply held. Ensor (2001) found that PTs tend to take what is learned through their coursework and recontextualize their beliefs to fit the social context when beliefs are not adequately challenged. As Ensor's study indicates, teaching practice is not effectively enhanced unless beliefs are challenged at a metacognitive level.

The second goal prevalent across the literature was to enhance PTs' understanding of the mathematics they will be teaching at the secondary school level. Reform-oriented teaching practices, as recommended by associations such as the National Council of Teachers of Mathematics (NCTM) and the National Science Foundation (NSF), require that teachers help their students communicate their thinking processes and develop a deeper understanding of mathematics. This means that PTs need a much deeper understanding of the mathematics they will be expected to teach. The literature in this area indicated that a majority of PTs have strong content level understanding of standard procedures; however, few PTs have developed a level of understanding that can be considered problem solving, epistemic, or inquiry level of understanding (Kinach, 2002). The literature indicates that teachers' conceptual level of mathematics knowledge has a strong correlation with how well they are able to teach for understanding (Borko et al., 1992; Monk, 1994; Nathan & Petrosino, 2003; Van Dooren et al., 2002).

Finally, the third goal that comes from the literature review was to develop PTs' reform-oriented PCK. This means understanding the pedagogical factors that affect student engagement in high levels of mathematical thinking (Ball & Bass, 2000; Chazan, 1996; Henningsen & Stein, 1997; Lampert, 1992) and being able to balance the pressures and tensions that affect pedagogical decisions (Borko et al., 1988; Henningsen & Stein, 1997).

The data for this study consisted of methods course syllabi, methods instructor interviews, and demographic information concerning the structure of the teacher training programs. Eight methods instructors known for their reform-oriented teaching practice and representing a broad range of teacher education programs within the state of Washington and from across the country participated in this study. The data derived from each participant constituted an individual case. The data were examined through case and cross case analyses.

The case analysis indicated that even when the three literature-derived goals were addressed in methods courses, many activities were considered by participants in this study as less than *effective* for challenging PTs' beliefs about teaching and learning mathematics. For example, some of the participants stated that despite their efforts to model reform-oriented teaching methods, ground learning in practicum experiences and emphasize the importance of promoting students' conceptual understanding of mathematics, many of the PTs still wrote very traditional unit plans (Bob, 2005, interview; Pam, 2005 interview; Rick, 2005 interview).

This chapter is divided into four distinct sections. The first two summarize the results determined through case studies and cross case analyses. In Chapter 4 of this study, the cases were individually examined and compared with the goals from the literature. Claims were made as to how the courses aligned with the goals from the literature, evidence was presented to support those claims, and the analysis was summarized in the first section of this chapter. The cross case analysis, as detailed in Chapter 5, examined the structural aspects of the activities mentioned by the participants as *effective* for challenging PTs' beliefs as compared with those designated by participants as *not effective*. A framework, called the Effective Activity Cycle (EAC) was identified and explained. A summary of the cross case analysis is detailed in the second section of this chapter. The last two sections of this chapter describe the limitations of the study and implications for future research.

Summary of Case Studies

The eight secondary methods instructors who participated in this study were identified by the pseudonyms: Bob, Jackie, Kim, Lilly, Mary, Matt, Pam, and Rick. Each agreed to be interviewed and provided their most current syllabus. The framework of the case study analyses was based on the three goals—challenging PTs' beliefs, enhancing conceptual understanding of mathematics, and developing PCK. The participants' syllabi and interviews detailed numerous activities (lessons, projects, and activities) which were sorted into two categories—field- and classroom-based activities. Many of participants indicated that they considered some of these activities to be more or less effective for challenging PTs beliefs about teaching and learning mathematics than others. The activities were examined to determine how they aligned with each goal derived from the literature. The following three subsections describe how the activities aligned with each goal, and the claims that were made, and summarize the evidence that was provided in support of those claims.

Challenge PTs' Beliefs about Teaching and Learning

The case study analyses revealed that although participants used more classroom-based than field-based activities, the field-based activities were considered by participants to be more *effective* for challenging PTs' beliefs about teaching and learning. The evidence in support of this claim indicated that of the 20 field-based activities 61% are considered *effective* by participants while only 14% of the 33 classroom-based activities are designated as such. In fact, 26% of the classroom-based activities are considered *ineffective* by the participants.

As for the types of lessons that challenge PTs' beliefs, there appeared to be no consensus among participants. The activities mentioned as *effective* by one participant may very well not be singled out as effective by another. For example, five of the eight participants mentioned using some sort of student interview activity. However, only two of the five participants stated that this activity is *effective* (Mary, 2005 interview; Rick, 2005, interview). In fact, Rick had two different activities that fit this category that he considered to be very *effective*. One is called "Showing Students You Care." This activity challenged PTs' beliefs about adolescent development, issues of equity, and classroom norms. The second student interview activity used by Rick was much more formal and structured, where the PTs interviewed secondary level students to determine their understanding of a particular mathematics concept. This sort of interview not only challenged PTs' beliefs about what it means to know and understand mathematics, as well as providing an appreciation for formative assessment as a viable method to inform lesson planning.

Mary (who also considered the student interview assignment to be very *effective*) used it to challenge beliefs about assessment methods. Mary suggested that her students examine the summative tests given at the end of a unit or lesson they had recently observed being taught in the schools. The PTs collected samples of the tests and interviewed students about the same mathematics topics. The information provided insight into what students know and are able to do, and how that information could be derived from each of assessment methods. This activity challenged the PTs' beliefs concerning standard forms of assessment and the assumptions made concerning student understanding of the mathematics.

The wide range of activities and the inconsistency between them concerning their perceived effectiveness for challenging PTs' beliefs requires a closer examination across the cases. The structural aspects of those activities designated as *effective* and those considered *ineffective* were described in detail in the Chapter 5 cross case analysis and summarized in the following section of this chapter.

Enhance PTs' Conceptual Understanding of Mathematics

One of the issues most participants in this study agreed on was that the PTs who attended their methods course(s) had strong procedural knowledge of mathematics; however, their conceptual level of understanding tended to be weak. What they disagreed with is the extent to which conceptual understanding of mathematics should be focused on in the methods course curriculum. Only 40% of the activities used by all participants aligned with the second goal—enhancing PTs' conceptual understanding of mathematics. The range of alignment was from a low of 20% up to a high of 67%. Although six participants mentioned algebra as an important topic, there was very little agreement as to the particular concepts that should be discussed. A topic that half of the participants agreed upon was how a mathematics concept was chosen as a focus for a lesson, suggesting that the most effective means was to examine mathematical ideas the PTs brought to the discussion. This could be the mathematics PTs were presently dealing with in their field placements or mathematics PTs had personal questions about. Four of the eight participants specifically said that they discussed math topics brought up by their students; although they dealt with the issue in different ways. For example, Rick said he tried something new this year rather than his choosing a math topic, instead he had the students share ideas they had for lessons they wanted to teach their students in the field. Rick said this had mixed results, but that he would use it again. In contrast, Mary incorporated close examination of mathematical topics in her peer teaching activity. The mathematics introduced in the micro-teaching activity was discussed by the class as part of the analysis of each PT's presentation.

Other than algebra and working on mathematics that connects to PTs' immediate interests, there seemed to be little agreement as to the math content that should be included in a methods course, and even less agreement as to how or to what extent to allot time to specifically address the PTs' enhancement of conceptual knowledge of mathematics

Develop PTs' Pedagogical Content Knowledge (PCK)

The final goal, developing PTs' PCK, was addressed in a majority of the activities across all but one of the cases. In fact all of the activities in three cases and all of the field-based activities in three other cases addressed the development of PTs' PCK. The participants in this study suggested that 33% of the field-based and 15% of classroom-based activities were *effective* for challenging PTs' beliefs concerned with developing their PCK. However, more than a third of the classroom-based activities were designated as *not effective*. Although a majority of the activities align with this goal, the participants indicated that a large number of the activities were *not effective*. One of the activities used by half of the participants for helping PTs develop their pedagogical skills was micro-teaching (peer teaching). Half of the cases mentioned some form of unit planning as an activity. However, as suggested in the summary of the first two goals, there was little agreement as to the structure of these activities or their *effectiveness*.

Overall Conclusions

The case analysis did not indicate a "canon" of knowledge that was being used by the participants. The math concepts varied based upon PTs' immediate needs and interest. As for the pedagogical content knowledge, lesson planning and to some extent unit planning was indicated consistently in all the syllabi, with more than half of the participants including some form of peer teaching to improve their teaching skills. Although there were a number of similar activities used by the participants such as the TIMSS report, unit planning, interviewing students, and peer teaching, there appeared to be different objectives for each. For example, Rick (2005, interview) had the PTs conduct secondary-level student interviews as a means of examining alternative assessment methods (formal test, long interview and short interview). This activity addressed the goal of developing PTs' PCK. On the other hand, Mary used student interviews to challenge PTs' beliefs about what it means to learn mathematics. The PTs questioned their secondary level students about a particular math topic that they assumed the children understood. Therefore, Rick used student interviews to develop PTs' PCK, while Mary used student interviews to challenge PTs' beliefs about teaching and learning.

Another example of the range of objectives motivating similar activities was the use of the TIMSS video. Lilly used the TIMSS video to provide a model of a reform-based classroom to challenge her students' thinking about classroom norms; while Rick used the same material to challenge his students' thinking about equity issues. Rick said he wanted to challenge PTs' acceptance of the U.S. cultural norms concerned with the belief that a person is either born with a mathematical mind or not. This he compared with the culture of Japanese classrooms which emphasized math ability as a product of how hard a person worked.

Therefore, even though many of the participants in this study used similar activities, there appeared to be little agreement as to the objectives for those activities. This indicates that there is no set “canon” and a need for more research to determine the best fit between an activity and the objectives.

Summary of Cross case Analysis

The cross case analysis revealed an interesting framework concerning the structure of activities that participants consider *effective* for challenging PTs’ beliefs about teaching and learning mathematics as compared with those they label as *ineffective*. This framework is defined as an Effective Activity Cycle (EAC), **Figure 2** in Chapter 5. The EAC is not an new idea, but rather is an adaptation of cyclical processes used and defined by Heibert, Carpenter et al. (1997), Ferrini-Mundy, Joyner et al. (2000), and Moses and Cobb (2001). The cross case analysis pattern called the EAC applies these processes concerned with effective reform-oriented teaching practice to the education of secondary mathematics teachers. The EAC identified three components that appear to be present in all the activities deemed *effective* by the participants in this study and some missing for those activities considered less *effective*. The three components were: (1) identification of an issue or dilemma, (2) data collection and reflection, and (3) critical analysis and action. There are a number of distinguishing aspects to each component which are described in the following three subsections.

Identification of an issue or dilemma

For identifying an issue or dilemma, there are three different aspects that are used successfully in the *effective* activities, although all three are not necessarily used together. These three aspects are: (a) having PTs involved in developing the essential questions for an activity, (b) developing a means to have the PTs 'buy-in' to the lesson objectives, and (c) validating and addressing PTs' questions and concerns. When these are not addressed, the instructors reported that the result appears to be that PTs lack motivation and self-authority, and PTs struggle when learning how to develop essential questions as they apply to secondary level curriculum development. The positive aspects observed by the participants when PTs are involved in identifying the issue or dilemma were that it provided a source of intrinsic motivation and enhanced skills in developing essential questions.

Data Collection and Reflection

The second component of the EAC dealt with data collection and reflection. PTs need to access multiple sources and opinions and be actively involved in the process. When this component was not effectively integrated into an activity, the instructors report that PTs performed at a superficial level and lacked motivation to provide constructive criticism to peers. The participants in this study who applied this component to their activities described how the multiple sources and opinions provided alternative perspectives that successfully challenged PTs' beliefs, and enhanced the PTs' skills in collecting data to assess student learning, teaching practices, etc.

Critical Analysis and Action

The third component of the EAC is critical analysis and action, defined as analyzed data with respect to issues of teaching, learning, and larger societal issues and then actively applying the result to practice. This component appeared to be missing from many of the activities designated as *not effective* by the participants. In those activities designated as *effective*, the knowledge gained from critical data analysis was applied to real teaching tasks with the expressed objective of improving teaching practice. When this component was missing, the participants indicated that theory was not grounded in practice, pedagogical concepts were learned at a cognitive level, and PTs' misconceptions were not adequately addressed. When applied effectively, this component appeared to raise the learning to a metacognitive level by exposing tensions between what was being learned with personally held beliefs. This component, as described by the instructors, helped PTs learn how to apply what was learned by having them re-evaluate their teaching practice.

Limitations

The limitations of this study are concerned with the data collection methods, sample size, and generalizations. The data for this study consist of eight methods instructor interviews, copies of their methods course syllabi, and internet research concerning the demographics of their institutions. Missing from this study is actual observation of the activities described in the data. In addition, some of the participants were not currently teaching the methods classes described in the data but were relying on their memories to respond to the interview questions. The interview protocol had open-ended questions, and the probing questions were tailored to the specific instructor in reference to their syllabi. This means that the interview questions varied slightly and may have led the participants to emphasize different aspects of their teaching. Since the cross case analysis focused on the activities mentioned by the participants as *effective* or *ineffective* for challenging PTs' beliefs, and the basis for this classification was left open for interpretation, it is possible that the instructors responses may have issues of verifiability. Also, since there were only eight nominated participants the sample may have been skewed towards a particular interpretation of reform-oriented practice. Finally, the PTs' learning and teaching practices were not considered.

Implications for Future Research

This study was not concerned with proving which activities were more or less effective, but rather was focused on patterns of practice. Areas it leaves open for future research would be examining more closely the individual activities mentioned in this study to determine how they can be used most effectively for promoting PTs' learning (Davis & Krajcik, 2005). One of the aspects of this sort of research would be to further examine the EAC to determine how the stages of this cycle correlate with the effectiveness of a lesson in challenging preservice teachers' beliefs and in smoothing the theory to practice continuum. This might be accomplished with a case study of a secondary methods course. The activities could be analyzed to determine their present fit with the EAC, and data collected to determine the effectiveness of the activities in challenging PTs' beliefs and in the PTs' ability to connect theory with practice. Then the activities can be altered to align with the EAC with follow-up assessment to compare it with the results of the initial set of data. Data could be collected through observation of the methods course activities, interviews with methods instructors and PTs, and observation of PTs in the field. These types of data collection would be conducted before and after applying changes to the activities to make sure that they include the three components of the EAC.

The last chapter of this dissertation, Chapter 7, provides an example of how the results of this study can be applied to the development of a secondary mathematics course syllabus and an activity assessment tool.

Chapter 7. Methods Course Syllabus and Activity Assessment Protocol

The purpose of this chapter is to provide a model for developing a reform-oriented secondary mathematics methods syllabus based on the findings from this dissertation study, and to demonstrate the use of the Effective Activity Cycle (EAC) as a framework for developing and assessing lessons and activities. The issues that need to be considered when developing a methods syllabus concern not only content but also include pedagogical decisions.

Secondary-level mathematics teachers need to learn more information and skills than a single course or academic program can address. A methods course syllabus needs to include content and pedagogy that model reform-based teaching as well as provide training to enhance PTs' ability to self-assess and initiate changes in their teaching practice. Other factors, that should be considered when developing methods course syllabi, are endemic to particular institutions. One such factor is how the methods course is situated within the teacher education program (TEP). This includes expectations for course content (what is and is not covered in other TEP courses) that align with program-wide objectives. Other systemic factors are the length of the course (number of semester or quarter hours) and integration with student teaching and field experiences, with some methods courses taught concurrently with student teaching while others precede field experience. Since systemic issues are dependent upon the institution, they will not be addressed in the syllabus developed for this dissertation. Only those factors that can be generalized across programs and institutions are included. The overview of objectives, expectations, learning goals, and assessment protocol that make up this syllabus provide a foundational tool that can be adapted and expanded upon by a broad range of secondary mathematics methods courses.

The data, summarized in the case study analysis chapter, indicated four general conclusions: Field-based activities were perceived by participants as more *effective* for challenging PTs' beliefs, enhancing their conceptual understanding of the math they will be teaching, and developing PCK than the *classroom-based* activities. Although algebra is considered the most important mathematics strand to focus on during methods course work, the majority of the participants suggested that math concept emphasis should be drawn from the PTs' immediate needs and interests, as this tends to produce the highest motivation. Peer teaching and unit planning were the most widely applied activities used by the participants in this study. There were 54 activities described in the syllabi and interviews and 20% addressed all three goals derived from the literature review.

The *effectiveness* of the activities was an issue addressed in the cross case analysis chapter. As a result of this analysis, an EAC was developed. This cycle indicated that the activities designated as *effective* by participants for challenging PTs' beliefs about teaching and learning mathematics had three components in common: (1) PTs were involved in articulating research questions; (2) they collected and analyzed data; and (3) they put the findings into action to enhance their teaching.

To develop a syllabus, the results of the case study and cross case analysis were framed within Wiggins and McTighe's (1998) performance-based syllabus model as detailed in their book, *Understanding by Design*. This model offers a set of stages for designing performance-based instruction and assessment, and includes criteria for developing the essential questions that constitute the course objectives. Supplementing this model, Taylor and Nolen (2005) offer insight concerning the structure of activities that enhance the learning experience and provide suggestions for incorporating validity and reliability into the assessment tools. These two sources provide a framework for applying the goals derived from the literature review, data analysis results from the case study, and the EAC determined through the cross case analysis.

The chapter is divided into four sections. The first section details the criteria for choosing a performance-based syllabus design by comparing it to a more traditional, content-based model. The second section provides a synopsis of the research results of this study reorganized and framed within Wiggins and McTighe's (1998) performance-based design model. The third section illustrates how the EAC can be used to enhance previously used activities and develop new ones. And, finally, the fourth section summarizes the chapter, providing suggestions for how this syllabus can be adapted and used by both experienced methods instructors and those new to the profession of educating secondary mathematics teachers.

Criteria for Choosing a Performance-Based Syllabus Design Model

Syllabi can be designed using numerous techniques (Casella, 2005; Davis, 1993; Sinor & Kaplan, 2005). However, the vast majority of resources concerned with syllabus design provide content and organization of the document with little or no suggestion concerning course organization and development. Since the syllabus is a reflection of the course design, it acts as a tool for communicating the instructor's expectations to the students. Therefore, rather than provide the details or content structure, this chapter details the course design process which needs to be communicated through the syllabus document. Most course design models can be categorized as either traditional or reform based. These two broad course design model categories are discussed and compared here.

The more traditional design model is based upon delivering a "canon" of knowledge. Traditional teaching methods include lecture and teacher-directed instruction where students are expected to memorize vocabulary and practice specified solution strategies. The traditional methods are referred to as a content-based design model. Content-based design has three distinct stages. The first identifies the course content and sequencing which is usually defined by the choice of text. This is followed by the development of units and lessons which include the selection of activities. The final stage is the development of tests, quizzes, projects, etc. that provide evidence of students' knowledge and skills. This course design model tends to be used when learning facts or a canon of knowledge is the main objective.

An alternative design model is a student-centered approach where students are encouraged to share their understanding and learning new material is inquiry-based with the instructor acting as a facilitator. This alternative teaching method is referred to as a performance-based design model. Performance-based curriculum design is applicable when conceptual understanding, critical analysis, and application standards are emphasized. Performance-based design also includes three distinct stages; however, these stages are in a reverse order as compared with the content-based design described in the previous paragraph. The first stage of a performance-based design, as suggested by Wiggins and McTighe (1998), is to "identify the desired results," determining what is worth knowing, what is important for students to be able to do, and what are the "enduring understandings" at the core of the course (pp. 9-12). This means developing course objectives based upon the desired performance outcomes. At the second stage, Wiggins and McTighe suggest that the instructor think in terms of the "collected assessment evidence needed to document and validate that the desired learning has been achieved" (p.12). This second stage is when the sequencing of the course is determined. These first two stages act as a lens or filter for "planning the learning experiences" which constitute the final stage of the Wiggins and McTighe syllabus development method (p. 13). It is during the final stage that the instructor designs and chooses activities and selects curricular materials that support the learning process.

The skills and knowledge that tend to be the main foci for a secondary mathematics methods course, as determined by the evidence from the case study data, are included in the category called pedagogical content knowledge (PCK). According to the participants in this study, the case study analysis indicated PCK skills were most *effectively* learned and applied when grounded in field-based activities. This suggests that PCK is more appropriately aligned with a performance-based course design than with a content-based model. In this chapter, a performance-based model is used to develop the course content and therefore needs to be reflected in the development of the secondary mathematics preservice methods course syllabus.

Table 8. Course Design Models Compared

	Performance-based model (Wiggins & McTighe, 1998)	**Content-based model**
Stage 1	Determine course objectives defined as performance-based expectations	Choose curricular materials which reflect course content and sequencing
Stage 2	Determine what constitutes acceptable evidence of the course objectives.	Choose and develop activities
Stage 3	Plan the learning experience by choosing the curricular materials and developing activities	Determine what constitutes the summative evidence of desired learning goals

Content- and performance-based syllabi design models are compared in **Table 8** showing the progression of the three stages for each model. Comparison of the two models indicates that the filter for choosing activities for a content-based course is based upon a canon of knowledge which is strongly influenced by the curricular materials. The filter for choosing activities for a performance-based course is developed through an analysis of the performance outcomes and is not applied until the end of the process. The performance-based filter is not only used to align activities but also acts as a lens for choosing curricular materials. **Stage 3** of the content-based model is in effect **Stage 1** of the performance-based design. In essence, content-based design starts with a canon of knowledge and curricular materials, ending with assessment, whereas the performance-based model starts with assessment goals and ends with the choice of activities and curricular materials.

A Secondary Mathematics Methods Course Syllabus

The literature review chapter indicated three goals that should be addressed when developing a secondary mathematics methods course. These goals were: (1) challenge PTs' beliefs about teaching, learning, and what it means to know and do mathematics, (2) enhance PTs' conceptual understanding of the mathematics that they will be responsible for teaching, and (3) develop PTs' reform-based pedagogical content knowledge. These three goals were used in this dissertation as a framework for developing the content of the secondary math methods course which the syllabus is being designed to address. The matrix, displayed as **Table 9**, provides an organizational tool for developing the syllabus objectives, assessment protocol, and choice of activities and curricular materials, with the literature-derived goals placed across the top row and the performance-based stages listed down the first column. The content that completes the matrix is taken directly from the goals derived from the literature review and the data collected through the case study analysis. The three stages of development of this secondary math methods syllabus are detailed here.

Table 9. Syllabus Development Matrix

Performance-Based Model	**Challenge PTs' Beliefs**	**Enhance Conceptual Understanding of Mathematics**	**Develop PTs' Pedagogical Content Knowledge (PCK)**
Stage 1 *Course objectives defined as performance-based expectations*	Understand that teaching is a complex process Consistently self-assess Develop a support network	Create and implement a system for enhancing their understanding of the mathematical concepts they will be responsible for teaching.	Implement inquiry lessons and discourse methods Examine multiple assessment methods Develop a working understanding of how classroom norms and expectations affect learning Maintain high expectations for all students
Stage 2 *Acceptable evidence of performance results*	Professional growth plan Teaching philosophy	Mathematical concepts portfolio	Unit plan includes assessment protocol and lesson plans Classroom management plan
Stage 3 *Planning the learning experiences*	Case studies and vignettes	Curriculum analysis Analyze, evaluate, and critique the math being taught in cooperating schools	Develop, analyze, critique and revise lessons, unit, and assessment tools Examine and analyze student work Design and conduct student interviews Peer teaching Video-record and self-evaluate teaching practice

Stage 1. *Course objectives defined as performance-based expectations*

The first stage of Wiggins and McTighe's (1998) design model suggests the development of course objectives based upon intended performance outcomes. The literature-derived goals are elaborated to align with what Wiggins and McTighe call "enduring understandings" (pp. 9-12), and are re-written as the *Course Objectives* (**Table 9**, row 2). The eight course objectives span the three literature-derived goals, articulate the "enduring understandings," and provide a foundation upon which PTs can develop their teaching skills.

Under the first goal, *Challenging Beliefs*, the literature indicated that the complexity of teaching for understanding was not fully realized by PTs when they first entered a TEP. This was due in part to their personal experiences as students in content-based courses, where procedures are demonstrated, students are expected to duplicate prescribed steps, and teachers work mostly isolated from their colleagues. Performance-based teaching challenges this vision of teaching and learning; encouraging teachers to work collaboratively to enhance their teaching skills, developing their ability to analyze student understanding of mathematical concepts, and improving the reliability and viability of their assessment methods (Taylor & Nolen, 2005). Under this theme of challenging PTs' beliefs, performance outcome expectations are that PTs' will understand that teaching is a complex process. This means that PTs need to consistently self-assess their teaching and apply what is learned to improve their practice. This cannot be adequately accomplished in isolation; therefore, PTs need to initiate the development of a support network that will help them to further enhance their professional teaching skills.

Under the second goal, *enhancing PTs' conceptual understanding of* mathematics, PTs should be able to demonstrate that they can create and implement a system for enhancing their understanding of the mathematical concepts they will be responsible for teaching. This goal indicates that PTs need, throughout their teaching careers, to work to develop a deeper understanding of the mathematics they are expected to teach.

Finally, to satisfy alignment with the third goal, *developing PCK*, PTs need to understand how to implement inquiry lessons and use discourse methods for teaching mathematical concepts as a foundation for developing their students' procedural and conceptual understanding of mathematics. PTs must demonstrate that they can develop, implement, and examine multiple assessment methods to better understand what their students know and are able to do. PTs also should demonstrate an understanding of how classroom norms and expectations affect learning, and implement that knowledge in a secondary classroom. And finally, PTs must maintain high expectations for all of their students, while supporting their students' personal needs and aspirations.

Stage 2. *Acceptable evidence of performance results*

The second stage of Wiggins and McTighe's design process is to determine what will be accepted as evidence of PTs' learning (**Table 9**, Row 3). Taylor and Nolen (2005) expand on this idea, suggesting that the instructor needs to make "reliable" decisions that are "valid" given the time restraints available for assessment and the limitations of observational data and personal judgment. This means taking steps to ensure the "validity and reliability" of the assessment methods and tools. Reliability means being able to make dependable statements concerning what has been learned in relation to the goals and objectives, ensuring that the PTs are aware of the expectations of the assessments, and that the assessment practices are consistent across students and over time. To address reliability, rubrics need to be established that clearly delineate standards for preservice, novice, and professional levels of development. These expectations should be introduced at the beginning of the course, with the PTs responsible for providing the evidence of their level of competency based upon those standards. These standards should align with expectations for each of the three levels of achievement: preservice, novice, and professional, with the preservice standards aligned with the state certification process (OSPI, 2004a). Novice standards indicate an intermediate level, whereas professional standards should align with national or state expectations for professional certification (NBPTS, 2004). Development and alignment of these standards are beyond the scope of this study; however, they are important and should be developed as an integral aspect of the assessment tools.

Validity refers to how well the assessment tools (a) "draw out learning," (b) "fit with [the] educational context and instructional strategies used," and (c) align with "what occurs as a result of assessment" (Taylor and Nolan, 2005, p.20). These issues of validity are taken into consideration when choosing the assessment tools for the syllabus. The assessment tools listed for **Stage 2** in **Table 9** not only provide evidence of what the PTs know and are able to do as they progress through the methods course, they also can be utilized throughout the PTs' secondary mathematics teaching careers. For example, the professional growth plan and teaching philosophy statement provide evidence of the PTs' beliefs and their ability to challenge those beliefs. The mathematical concepts portfolio documents the PTs' growing understanding of the mathematics concepts they will be expected to teach. Unit plans and a classroom management plan are important field-based assessment tools documenting the on-going development of PTs' PCK. The expectation is that these instruments will evolve as the PTs progress through student teaching, providing evidence for initial state certification and beyond to professional certification in alignment with Washington state's performance instrument (OSPI 2004) and the national professional teaching certification (NBPTS, 2004).

Stage 3. *Activities, lessons, units, projects, etc.*

The activities and curricular materials drawn from the data and included in **Stage 3** of the *Syllabus Development Matrix* (**Table 9**, row 4) are representative of the effective activities indicated in the case study analysis chapter. As suggested by the cross case analysis, the activities need to be structured so that they align with the Effective Activity Cycle (EAC) which has three components: (1) identification of an issue or dilemma, (2) data collection and reflection, and (3) critical analysis and action (Chapter 5, **Figure 2**). The list of activities provided in the matrix is not comprehensive, but rather suggests activities that align with each theme. For example the activity listed under *Challenging PTs' Beliefs*, case studies and vignettes might include readings or video clips from *TIMSS* & *Learning Gap* or PTs' personal experiences. To align with the EAC, PTs would need to share, analyze and critique what they have read or observed to inform their Professional Growth Plan and Teaching Philosophy.

Under *enhancing conceptual understanding of mathematics*, the two activities included are curriculum analysis and having the PTs analyze, evaluate, and critique the math being taught in cooperating schools. The data collection component of the EAC is field-based, with PTs collecting and analyzing curricular materials used in the local schools. The PTs use this data to determine the big ideas and concepts, distinguish between procedural and conceptual understanding, and discuss what students are struggling with, analyzing their students' different cognitive levels of understanding. This informs the PTs' Mathematics Concept Portfolio as well as their lesson and unit plans. The last goal, developing PTs' PCK, is the most comprehensive, listing five activities: develop, analyze, critique, and revise lessons, unit, and assessment tools to be used during student teaching; examine and analyze student work, determining the types of assessment tools that answer the question: What do students know and what are they able to do?; design and conduct student interviews to assess student understanding of math concepts, to analyze multiple assessment formats, and understand how equity issues relate to student achievement; peer teaching to enhance peer-assessment skills; self-evaluation of teaching practice, which might include video-recording of instruction. The activities chosen for this syllabus are designed within the framework of the Effective Activity Cycle (EAC) developed in Chapter 5 of this dissertation. This cycle has the PTs actively involved in all aspects of the learning process. PTs, with the instructor's guidance, develop questions, collect and analyze data, then critique the data, applying what is learned to enhance their teaching skills. This framework is explicitly taught as a means of self-assessment with the expectation that it will be used for on-going professional development throughout the PTs' professional careers.

Designing or Enhancing Activities

The Effective Activity Cycle (EAC) offered a framework for analyzing existing activities or designing new ones. For example, one of the activities suggested for a methods course was to have the PTs develop a math unit that they can use during their student teaching experience. This section includes a unit plan for designing a secondary level math unit that includes all the components of the EAC.

All the participants in this study mentioned unit planning as an activity; however, most of them did not believe it was very effective for challenging PTs' strongly held beliefs about teaching, learning, mathematics, and pedagogy. Some said that they were actually disappointed in the results which indicated that, even after the methods course had focused lessons emphasizing conceptual understanding and had modeled inquiry style lessons, their students developed very traditional lessons and units. Examination of the syllabi and interviews indicated that the unit planning activities for the most part were done on an individual basis with little or no input from their peers or the instructor during the planning process. Of all the participants, only Kim mentioned that the unit plan as effective.

Kim's unit plan activity was an interactive team project that spanned two semesters. Kim had her students start the project during the semester prior to student teaching and integrated the development of the unit during the student teaching experience. Although other methods courses did not have the same integration of field and academics, Kim's model, when examined through the framework of the EAC, is adaptable to other institutions. During the semester prior to student teaching, Kim's students research different unit planning design models. Kim is not as interested in whether they can write a unit plan that follows a particular model, as whether her students are able to validate their reasoning and choices.

The other methods courses described in the case study did not have the extended time frame that Kim had with her students. However, examined through the lens provided by the EAC, her activity can be modified and still maintain the important aspects of the cycle that appear to make it successful. The EAC's first component is to identify an issue. Kim's activity was structured in such a way that it encouraged the PTs to develop an understanding of various unit and lesson planning models prior to their full-time student teaching experience. This discussion of the merits of different plans and design process models was the initial stage of the project. This initial stage provided the PTs with an opportunity to identify and critique how the design phase of unit planning was related to their teaching philosophy. It also helped the PTs develop critical analysis skills in that they were expected to communicate how their lesson plans illustrated what they had learned, citing the different unit planning design models.

The next lesson in the project was to develop a unit plan they could use during student teaching. PTs were assigned to teams based upon the subject they planned to teach. For a more generalized activity format, PTs could self choose the subject-matter based on what they anticipated having to teach or discuss the issue with their cooperating teachers to identify a reasonable unit topic. The teams were comprised of PTs who would be teaching the same content focus at different schools. This provided an opportunity to collect and examine the various curricular materials from across the district. The various unit plan design models and the collection of curricular materials offered the PTs a broad choice and stimulated discussion amongst the team members who would be presenting this unit at their various schools; therefore it was a collaborative activity that integrated classroom and field.

After the unit plan was created, there was a third distinct activity where the PTs collected feedback from their cooperating teacher (CTs), their peers, and their methods instructor. The expectation was that the suggestions would be used to revise the unit prior to presenting it to students. The PTs shared the lesson plan with their CTs and revised the unit as a team effort. Then the PTs collaborated with team members to present micro lessons to their peers. These lessons were drawn from the team's unit plan. The peer and instructor responses to the micro lesson were then incorporated into the unit, prior to implementing the unit plan in the public schools.

The last activity of the project was to present the unit in their CTs' classrooms during student teaching. The final write-up was done individually in response to student outcomes.

Lesson plan for designing a secondary level math unit

To summarize, using Wiggins and McTighe's (1998) design model, the first stage of a methods course unit focused on teaching PTs how to develop a secondary math unit, would be to identify the unit objectives based upon the desired results. This would be to have PTs design a secondary math unit plan focused on a math concept and teach that unit in their cooperating teacher's classroom. The second stage is to determine what would constitute acceptable evidence that PTs had met the objectives. This would be the completed unit plan, which would include fully designed lesson plans, justification of the lesson and unit planning model, and an assessment protocol. The third stage of Wiggins and McTighe's model is to plan the learning experiences.

Using Kim's project, I chose to include her activities in this stage of the methods course unit: understanding various unit planning models; developing a secondary math unit based on a particular concepts as a team activity; revising the unit based on CT, peer, and methods instructor feedback (which includes a CT interview and peer teaching.)

The first lesson, examination of a number of lesson/unit planning models, would be done prior to full-time student teaching. When PTs design a lesson, they are asked to justify their design model, citing specific model criteria. Lesson two would commence once the PTs are given their student teaching assignment. They would then identify a math concept that they will be teaching during their placement. The PTs would then be assigned to a team. Each team would bring in the curricular materials available to them at their teaching location. The teams discuss the plan objectives and decide upon a plan model. They need to justify the model based upon their teaching objectives. Once they have done so, they collaborate to develop a unit plan that can be used by all the team members. For lesson three, each team member chooses an activity from their unit. They discuss the unit plan with their cooperating teacher, collect recommendations, share these with team members and together revise the unit. Each PT creates and presents a micro lesson from their unit plan which allows them to collect peer and instructor feedback to further refine the unit. The fourth and final lesson of the methods unit would be the final presentation of the math unit to students at the public school, which would be followed up with a collection of student work. The concluding aspect of this multi-staged activity is when the PTs write a summary of how the presentation of the unit went and any changes they would make based on student outcomes.

Identifying the aspects of an activity that align with the stages of the EAC is important for determining the likelihood that that activity will be effective. The majority of the participants in this study, as described in Chapter 4, had their students develop unit plans. However, the results of the activities did not meet the expectations of the instructors. The *lesson plan for designing a secondary level math unit*, as described here, illustrates how an activity can be adapted to include all the stages of the EAC.

Chapter Summary

Since it is not plausible to expect that everything a teacher needs to know and be able to do can be taught and learned within the finite bounds of an academic course, the EAC provides the framework by which the PTs can continue the learning process into the future. PTs within a class progress at their own pace and may very well be at different levels of development upon their completion of the course. However, the course objectives do not provide the PTs with a canon of knowledge but rather with the performance expectations that they will continue to challenge their beliefs, enhance their understanding of mathematics, and develop their pedagogical content knowledge throughout their teaching careers. This means developing their skills of self-assessment, collaboration, problem solving, critical analysis, communication and listening. It also means that the PTs will continually work to enhance their understanding of mathematics and developing their knowledge about students, teaching and learning.

The syllabus and unit plan discussed in this chapter can be expanded to cover a full year or aspects can be applied to keep it brief enough for a single quarter-length course. It is flexible enough to be used with PTs who are presently involved in student teaching, working intermittently in the field or prior to practicum experiences. When developing the standards-based performance rubric, the first level of the rubric should align with the state certification standards for beginning teachers (OSPI, 2004a) so that the assessment tools, as described in **Stage** 2 of this syllabus, can be used as evidence that the PTs are ready to begin their teaching careers. Likewise, the national and state professional standards (NBPTS, 2004) need to be addressed in the rubric to indicate the expert level that the PTs are aiming for as they develop and enhance their teaching skills throughout their careers. The rubric needs to be designed to reinforce the notion that teaching is a complex profession and that graduating from a teacher preparation program is not the end, but rather the beginning of their professional development as secondary mathematics teachers.

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Appendix A

This is the Interview Protocol in the format sent to instructors prior to the actual interview. Probing questions developed as a result of examination of the syllabi and follow-up questions that naturally developed over the course of the interview were unique to each participant.

Interview Protocol

This will be a 30-40 minute interview depending upon the length of your responses. I have looked over your syllabus and have a few questions.

1. **What are the goals you have for your course?**
   Probe concerning content, pedagogy, teacher beliefs
   a. Tell me about goal …

2. **Is this methods course part of a series? _________ (or I noticed in the syllabus that this methods course is part of a series.)**

   If yes, **are you responsible for teaching the entire series? ________**

3. **What do you consider to be the main content focus for this course/series?**
   Probes—check syllabus and choose probes that clarify areas that may not be explicitly described in the syllabus

   a. How would you describe your students' level of content knowledge?

   b. Is there a particular area of mathematics that you focus on for this methods course/series?
   Algebra Geometry Statistics/Data Analysis Calculus
   Number Sense Measurement Other _________________________

   c. Why have you chosen the strand you mentioned (or suggested in the syllabus)?

   d. How do students approach_______________, what do they learn?

4. **How do you think teachers learn?**
   Probes
   a. The research literature seems to indicate that student teachers come into our methods courses with preconceived ideas about teaching and learning mathematics. Have you found this to be true? And if so, what pedagogical methods do you use in your course to challenge their beliefs?

b. From your syllabus, I noticed that you use _______(pedagogical methods). Please tell me about it.

c. What other pedagogical methods do you use? And, please explain your motives for using them.

d. Some of the research literature suggests that student teachers learn best when that learning is grounded in practice. What methods do you use in this course that you feel ground the learning experience in practice?

e. How do you use these methods and what do your students learn?

5. What assessment and planning methods do you cover in this course?

Probes

a. Why do you emphasize these methods?

6. **In a previous question I asked you about student teachers' preconceived ideas about teaching and learning. This can include preconceived ideas about mathematics, about pedagogy and about teaching and learning in general. How do you see these needs being addressed in your methods course and in other aspects of the teacher education program?**

Thank you for your participation. If you have a few more minutes I have some very short biographical questions to ask you. (*If not*, can I send you these questions by email?)

Teaching background

7. What types of secondary mathematics teaching experience do you have?

YEARS:	0-2	2-5	5-10	10 or more years
Small group or individual tutoring sessions				
Substitute teacher				
Part time teaching				
Full time teaching				

Other: ____________________

8. What levels of mathematics have you taught?

YEARS:	0-2	2-5	5-10	10 or more years
Elementary level				
Middle school or junior high school level				
High school (not including calculus)				
College level (calculus or above)				

Other: ____________________

9. What types of teacher education teaching experiences do you have?

YEARS: 0-2 2-5 5-10 10 or more years

Elementary math methods

Secondary math methods

Other education courses: (Please describe and give number of years)

____

Relationship to institution—Please check appropriate boxes for the following:

10. How many years have you taught at this institution?

0-2 2-5 5-10 10 or more years

11. How would you classify your position at this institution?

Part time adjunct professor/lecturer/instructor

Full time adjunct professor/lecturer/instructor.

Non-tenure track fulltime professor Tenure track professor

Other: ____

12. How many years have you taught this particular methods course (or similar methods courses)?

YEARS: 0-2 2-5 5-10 10 or more years

Information about this particular methods course—Please respond to the following:

How many students are attending this course?

1-5 5-10 10-15 15-20 20-25 over 25

Is this typical? __________

If no, please indicate the number of students normally attending this class and explain why this group is not representative of that norm.

Again, thank you for your time.

Vita

Andrea S. Levy was born in Montreal, Quebec, Canada. She has lived in many places throughout the United States and Canada. After settling with her husband and two sons in Redmond, Washington in 1984, she attended Bellevue Community College where she earned an Associate of Arts Degree. Upon graduation, she transferred to the University of Washington where she earned a Bachelor of Arts Degree in mathematics and physics, and a Master of Education Degree specializing in secondary level mathematics. The following four years, she worked as a mathematics teacher at Evergreen Junior High School and Redmond High School in the Lake Washington School District. She then returned to the University of Washington as a doctoral student, while working in numerous education-related positions: part-time as a substitute and summer school teacher at local junior and senior high schools, and adjunct professor, preservice teacher supervisor, and teaching assistant at the university level. In 2005, she earned a Doctor of Education Degree in Curriculum and Instruction, with an emphasis in secondary mathematics teacher preparation. Today, Andrea S. Levy is a tenure-track mathematics faculty member at Seattle Central Community College where she teaches mathematics and is developing a mathematics program for prospective teachers.