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AN ELEMENTARY MATHEMATICS METHODS COURSE
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PRESERVICE TEACHERS' BELIEFS ABOUT
MATHEMATICS AND MATHEMATICAL PEDAGOGY:
A CASE STUDY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by
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****

The Ohio State University
1999

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ABSTRACT

Research suggests that a necessary condition for elementary teachers to provide mathematical environments envisioned by the NCTM Standards is for those teachers to hold beliefs consistent with the Standards' recommendations. However, research shows that many teachers hold beliefs orthogonal to those messages. Because preservice teacher education provides an extended opportunity to have an impact on teachers' mathematical beliefs, it is vital to organize programs toward maximizing that impact. It is particularly vital to consider the role, structure, and pedagogy of mathematics methods courses: the most likely venues in which both mathematics and its pedagogy can be examined.

Toward addressing such considerations, this study used the experiences of three preservice elementary teachers in their mathematics methods course and concurrent field experiences to find factors that may have influenced their beliefs about the nature, curriculum, learning, and teaching of elementary mathematics. A case study design was implemented, in which key informants were interviewed and non-participant observations of the course and field experiences were made. Data analysis was performed using the constant-comparative method in detecting alterations of beliefs and potential factors toward the (non)-alterations.

It was found that the three interns' stated beliefs changed little over the quarter, with the exception of the pedagogical beliefs of one intern who entered the course with a
reflective pedagogical disposition and had a field experience compatible with the course. Potential factors toward the lack of belief change included the interns' lack of reflective dispositions, their complacency with their mathematical subject matter and pedagogical content knowledge, the course's lack of requirements to reflect on experiences, the course’s implicit messages that were contrary to its intended messages, and the lack of connection between course and field experiences.

Recommendations for teacher education programs include the implementation of mathematics content courses that address interns' beliefs about the nature of mathematics prior to the methods courses, education courses consistently encouraging reflection and the valuing of theory, methods course tasks centered on debates and reflection on model and personal teaching experiences, qualified cooperating teachers and environments, and preparation for course instructors. Sample syllabi are included.
ACKNOWLEDGMENTS

This endeavor would not have been possible without the assistance and support of many people.

Professionally, I would like to thank my committee members, Dr. Mary Ellen Schmidt and Dr. Betsy McNeal for their kind and constructive comments. I especially thank my adviser, Dr. Sigrid Wagner, who graciously allowed me back in the program after my hiatus, expertly guided this study by forcing me to stick to the purpose at hand, and deftly led me to a whole new level of writing. If the reader can find coherence in this document, it is thanks to Dr. Wagner!

I also thank my former advisers, Dr. Marilyn Suydam and Dr. Lorren Stull, for without their help and support of my interest in mathematics teacher education, this study would never have gotten off the ground. Others who have guided this study to fruition include Dr. Patricia Brosnan and Dr. Richard Shumway, the latter whose unique point of view of mathematics education opened my mind to new and unanswered questions.

I also would like to thank Dr. Marty Hartog, Dr. Joe Kunicki, Dr. John Drury, and Dr. Jeff Smith for their help and friendship throughout our days in the doctoral program.
Finally, I would like to thank the instructor of the methods course, the cooperating teachers, the field supervisors, and especially the three preservice teachers who gave their busy time to open their classrooms and minds for the sake of improving mathematics teacher education.

Personally, I thank my parents David and Lois Ferdinand who have supported me from day one with their hard work, sacrifice, and love. I also thank my grandmothers, Estella Ferdinand and Madeline Gallagher for their perpetual loving kindness. I truly wish that my grandfathers Paul Ferdinand and Harry McAnaney and step-grandfather Bob Gallagher could also be here to share in this accomplishment. I hope I did them proud.

Last, but certainly the greatest, I thank my wife Lori and my children Michelle, Matthew, Neil, and Nathan, for giving up so much of their lives so that I could complete this ordeal. It is with sadness that I recall the many times I could not be with my family doing family things like playing catch, going on vacations, or working on school projects because I was busy with this book. I especially thank four-year-old Nathan, who endured many trips to and meetings at "Daddy’s stupid school."
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FIELDS OF STUDY

Major Field: Education
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CHAPTER 1

OVERVIEW

This study will explore the potential influence of an elementary mathematics methods course on three preservice teachers' beliefs about mathematics and its pedagogy through both the intended goals and activities of the course and the actual course experiences of the interns. A case study design will be implemented in which the interns will be interviewed before, during, and after the course to interpret the restructuring of their beliefs and their personal experiences in the course. The investigator will also interview key informants and serve as an observer in the course in a search for course factors that may influence the restructuring of the interns' beliefs. A theory of how subject-specific teacher education coursework interacts with interns' subject matter and pedagogical beliefs will be constructed for the purpose of making recommendations for the role, structure, and pedagogy of such coursework.

Background for the Study

Recent recommendations have called for all American citizens to be mathematically literate (National Council of Teachers of Mathematics, 1989; National Research Council, 1989). The National Council of Teachers of Mathematics (NCTM) has recommended that every citizen should have the ability to "explore, conjecture, and reason logically,
as well as the ability to use a variety of mathematical methods effectively to solve nonroutine problems" (NCTM, 1989, p. 5). Specifically, NCTM (1989) sets the following goals for all students: 

"(a) that they learn to value mathematics, (b) that they become confident in their ability to do mathematics, (c) that they become mathematical problem solvers, (d) that they learn to communicate mathematically, and (e) that they learn to reason mathematically" (p. 5). Toward these ends, NCTM (1991) has called for shifts in school mathematical environments:

(a) toward classrooms as mathematical communities - away from classrooms as simply collections of individuals; (b) toward logic and mathematical evidence as verification - away from the teacher as the sole authority for right answers; (c) toward mathematical reasoning - away from merely memorizing procedures; (d) toward conjecturing, inventing, and problem solving - away from an emphasis on mechanistic answer-finding; and (e) toward connecting mathematics, its ideas, and its applications - away from treating mathematics as a body of isolated concepts and procedures. (p. 3)

Recent reports, however, suggest that American students and schools are far from attaining the aforementioned goals. At the elementary, middle, and secondary school levels, a large percentage of students possess few mathematical abilities beyond those of performing rote-learned arithmetic and algebraic computations (Lindquist, 1988; McKnight et al, 1987; Stigler, Lee, and Stevenson, 1990). Relatively few students possess the ability to reason about a problem situation without the knowledge of a known formula (Lindquist, 1988).

Many mathematics educators (e.g., Hiebert, 1984; Porter, 1988; Stodolsky, 1988) blame this state of affairs in part on the typical elementary school curriculum in which mathematics is looked upon as a set of computational algorithms that should be learned through teachers' directions and practiced until they are mastered. These educators argue
that students educated in this manner will continue to be dependent on others for mathematical knowledge and possess a restricted view of both mathematics content and mathematical ways of knowing (NCTM, 1989, 1991; Putnam, Lampert, & Peterson, 1990).

A contributing factor to the current status of elementary school mathematics is the knowledge of mathematics and its pedagogy (McDiarmid, Ball, & Anderson, 1989; Shulman, 1986) held by elementary school teachers. Research results indicate that many preservice and inservice elementary teachers are lacking in knowledge about specific mathematical concepts (e.g., Ball, 1988a; Tangretti, 1994; Zazkis & Campbell, 1996). Perhaps more importantly, many teachers also hold traditional beliefs about what mathematics is as well as why and how it should be taught and learned in elementary school (e.g., Ford, 1989; Good, Grouws, & Mason, 1990; Peterson, Putnam, Viewdeoogd, & Reineke, 1992; Sherman & Richardson, 1995).

Evidence is mounting that a teacher's beliefs about a subject and its pedagogy are major influences on what and how mathematics is portrayed in that teacher's classroom (e.g., Knapp & Peterson, 1991; McDonnell, 1990; Raymond, 1997; Thompson, 1984). Although the nature of those influences is still in question, it appears that a necessary condition for a teacher to provide and maintain a Standards-based environment is to hold corresponding beliefs (Hannaford, 1992; Jaworski, 1992; J. E. Schwartz & Riedesal, 1994). Thus, many mathematics educators have asserted that for reform of mathematics education to have a reasonable chance of becoming a reality, teachers' beliefs need to be
taken into account and adjusted toward beliefs conducive to the NCTM position (e.g., Battista, 1994; Cooney, Grouws, & Jones, 1988; Silver, 1985; J. P. Smith, 1996).

There are four major phases in which a teacher's beliefs may be formed, strengthened, or restructured (Feiman-Nemser, 1983): (a) pretraining (coursework before entering a formal teacher education program), (b) preservice (the teacher education program), (c) induction (the first few years of teaching), and (d) inservice (the remainder of the teaching career). Recent research results suggest that students' beliefs about mathematics and its pedagogy are largely a function of how the students experience mathematics in their courses (e.g., Cobb, Wood, & Yackel, 1992; Lester, Garofalo, & Kroll, 1989; Schoenfeld, 1985, 1988, 1989; Underhill, 1988). This suggests that, because of the typical portrayal of mathematics as rotely-learned computational skills taught in a teacher-centered environment, most prospective teachers will form traditional beliefs through their observations and experiences as students (Broekman & Weterings, 1987; Lortie, 1975).

Also, recent results on inservice education indicate that, because of the traditional beliefs and expectations about mathematics prevalent among colleagues, students, parents, district officials, and themselves, it is difficult to restructure induction or inservice teachers' beliefs without strong interventions with sustained support (e.g., Carpenter et al, 1989; Grant, Peterson, & Shoigreen-Downer, 1996; Maher & Alston, 1990; Peterson, McCartney, & Elmore, 1996; Wilcox et al., 1992; Wood, Cobb, & Yackel, 1990).

The remaining venue for affirming or restructuring teachers' beliefs about mathematics and its pedagogy is during the preservice teacher education program. Here,
interns have an opportunity to experience mathematics and be exposed to mathematical pedagogy both as learners and teachers by people (such as mathematics educators) who hold beliefs similar to those advocated by NCTM (American Mathematical Association of Two-Year Colleges [AMATYC], 1995; Mathematical Association of America [MAA], 1991; NCTM, 1991, Texas Statewide Systematic Initiative [Texas SSI], 1997).

However, not much has been documented about what goes on with respect to mathematics in the various components of a teacher education program (content courses, professional courses, field experiences, and practicum). In particular, not much is known about the content and activities provided to and experienced by interns in elementary mathematics methods courses, which are usually the only courses in preservice programs where the curriculum and pedagogy of elementary school mathematics is emphasized (Ball, 1990; Green, 1981; Phillips & Uprichard, 1989). Specifically, little is known about what factors in such courses work toward or against influencing interns' beliefs about the nature and pedagogy of mathematics (Brown & Borko, 1992; Ginsburg & Clift, 1990; Wilson & Ball, 1996; Zeichner & Gore, 1990).

In light of the previously discussed importance of beliefs in teachers' decisions and actions about mathematics as well as the opportunities that preservice teacher education has for restructuring these beliefs, it is essential that knowledge about elementary mathematics methods courses be compiled that will enable educators to better construct such courses and programs to optimize the impact on interns' beliefs about mathematics and its pedagogy.
As a contribution to this compilation, this study is an endeavor to (a) describe an elementary mathematics methods course, (b) examine and describe three interns' experiences with the course, (c) examine and describe how the interns' beliefs did or did not change during the course, and (d) search for factors that may have influenced those (non-) changes.

Statement of the Problem

The purpose of the current study is to construct a theory of the interactions of elementary mathematics methods courses with preservice teachers' beliefs about mathematics and its pedagogy. Specifically, the study will explore the following questions:

1. What are three preservice elementary teachers' beliefs about the following at the beginning and end of an elementary mathematics methods course and field experience: (a) the nature of mathematics, (b) mathematics in the elementary school curriculum, (c) teaching elementary school mathematics, and (d) how children learn mathematics?

2. What differences exist between their beliefs at the beginning and end of the course/field experience?

3. How do the three interns describe and interpret their experiences in the course/field experience from the perspective of their beliefs?

4. How do the interns' descriptions and interpretations of their course and field experiences compare to the goals and descriptions of the course instructor, field supervisor, and cooperating teachers?
5. What hypotheses can be made regarding which factors of the course/field experience or of the interns contribute to their beliefs and/or changes in their beliefs?
LITERATURE REVIEW

Theoretical Model

Beliefs

A consensus definition of beliefs has eluded philosophers, psychologists, and educators. Most agree, however, that beliefs are part of a person's cognitive domain (Fishbein & Ajzen, 1975; Green, 1971; Sigel, 1985). For example, Fishbein and Ajzen (1975) define a belief about an object (e.g., mathematics) to be "the subjective probability of a relation between the object of the belief and some other object, value, concept, or attribute" (p. 131). That is, one's beliefs about an object are those attributes, concepts, values, or other objects that he or she thinks are linked to the object in question. For example, one may believe that mathematics is an unchanging discipline (an attribute) made up of a set of unrelated rules and formulas (other objects) about arithmetic and algebra (concepts) that is only important for practical activities such as balancing a checkbook (a value). Beliefs may be held consciously or unconsciously and at varying degrees of commitment (i.e., the person's probability that a belief is true).
Green (1971) argues that beliefs are that part of one’s cognitive structure that does not contain the truth condition. That is, one can believe something about an object with or without it being true, but one cannot *know* that same thing about the object unless it is true.

An individual’s beliefs are said to be structured in such a way that there is a personal set of *primary* beliefs from which all other beliefs are derived in quasi-logical and psychological fashions (Green, 1971). That is, beliefs are not ordered in a logical fashion from the primary beliefs but are organized in a personal way according to what object(s) a belief is referring to, the origin of the belief, the strength of the belief, and how the belief is held.

Several authors hold that beliefs about related objects are held in clusters or schema (Abelson, 1979; Nisbett & Ross, 1980; Sigel, 1985) in which beliefs about one object (e.g., mathematics) may be related to beliefs about a similar object (e.g., mathematical pedagogy). Green (1971) argues that clusters can be highly independent from one another, leading to apparent inconsistencies in one’s thoughts. For example, one may hold economic beliefs that competition among humans is the best way for growth to occur, yet hold moral beliefs that cooperation among humans is the only way toward a peaceful world.

Within each cluster, beliefs vary in their origin (Fishbein & Ajzen, 1975; Green, 1971; Rokeach, 1975; Sigel, 1985). Fishbein and Ajzen (1975) argue that beliefs are either formed through direct experiences with the object of belief (descriptive beliefs),
acceptance of information from an outside source (informational beliefs), or through inferences from descriptive or informational beliefs (inferential beliefs).

Beliefs vary in certainty and strength according to their origin (Fishbein & Ajzen, 1975; Rokeach, 1975; Nisbett & Ross, 1980). Because a person’s interpretations of his or her own experiences are usually reliable to him/herself, descriptive beliefs are usually held with a high degree of certainty and commitment. Primary beliefs are usually descriptive in origin, forming from one’s early experiences with an object and serving as interpretive guides to future experiences (Rokeach, 1975; Nisbett & Ross, 1980). Informational beliefs are held with varying degrees of certainty and commitment, depending on one’s trusting of the source and/or compliance with one’s descriptive beliefs. These are sometimes the origin of primary beliefs. Inferential beliefs also vary in strength, depending on their relation with the beliefs they are taken from.

Beliefs are not only considered on their content, origin, or strength, but in how they are held. Green (1971) argues that some beliefs are held evidentially. That is, they are held because there exists rational evidence for them. These beliefs can be restructured if further evidence or rational criticism warrants the restructuring, although, depending of the strength of the beliefs in question, the person may transform conflicting evidence into support for the existing beliefs (Nisbett & Ross, 1980; Rokeach, 1975). Nonevidential beliefs are held as a matter of ideology with little chance of being restructured by affirming or conflicting evidence.
Changing Beliefs

Green (1971) argues that the activity of teaching can be looked upon as convincing a person what is reasonable to believe from the point of view of the experiences and evidence of mankind (e.g., what is known from research on learning mathematics) by leading that person to assess what is reasonable to believe from the point of view of that person's experiences and evidence (e.g., what that person has experienced in learning mathematics). That is, teaching is aimed at providing experiences that, with respect to the person's current beliefs, will enable the person to use evidence from those experiences to continue forming or restructure his or her beliefs toward what is reasonable to believe.

Green's conclusion is suggestive of a constructivist approach to learning. In that theory, a person's cognitive structures are developed through interactions between that person's environmental experiences and his or her existing cognitive structure (von Glasersfeld, 1988). Each new experience relating to a particular object is reflected upon and attempted to be assimilated into existing schemas (Orton, 1988). Therefore, a new experience with an object is attempted to be "fitted" into an existing structure and that structure changes as a result of the experience and the assimilation.

However, if an experience involving an object is incompatible with one's beliefs about the object to the extent that the experience cannot be ignored, resolved, or fitted into the existing structure, then the existing belief structure may be replaced or reorganized. Such an experience is called a perturbation; and the replacement or reorganization of beliefs about an object is called accommodation (Bettencourt, 1993; Posner et al., 1982; von Glasersfeld, 1987).
Beliefs about an object then, as part of one's cognitive structure, are formed and restructured (or replaced) through reflection upon one's experiences with and about that object along with one's existing structure. Therefore, to restructure or replace an intern's beliefs about mathematics and its pedagogy, one must take into consideration the intern's existing beliefs: their strengths, origins, relationships, and how they are held. Then, the teacher educator must formulate experiences that would provide evidence they could weigh against their prior beliefs and restructure (or replace) their beliefs with beliefs that might be closer to those considered desirable.

*Conditions required for accommodation: The Strike and Posner model.* Green (1971) argues that one's belief systems have the best chance to be altered if one has a holistic point of view about an object(s). That is, the person should have a minimal number of core beliefs, a minimal number of belief clusters, a maximal number of relations between the clusters, and a maximal amount of evidential beliefs in the system. Therefore, if one hopes to change a person's beliefs about mathematics and its pedagogy, it would be best if those beliefs about mathematics and its pedagogy are a connected whole that is known to the person and open to internal and external question (Green, 1971; Rokeach, 1975).

Although a teacher educator may not be able to control the connectedness and evidentiality of the belief systems preservice teachers bring to teacher education, the educator has an opportunity to make interns aware that they have beliefs and then call those beliefs into question through confrontational experiences. And it is this awareness
that is precisely the first step many researchers and theorists claim is the first step toward effecting change in beliefs (Bennett and Spalding, 1992; Korthagen, 1993; Pintrich, Marx, and Boyle, 1993).

Once a person is cognizant of his or her conceptions about mathematics and its pedagogy, these beliefs may now begin to be called into question for the person. Therefore, teacher educators can begin to provide experiences that may begin to alter a person's philosophy. However, simply providing experiences may not guarantee that the intern will eventually decide that the philosophy underlying the new experiences is better than what he or she believed before (Civil, 1993). Theorists argue that there are further conditions that must be met before accommodation can take place.

Posner et al. (1982) argue that, not only must a person be made aware of his or her beliefs, he or she must also be made dissatisfied with those beliefs. If one is satisfied with existing conceptions of an object, then he or she will attempt to interpret all situations to fit those beliefs, even those situations conflicting with the beliefs in logic, reason, and observation. This "assimilation at all costs" occurs to avoid the painful process of accommodation, in which existing (and familiar) beliefs must be discarded and one must regard the object with respect to a new paradigm and perhaps change other conceptions of related objects. However, if the person is not satisfied that his or her beliefs can explain an experience(s), then the person is forced to decide which model best represents his or her reality. Thus, accommodation can occur.

Within the process of becoming dissatisfied as the result of an anomalous experience(s), certain cognitive conditions must hold before a person finds the anomalies
uncomfortable enough to actually accommodate the new information. Posner et al. (1982) and Strike and Posner (1992) contend that a person must understand that the new information is an anomaly with respect to his or her existing beliefs. The person must also believe the new information must be reconciled with the existing beliefs (i.e., the person must have a reflective disposition and attempt to assimilate the new information). Third, the person must want to reduce inconsistencies among beliefs (see Pintrich, Marx, & Boyle (1993)). Finally, after trying to assimilate the new information, the person must consider the attempts unsuccessful, thereby leaving the person with no choice but to consider a new paradigm for thinking about the object.

Posner et al. (1982) and Strike and Posner (1992) further argue that, in order for a person to consider and accept a new paradigm that may replace his or her existing beliefs, the new paradigm must satisfy a number of other conditions within the person. First, the person must find the new paradigm intelligible. Second, the person must consider the new paradigm plausible for solving the problems presented by the experience(s) as well as make sense with respect to other beliefs the person may hold. Finally, the new paradigm must be seen as worthwhile for both overcoming the problem at hand as well as allowing new ways of looking at other objects and/or opening up new avenues of inquiry. This model of necessary conditions for the alteration of beliefs shall subsequently be called the Strike and Posner model (see Figure 2.1).

**Teachers' Beliefs About Mathematics and Its Pedagogy**

*Structure of teachers' mathematical beliefs.* Ernest (1989) argues that teachers' beliefs about mathematics and its pedagogy can be partitioned in a way similar to
Incoming Traits
Personal history, including:
1. Awareness of one's beliefs
2. Reflective disposition/ valuing of beliefs

Contradictory Experiences

Cognitive Actions via Reflection on Experiences
1. Recognize anomalies with existing beliefs
2. See need/motivation to reconcile experience with existing beliefs
3. Attempts to reconcile are unsuccessful
4. Need to consider alternative paradigm

Consideration of Alternative Paradigm
1. Paradigm must be intelligible
2. Paradigm must be plausible to explain experiences
3. Paradigm must be worthwhile toward achieving goals

Acceptance of New Paradigm

Figure 2.1: Strike and Posner Model for Belief Change
Shulman's (1986) breakdown of teachers' subject matter knowledge, with emphasis on content and pedagogical content knowledge. Ernest (1989) breaks down a teacher's belief system about mathematics and its pedagogy into beliefs about the nature of mathematics, beliefs about teaching mathematics, and beliefs about learning mathematics.

Beliefs about the nature of mathematics can be broken down into any number of categories, depending on the author (Ball, 1988b; Collier, 1972; Dionne, 1984; Ernest, 1989, 1991; Van de Walle, 1972). Ernest (1989) argues that each category belongs to one of three major philosophies:

First of all, there is a dynamic, problem-driven view of mathematics as a continually expanding field of human inquiry. Mathematics is not a finished product, and its results remain open to revision (the problem-solving view). Secondly, there is the view of mathematics as a static but unified body of knowledge, consisting of interconnecting structures and truths. Mathematics is a monolith, a static immutable product, which is discovered, not created (the Platonist view). Thirdly, there is the view that mathematics is a useful but unrelated collection of facts, rules, and skills (the instrumentalist view).

(16)

Both Ball (1989b) and Ernest (1989) argue that a teacher's beliefs about the nature of mathematics are part of the basis for his or her beliefs about how mathematics should be taught and learned. These pedagogical beliefs can be placed on a continuum ranging from a view that mathematics can be taught via problem solving and posing according to children's autonomous interests to a view that mathematics should be taught in teacher-controlled environments where children master skills and facts in a linear scheme (Ernest, 1989).

Ernest (1989) asserts that a teacher's beliefs about teaching and learning mathematics may also be influenced by his or her general principles of education. These include a
teacher's views of the aims, purposes, and nature of education. These principles may bring a teacher's beliefs about mathematics to be a combination of several of the models along the continuums listed above (Thompson, 1992). However, the influence of these principles on a teacher's models of teaching and learning mathematics depends on the extent of integration within and among one's belief clusters, as well as their relationship to the teacher's primary beliefs.

Status of preservice elementary teachers' mathematical beliefs. Although few generalizable studies have been done to ascertain the status of preservice elementary teachers' beliefs and knowledge with respect to mathematics and its pedagogy, the studies that have been reported have similar results. Unfortunately, for those desiring teachers to hold Standards-like beliefs, the strong beliefs of preservice elementary teachers mirror their often traditional experiences and are instrumentalist with respect to mathematics and behaviorist with respect to mathematical pedagogy. Interns often believe that elementary mathematics is a linear sequence of fixed arithmetic algorithms with problems consisting of one-step word problems and connections meaning practical applications (Ball, 1989a; Civil, 1993; Hau, 1993). They often view the process of learning mathematics as accruing facts and memorizing algorithms so they can quickly state and perform them and, if one uses manipulative materials in that process, that person does not understand mathematics (Civil, 1993; McDiarmid, Ball, & Anderson, 1988; Watanabe & Kinach, 1996). Finally, many interns consider a teacher of mathematics as a person who exhibits
the facts and skills to students in such a way that the students are neither bored nor frustrated (e.g., Civil, 1993; Holt-Reynolds, 1992; McDiarmid, Ball, & Anderson, 1988; Risacher, 1996).

The problem is compounded by the fact that these traditional beliefs often interact with weak mathematical content knowledge (Alexander & Dochy, 1995; Carpenter & Fennema, 1991; Schoenfeld, 1983), particularly conceptual knowledge of multiplication and division (Azim, 1996; Ball, 1988a; Simon, 1993; Tirosh & Graeber, 1990), decimals (Thipkong & Davis, 1991), area of rectangles (Baturo & Nason, 1996; Simon & Blume, 1994), geometry (Mayberry, 1983), zero (Wheeler & Feghali, 1983), number theory (Zazkis & Campbell, 1996), proof (Martin & Harel, 1989), and in general the domains deemed important by the Curriculum Standards (Dyas, 1993; Knight, 1993).

Thus, the preponderance of the evidence from studies involving preservice elementary teachers suggests that many people aspiring to teach elementary school mathematics have traditional beliefs about mathematics and its pedagogy as well as weak conceptual knowledge of mathematics. Mathematics teacher educators must find ways to work with these interns in developing Standards-like mathematical communities within our nation's schools.

**Barriers to changing preservice elementary teachers' beliefs.** Because many interns' beliefs about mathematics and its pedagogy are almost completely at odds with the vision of mathematics education presented by the Curriculum and Teaching Standards, it appears that for interns to have "Standards-like" beliefs, they must replace their current beliefs with new ones. Therefore, if a goal of teacher education is for teachers to have beliefs
congruent with those of the NCTM Standards, teacher educators must provide experiences that are perturbations with respect to interns' current beliefs so that accommodation has a chance to occur in the interns' minds (Edwards, 1994).

Providing perturbations that will result in the replacement of interns' traditional beliefs about mathematics and its pedagogy is a difficult and complex task for mathematics teacher educators. Many barriers exist to the goal of radically changing interns' beliefs with respect to the Strike and Posner model of change. These obstacles include strong traditional beliefs originating early in life, a lack of awareness of beliefs that hinders recognition of contrary experiences, an implicit satisfaction in their beliefs with a lack of motivation toward changing them, and a lack of a disposition to reflect on experiences.

First, interns' beliefs about mathematics and its pedagogy were formed through experiencing thousands of hours in traditional mathematical environments as students. These experiences, and thus the formation and structuring of their beliefs, began early in school and continued through high school or college (e.g., Brookhart & Freeman, 1992; Buchmann & Schwille, 1983; Holt-Reynolds, 1992; Lortie, 1975). Researchers and theorists agree that beliefs that are developed early in life and are affirmed throughout life are the strongest and, thus, the most difficult to overcome and alter (Nespor, 1987; Nisbett & Ross, 1980; Posner et al., 1982; Rokeach, 1975; Shealy, Arvold, Zheng, & Cooney, 1993; Sigel, 1985). The fact that interns have served many years as students gives their (implicit or explicit) beliefs and assumptions about mathematics education credibility in their own minds as they set out to become part of
that same system (e.g., Calderhead & Robson, 1991; Kagan, 1992a; O'Loughlin, 1990; Wilson, 1992). Even if they feel they received a poor education and want to provide a better one for their students, interns often have only those poor experiences to serve as a model for what mathematics education is (Civil, 1993; Raymond, 1997; Schifter & Fosnot, 1993). Pajares (1992) notes that it is easier to reshape the beliefs of students desiring to be in other professions (e.g., law or medicine) than those aspiring to be educators simply because students usually have not been on the inside of those other professions prior to college as preservice teachers have. Thus, their beliefs about other professions do not have the foundational strength developed over the years like the educational beliefs of preservice teachers. Indeed, Holt-Reynolds (1991b) concludes that preservice teachers' personal history-based beliefs influence what they learn in a teacher education program, rather than the program influencing their beliefs (also see Borko & Putnam, 1996; Calderhead & Robson, 1991).

A second barrier to changing preservice elementary teachers' beliefs about mathematics and its pedagogy is that they are unaware that they have such beliefs. Angell (1991) found that when preservice teachers enrolled in a social studies methods course were given experiences or messages about social studies or its pedagogy, they unconsciously selected messages congruent to their existing beliefs and discarded messages that were in conflict with those beliefs. Thus, rather than attempting to fit conflicting messages with their existing beliefs (and opening themselves to possible accommodation), Angell's interns ignored the messages. Angell terms this filtering of

Angell (1991) argues that the controlled receptivity was in large part due to the interns being unconscious of their beliefs. Because they were unaware that they *had* beliefs about social studies and its pedagogy, the interns were not receptive to and reflective of messages that conflicted with those beliefs. Therefore, their unconscious beliefs were becoming less open to question and, thus, less likely to change. Consequently, Angell (1991), in agreement with the Strike and Posner model of belief change, recommends that before any attempt is made to change interns' beliefs, those interns must be made aware of those beliefs so that they may consider *any* message and consciously compare it to their existing theories. Then, beliefs will no longer serve as an automatic filter for messages, but a basis for argument.

However, awareness does not imply dissatisfaction or desire for change. First, in Fuller’s (1969) model of teachers’ general concerns, interns are seen to be initially concerned with how they are seen as teachers with a gradual movement toward being concerned with their students' learning. Kagan (1992b) supports the model in an analysis of selected studies involving preservice and beginning teachers. If this model is viable, then teacher educators must convince interns that it is *important* to consider their beliefs about pedagogy in addition to their general concerns and expectations for teacher education.

Specifically in mathematics, it appears that many, if not most, preservice elementary teachers are not concerned about their abilities to teach elementary school mathematics
and, thus, are not intrinsically motivated to change them. This lack of concern stems, in part, from beliefs that elementary mathematics consists mostly of easy arithmetic skills with little emphasis on conceptual knowledge (Ball, 1988b; Civil, 1993; Fisher, 1993; Wood & Floden, 1990). They also feel they have, from their observations as students, enough general ideas about what teachers need to do in order for students to learn mathematics (and other subjects), often ignoring the complexities that teaching involves. Many of these ideas are concerned only with students learning procedural mathematics from an affective (fun), rather than cognitive, viewpoint (Berenson & Blanton, 1996; Brookhart & Freeman, 1992). Therefore, they only look to courses and field experiences in teacher education as opportunities to observe excellent teachers, gather specific activity ideas, and gain experience in working in real classrooms like the ones they experienced (e.g., Ball, 1989a; Bird, Anderson, Sullivan, & Swidler, 1992; Book, Byers, & Freeman, 1983; Weinstein, 1989). Thus, interns take for granted what is entailed in elementary mathematics and its pedagogy and expect teacher education to give them experiences and ideas that fit their paradigms. As Calderhead (1988) points out, interns rarely ask, "How am I going to learn to teach?" or "What have I got to learn in order to teach?" (p. 52). Thus, according to the Strike and Posner model of belief change, mathematics teacher educators are faced with the additional burden of overcoming interns’ implicit satisfaction with their perceptions of mathematics and teaching of mathematics and their consequent lack of motivation toward changing them.

Finally, for assimilation or accommodation to occur within a belief system pertaining to an object, a person must reflect on the experience one has with the object. However,
many preservice teachers may not be predisposed to reflect. In a study of a mathematics teacher education program in which reflection was emphasized, Korthagen (1988) found that many of the interns had no disposition to reflect or to value the potential learning that could be realized through reflection. These interns either dropped out of the program or developed (with assistance) reflective dispositions. Labosky (1990) and Danielson (1993) report similar results regarding differing dispositions to reflect. Therefore, in order to persuade interns to become aware of their beliefs, value the importance of their beliefs, and become dissatisfied with their beliefs, mathematics teacher educators must generate dispositions within the interns to reflect on the experiences provided for them.

Recommendations toward changing preservice elementary teachers' beliefs. Convincing preservice teachers to examine and change their beliefs about something they have assumed all their lives is a difficult and painful task for all involved, particularly at a time when interns feel ready to re-enact their strongly-held images of teachers that they probably possess (Ball, 1989a; Buchmann, 1987; Florio-Ruane & Lensmire, 1990; Fullan, 1991). Nevertheless, the chasm that exists between typical traditional beliefs about mathematics and its pedagogy and those beliefs espoused by the Standards necessitates providing these interns with powerful experiences in order for the gestalt to change (Nespor, 1987), that is, for accommodation to occur.

The general Strike and Posner model of belief change and the barriers that interns present have brought about recommendations for preservice teacher education programs that should be followed in order to meaningfully change interns' beliefs about education.
Most authors making these recommendations recognize that learning to teach in preservice teacher education is a complex process involving interactions between and within the intern and the program (Brown & Borko, 1992).

First, most authors agree that for interns to change their beliefs through teacher education, a program or course should espouse a reflective orientation toward learning to teach (Bauersfeld, 1980; Lawrence, 1992; Ojanen, 1993). Although there is little agreement on how reflection should be defined, it is apparent that most authors consider it to involve a meaningful thinking process about one's experiences, thoughts, and/or feelings (Korthagen, 1993). This process is needed in order for interns to become aware of their current beliefs and consciously compare them with new experiences.

Because many interns may not be accustomed to a reflective atmosphere, it is also recommended that teacher education programs help interns develop a reflective orientation as early as possible so that they can thoughtfully consider the experiences they are having in light of both the program's and their own goals, rather than having the interns' agenda compete with that of the program (Gore & Zeichner, 1991; Korthagen, 1988).

Also, interns need to be aware of their personal history-based beliefs and expectations as well as the importance of coming to terms with one's beliefs. This awareness should be accomplished early in the program so the interns can meaningfully try to compare their current experiences with their past. The awareness of their beliefs and subsequent recognition of their beliefs' importance are necessary because interns need to identify experiences that present conceptions divergent from their own as well as be motivated
toward resolving conflicts brought on by those experiences so that accommodation has a chance to take place (e.g., Feiman-Nemser & Buchmann, 1986b; Leinhardt & Greeno, 1986; O'Loughlin, 1990; Pintrich, Marx, & Boyle, 1993).

It is also recommended that teacher educators become aware of and value their interns' personal history-based beliefs and expectations. Teacher educators, like all teachers, must know and respect what their students are thinking in order to successfully link new experiences to their students' beliefs. Teacher educators must concede that their program is going to be perceived and valued by interns from the point of view of those beliefs (e.g., Anderson & Holt-Reynolds, 1995; Cooney, 1994b; Kagan, 1992a; Tillema, 1994).

As such, teacher educators cannot be seen as the authority in the process of learning to teach. If one tells interns what to believe, they may take what has been told to them and filter it through their beliefs, misinterpret what has been said, or ignore the given message altogether. Instead, interns must be given the freedom to take risks and the authority to internally examine experiences with respect to their beliefs so that they can resolve contradictions within themselves. The teacher educator should only be seen as the provider of the experiences in this process (e.g., Bird et al., 1992; Mewborn, 1996a; Ojanen, 1995; Shymansky, 1992).

Finally, several authors recommend that the experiences provided to interns be ones that break from the prior experiences that the interns have had as students. That is, instead of giving them strategies or ideas to use in the classroom, teacher educators should give interns chances to experience alternative conceptions which the interns can
compare against their assumed conceptions. These experiences can involve them in the role of student, teacher, or observer of teachers and students. It is hoped that these experiences will act as perturbations that will make the interns personally dissatisfied with their existing beliefs and force them to begin the painful process of replacing those beliefs with understandable, plausible, and worthwhile paradigms compatible with those of the teacher educators. Without providing such challenges, changing interns' beliefs would be nearly impossible (Calderhead, 1987; Fox, 1993; Taylor, 1990; von Glasersfeld, 1988).

To summarize these recommendations with respect to mathematics, if one agrees that the conditions outlined by the Strike and Posner model must hold in order for preservice elementary teachers to meaningfully replace their traditional beliefs about mathematics and its pedagogy with beliefs congruent to the *Curriculum and Teaching Standards*, and given the obstacles that exist in many interns that prevent such a replacement from occurring, then the following model outlines what mathematics teacher educators must accomplish:

1. Encourage a reflective disposition in the interns.

2. Make the interns aware that they have beliefs about mathematics and its pedagogy and make them aware of what they are.

3. Convince the interns of the importance their beliefs play in understanding and decision-making.
4. Provide mathematical and pedagogical experiences for the interns that not only are congruent to the Standards' point of view, but which also cannot be reconciled from a traditional perspective.

5. Allow and motivate the interns to recognize the differences between the two viewpoints and to make arguments for and against each perspective, hopefully invoking dissatisfaction with their existing beliefs.

6. Allow and motivate the interns to reflect upon and discuss these experiences within and among themselves, encouraging them to consider (using Strike and Posner's terminology) the plausibility, intelligibility, and worthwhileness of the new viewpoint that these experiences represent, thus encouraging rejection of their existing beliefs in favor of the new viewpoint.

Although there have been no previous models put forth specifically treating the process of belief change in preservice elementary teachers (Feiman-Nemser & Remillard, 1996; O'Loughlin, 1989), particularly in the area of mathematics, there have been several studies about changing beliefs or knowledge while learning to teach that support the Strike and Posner model and the specific recommendations outlined above.

**Related Literature Supporting the Strike and Posner Model in Teacher Education**

Results of several studies support the tenets of the Strike and Posner model of belief change within preservice teacher education. Some note elements of the model that were missing and thus led to no change taking place while others have found that change can take place, despite the many barriers noted above, if the model is heeded.
Studies involving few variables toward belief change. First, several studies have found that preservice teachers will likely exhibit the same filtering effect that Angell’s (1991) students did when encountering messages about education in a social studies methods course. In this case, the interns only accepted messages that were congruent to their own beliefs while ignoring messages that differed from their beliefs. This controlled receptivity has been noted in other studies with interns not only ignoring in favor of their beliefs, but also ignoring in favor of expectations, pretending to agree with, or misinterpreting messages that were contrary to their existing beliefs. Most of this phenomena could be attributed to teacher educators providing conflicting experiences, but failing to heed the rest of the model’s guidelines, particularly in not making the interns aware of their beliefs and/or not engendering a reflective disposition among them with respect to the experiences.

Other authors report results similar to Angell’s (1991). Feiman-Nemser and Buchmann (1989) investigated how preservice teachers interpreted their teacher education experiences with respect to their prior ideas about teaching. The researchers conducted case studies of six interns, three of whom were enrolled in an academic-based program and three of whom were enrolled in a program stressing generic theories of teaching and decision-making. Data were collected through interviews with the students and observations of their field placements. Feiman-Nemser and Buchmann (1989) found that all of the interns’ interpretations of experiences in each program were filtered through the lenses of their prior and familiar educational experiences and beliefs. Thus, the program
messages were reconstructed as messages that reaffirmed their beliefs, rather than their beliefs being reconstructed toward that which reaffirmed the messages.

Holt-Reynolds (1991a, 1991b) reports on a content-area reading course in which she studied the interactions between secondary preservice teachers' personal history-based beliefs and knowledge and their decisions about the potential value of the course. From interviews with nine interns, Holt-Reynolds (1991a) reports that when the instructor gave a research-based argument for the use of certain activities, the interns rejected his arguments in favor of their own lay theories that lectures are the best way to learn. The interns argued that, at best, the instructor's activities could be used as "add-ons" for the purpose of breaking the monotony of classroom routine as opposed to methods that allow students to construct their own knowledge. Holt-Reynolds (1991b) argues that interns unconsciously consulted themselves in internal dialogues that determined the validity of a particular experience or message of the course. She notes that:

Instructors assume preservice teachers will take the principles of the teaching profession as a "given" against which to adjust their student-based beliefs and points of view. Rather, the preservice teachers assume that the principles of the teaching profession are ideas that must be proved against the givens of their student-based beliefs. (1991a, p. 22)

Other studies in which preservice teachers ignored ideas from their teacher education program in favor of their existing conceptions include Essery (1993), Foss and Kleinsasser (1993), Hughes (1994), Lorsbach (1992), Shealy (1994), and Zeichner, Tabachnik, and Densmore (1987). In the Foss and Kleinsasser study, interns in a
mathematics methods course conducted in a *Standards*-like environment unknowingly imposed their dissonance toward such messages on the learning environment, eventually forcing the instructor to become a "desperate lecturer."

Other authors have found that preservice teachers often reject a program's purposes in favor of their concerns about becoming a teacher and/or their expectations of their teacher education program. Hollingsworth (1989) investigated the development of four preservice elementary teachers' knowledge and beliefs about reading instruction during a fifth-year teacher education program that included a reading methods course. She found that before the interns could learn about reading content and pedagogy, they needed to achieve a balanced managerial style. That is, interns' concerns (e.g., Fuller, 1969) during the course needed to be addressed before any intervention regarding subject matter content and pedagogy. Similar results are reported by Richards, Moore, and Gipe (1994), Garmon (1993), Bruneau, Niles, Slanina, and Dunlap (1993), Boone (1993), Wilson (1992), Foss and Kleinsasser (1996) and Munby and T. Russell (1994). In each of those studies, interns complained that their teacher education experiences were too theoretical. Instead, the interns valued specific activity ideas or management skills from the courses or field experiences.

Other authors have found that preservice teachers, while seemingly expressing changed beliefs, are really engaged in a masquerade of *strategic compliance*. Rodriguez (1993) studied six preservice secondary science teachers enrolled in a combined methods course and field experience. He found that the interns temporarily surrendered to the demands of the program by agreeing to their instructor's point of view over the duration
However, the interns were hiding their actual beliefs about science education. They, like the interns in the previously cited studies, harbored thoughts that the course was too theoretical and not meeting their expectations of fail-safe ideas for use in the field and their future classrooms. Also, because the cooperating teachers' pedagogical actions were compatible with the interns' personal history-based beliefs and not the instructor's pedagogical messages, the interns were supported in favoring the science education they were familiar with. Thus, as Rodriguez (1993) put it, when the instructor of the course spoke with the language of persuasion, the interns listened with the language of perception. Olson (1995) and Ehrig (1992) report similar results of interns temporarily giving in to the demands of their programs while secretly maintaining their own beliefs.

Still other authors report that preservice teachers may not reject any messages that are at odds with their beliefs or expectations, but instead misinterpret the instructor's intent as being the same as their beliefs or expectations. For example, the Learning to Teach study at Virginia Tech (see Brown & Borko, 1992) investigated a teacher education program and its specific influences on interns' knowledge and beliefs. In particular, the elementary mathematics methods course, including a concurrent field experience, was investigated through participant observation, interviews with selected students, and interviews with the instructor, field supervisor, and cooperating teachers. It was found (Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993) that the instructor of the course tried to emphasize conceptual over procedural knowledge while providing the interns with "survival" strategies for their field experience. However, the interns looked
upon the instructor's intent as providing them with routines to memorize that worked in the classroom. Also, the concurrent field experience did not offer the interns the opportunity to work in an environment envisioned by the instructor. Instead, it only encouraged them to teach mathematical procedures without the conceptual underpinnings (Borko et al., 1992). This lack of connection between course and field, along with the interns' being left on their own to resolve the conflicting messages, only reinforced their misinterpretation of the course's purpose.

Another instance of a preservice teacher using existing beliefs to misinterpret the messages of a course is reported by Holt-Reynolds (1993). Within another content-area reading course, one preservice teacher agreed with the messages she thought her instructor was imparting. However, she was accepting these messages with respect to her own beliefs that a good teacher emphasizes affective traits such as making students comfortable and the learning experiences exciting. For example, she accepted the instructor's rejection of lectures on the grounds that a variety of teaching techniques is needed to energize a class. However, the instructor indicated to the class that the rejection was on the grounds that lectures impede autonomous learning. Thus, the intern never rejected her instructor's guidelines and their rationale; she instead substituted her own. Because the instructor assumed the intern was reflecting on his messages with his interpretation, there was no confrontation between the two views.

In reviewing the failure of their efforts to restructure preservice teachers' beliefs, the authors in these studies and others (e.g., Smith, 1992; Wiggins & Clift, 1995) point out that the responsible teacher educators should have made use of the interns' incoming
beliefs by first making them aware of their beliefs so they could be used as points of comparison throughout the various experiences provided for them. In addition, some authors point out that the teacher educators should have been more aware of the interns' expectations for the courses and somehow convinced the interns that their coming to terms with their beliefs is, in the long run, equally if not more important than those expectations. Finally, some authors suggest that the teacher educators should not have assumed that the interns would automatically reflect on the experiences provided with respect to the teacher educator's point of view and instead should have encouraged a reflective disposition toward the messages with respect to the interns' beliefs.

Studies involving some variables toward belief change. In some studies, attempts have been made to expose and confront preservice teachers' beliefs with the expressed purpose of changing beliefs through reflection. Yet, these studies report no better success toward belief change. With respect to the model of belief change in preservice teachers, these failures may be a result of the teacher educators ignoring the need for the alternative viewpoints to become plausible and worthwhile to the interns.

Civil (1993) taught a mathematics content course for preservice elementary teachers in which the purpose was to have the interns learn mathematics through problem solving, with tasks that the interns mistakenly consider obvious and tasks aimed at creating cognitive conflict. It was found that, although the interns did increase their ability to learn mathematics and its pedagogy through reflection, their beliefs did not change. Civil notes that the interns' expectations for the course (mostly involving management concerns) and the course's purpose were orthogonal, leading the interns to consider the
course's approach to learning mathematics irrelevant to their future careers. Also, the interns were sensitive to the issue of frustrating children during problem solving, rendering the course activities as not only irrelevant, but too different from their backgrounds. They could not understand the notion that this new way of learning mathematics could be better than what they had previously experienced.

Bird et al. (1992) describe experiences in teaching an introductory education course in which the goal was to help preservice teachers examine ideas about teaching that they bring with them. The interns were to observe videotaped examples of teaching that either agreed with traditional roles or broke away from those roles (e.g., Magdalene Lampert teaching third grade mathematics). Then, the interns read articles complementing a particular videotape and wrote a "conversation" with the author of the article. The authors report that, as the change model predicts, the interns made their decisions of agreement or disagreement with a videotape's point of view on the basis of their own traditional beliefs. No intern wanted to question their point of view in favor of an alternative. Instead, they tried to assimilate the new ideas as best they could. For example, after the lesson by Lampert, the interns were uncomfortable with allowing children to struggle with mathematics. Bird then taught mathematics like Lampert with the interns as "students." This experience was successful for the interns' understanding of mathematics, but not for changing their beliefs about challenging students. Bird (1992) hypothesizes that the interns were not motivated to change their beliefs because of the differences between the agenda of the course instructor (comparing beliefs to other points of view) and that of the interns (quickly learning correct answers).
Hammrich (1997) describes an elementary science methods course that aimed to familiarize preservice teachers with science reform initiatives (American Association for the Advancement of Science, 1995) and the role of teachers as decision-makers in promoting scientific literacy. To accomplish those goals, the instructor utilized the Posner et al. (1982) theory of belief change in constructing four phases the interns would progress through: (a) Challenge the interns' beliefs about the nature of science, (b) Apply their new awareness of the reform effort, (c) Evaluate different curriculum resources with respect to the reform philosophy, and (d) Utilize the designed and ready-made lessons with children. Hammrich (1997) found that, although the interns evidenced some change of stated beliefs with respect to the nature and pedagogy of science, they adhered to their traditional practical beliefs about the classroom. For example, the interns agreed that many of the reform principles were representative of the true nature of science and theoretically beneficial to students but were impractical because they would be more time consuming than traditional instruction. The course may have been only partially successful because the interns compared points of view only to the baseline of the reform principles, thus making the course's viewpoint intelligible, but they were not given opportunities to consider it as plausible or worthwhile to replace their personal-history-based beliefs for future use. Similar results are reported by Florio-Ruane and Lensmire (1990) and Walker and Tedrick (1994).

The results of these studies support the Strike and Posner model because the teacher educators only made interns aware of their beliefs and provided experiences that forced them to consider alternative points of view through reflection; but failed to motivate the
interns to reconcile the existing beliefs with alternative viewpoint(s) and/or consider the alternative viewpoint(s) to be understandable, plausible, and worthwhile to pursue. It is likely that, because the teacher educators in the reported studies did not accomplish the latter requirements, the desired belief changes did not occur.

*Studies reporting successful belief change.* There are studies in which changes in preservice teachers' beliefs are reported. In each of the following studies, the model's criteria for change are met, mainly because the interns were given control over their own learning, which forced them to make decisions that had to be justified by their beliefs or alternative viewpoints.

Anderson and Holt-Reynolds (1995) report on a secondary content-area literacy course that Holt-Reynolds taught. She developed her course with pedagogical strategies designed to make interns aware of their own beliefs as well as accept the ideas from the course as reasonable and worthwhile to use in their future careers.

In formulating her strategies, Holt-Reynolds focused on the belief clusters that would most likely influence the interns' experiences in the course. She predicted that the interns would believe that learning is highly centered on affective variables so she centered the course goals on beliefs that learning is based on mental construction of meaning and teaching is a series of thoughtful decisions on developing and implementing tasks. Holt-Reynolds conjectured that the interns would either value or reject course messages based on their efficacy with students.

To counteract these projected outcomes, Holt-Reynolds developed a series of pedagogical "moves" that implicitly follow the Strike and Posner model by eliciting,
engaging, and challenging the interns' beliefs in contexts in which they are still using their "self-as student" voices. The moves included the posing of situations by Holt-Reynolds so that the interns were forced to begin focusing on students' cognitive strategies. This move allowed the interns the opportunity to see that the cognitive goals of those teaching strategies were different than the affective goals they initially held. Then, the interns were placed in situations in which traditional teaching and learning strategies based on their incoming affective beliefs failed to elicit the same kind of cognitive constructions. Finally, the interns were invited to be students themselves to see that the strategies modelled by Holt-Reynolds do what their incoming beliefs could not.

Holt-Reynolds examined the effectiveness of these moves by studying three interns in the course. For two of the three, Holt-Reynolds' conjectures were substantiated. The third student did not initially hold the beliefs that Holt-Reynolds predicted in that he did not consider students' internal states as important to learning and Holt-Reynolds' moves did not influence his outlook on learning. As a result of this occurrence, Holt-Reynolds made adjustments to her moves for the next course.

Casey and Howson (1993) describe an elementary preservice course designed to develop creative and independent problem-solving teachers who, in turn, would develop the same traits in children.

In order for the interns to understand the differences between their incoming behaviorist beliefs and the developmental goals of the course, they were engaged in tasks as learners in environments conducive to each point of view. Then, they observed
children learning in the same types of environments and reflected on the educational goals, methods, and roles of teachers and learners in each environment.

Each intern was then given a problem to solve as a team with their instructor, supervisor, and cooperating teacher: Pose a problem to children and develop a content lesson around a knowledge base needed to solve the problem. The interns focused on the thinking processes involved in developing such a lesson as well as the processes the children would be involved in. The interns experimented with their ideas, reflecting on why they felt the lesson was effective and/or ineffective with respect to philosophies and procedures and were assessed only on their ability to analyze their perceived effectiveness.

As their lessons evolved, the interns became convinced that their incoming beliefs were not conducive to solving the problem at hand. Thus, they began to discard their old beliefs and accept the notion of a developmental problem-centered curriculum. Herrmann and Sarracino (1993) and Roskos and Walker (1994) also report success through structuring literacy courses so that preservice teachers gradually become autonomous decision-makers in teaching situations.

Within mathematics education, there are a few studies in which preservice elementary teachers changed their beliefs about the mathematics or its pedagogy as a result of cognitive perturbations that caused dissatisfaction with their incoming conceptions.

Schram, Wilcox, Lanier, and Lappan (1988) investigated how a mathematics content course for preservice elementary teachers based on problem solving influenced their beliefs about mathematics and its pedagogy. In the course, the interns learned
mathematical concepts through exploring, solving, and extending problems in cooperative groups using multiple representations. There was little or no intervention by the instructor while the interns worked on the problems so that they could resolve the problems on their own. Within and after the problem-solving sessions, the interns were encouraged to discuss their reflections on the learning process they were engaged in as well as their mathematical ideas with their peers, the instructor, and themselves. Thus, as a result, the interns began to view their former experiences of doing and learning mathematics as inviable and came to embrace the problem-solving environment they were immersed in. However, they maintained that children should be taught the basics before they can engage in any problem-solving activities. Kloostermann, LeBlanc, Lester, and Kroll (1992) and Steele (1994) report similar results with other content course interventions based on learning via problem solving.

Meyerson (1977) investigated the influence of a mathematics methods course on preservice teachers' beliefs about mathematics and its teaching with respect to the adult cognitive developmental model formulated by Perry (1970). Students in the course engaged in mathematical discourse over problem situations designed to invoke doubt, controversy, and confusion. The situations led the interns to openly debate whether these experiences represented doing mathematics. These debates centered on questioning their prior traditional experiences in which there was an external authority to dispel any confusion before it started. Although the course was not fully successful in moving the students along Perry's continuum, Meyerson (1977) found that the interns did change their beliefs about where mathematical authority should lie.
Hill (1997) describes an elementary mathematics methods course taught at an elementary school that was designed to facilitate preservice teachers' willingness to teach mathematics to children for relational understanding (Skemp, 1987). The course explicitly utilized the Strike and Posner model and occurred within a continuous cycle of considering personal histories and theory of learning mathematics relationally, then using theory at the school and reflecting on those experiences to incorporate their findings for the following week's class.

The interns were encouraged to take risks in developing and/or experimenting with alternative environments for developing relational understanding within the children. They were not under pressure to succeed right away as mistakes and successes were welcome fodder for reflective discussion and subsequent improvement within the cycle. Hill (1997) reports that, from this atmosphere of cooperation, risk-taking, and reflective discussion, the interns began to consider a developmental learning and teaching paradigm as worthwhile to pursue in attaining relational understanding within children.

Wubbels, Korthagen, and Broekman (1997) report their successful preparation of interns to teach within the Netherlands' Realistic Mathematics Education (RME) curriculum. The teacher educators formulated a cyclic process based on reflection that the interns experienced first within their own mathematical thinking, then others' thinking, and finally, students' thinking. This cycle (called ALACT) involved five steps: confronting a situation requiring action, looking back on actions one took on the situation, becoming aware of the essential aspects of the situation or actions, creating alternative solutions to the situation, and attempting those alternative solutions to the
situation. These situations occurred through activities and reflections that emphasized the freedom to take risks when formulating, debating about, and implementing solutions. Through results of a longitudinal study, the authors report that the ALACT strategy was successful in changing preservice teachers’ beliefs toward using an inquiry approach to learning and in promoting effective teaching behavior.

An underlying commonality among these successful studies in which belief changes are reported that is not present in unsuccessful studies is that preservice teachers were given tasks that required them to justify theirs or the alternative viewpoint(s). Thus, they were forced to consider the viewpoints’ plausibility and worthwhileness in coming to terms with what they believe about the object with respect to what they have experienced. The tasks also provided interns with empowerment of their own learning so that they could resolve contradictions in the respective viewpoints themselves with respect to their own perceptions of their personal history and current alternative experiences (see Cook, 1993; Jones & Vesiland, 1996; Lundeberg & Fawver, 1994; Stofflett & Stoddart, 1994). These tasks are in contrast to those in the unsuccessful studies in which interns were by an instructor led toward how he or she wanted them to change, thus leaving the interns without motivation to consider alternative viewpoints or even their existing beliefs.

From the evidence given by the above studies, it appears the Strike and Posner model of belief change through teacher education is supported as a description of necessary conditions for such changes. Thus, it is through the model that specific factors in the mathematics methods course and interns toward or against the interns’ belief changes will be detected in the current study.
Pedagogy and Structure of Elementary Mathematics Teacher Education

As recommendations for the reform of elementary school mathematics have been recently developed, so too have recommendations for the education of prospective elementary teachers. There have been many recommendations made about the nature of interns’ experiences within courses related to mathematics and its pedagogy. However, little has been suggested as to how these experiences should be structured within teacher education programs, particularly with respect to the role of mathematics methods courses.

Recommendations for Preservice Elementary Teachers’ Experiences Within Mathematics Education

Several authors (AMATYC, 1995; MAA, 1991; NCTM, 1991; Texas SSI, 1997) suggest particular types of experiences for preservice teachers that would provide opportunities for them to change their traditional beliefs in favor of beliefs congruent to the Standards (NCTM, 1989; 1991). The recommended experiences often parallel the Strike and Posner model for belief change, particularly focusing on the development of mathematical pedagogical content knowledge while simultaneously changing interns' conceptions of what pedagogical content knowledge means.

Most, if not all, of these recommendations are summarized as part of the Professional Standards for Teaching Mathematics (NCTM, 1991) under the category "Professional Development of Teachers of Mathematics." This document makes several assumptions about the process of learning to teach mathematics. In particular, it assumes that interns' beliefs influence what they will experience in preservice teacher education. In addition, it assumes that interns should learn in environments that will integrate theory and practice.
of learning and teaching mathematics. For example, it states that interns should be involved in learning mathematics content *during the same period* they are engaged in teaching in similar environments so that the interns can reflect on their own mathematical learning and appropriate pedagogy for children.

NCTM (1991) also makes several recommendations for preservice teacher education. With respect to preservice teacher belief development, it states that mathematics teacher educators should provide opportunities for interns to "examine and revise their assumptions about the nature of mathematics, how it should be taught, and how students learn mathematics" (p. 160).

With respect to preservice teachers as learners of mathematics, the *Teaching Standards* urge teacher educators to model good mathematics teaching by:

- posing worthwhile tasks;
- engaging teachers in mathematical discourse;
- creating learning environments that support and encourage mathematical reasoning;
- and expecting and encouraging teachers to take intellectual risks in doing mathematics and to work independently and corroboratively [sic].

(p.127)

The *Teaching Standards* further recommends that these experiences represent mathematics as the *Curriculum Standards* portray the discipline; that is, based on problem solving, communication, reasoning, and connections. The experiences should also involve topics in the discipline that should be emphasized in elementary school (also described in the *Curriculum Standards*).

In addition to mathematical experiences for preservice teachers as learners, the *Teaching Standards* recommend that the interns have experiences with children learning mathematics in similar environments, with particular focus on tasks, discourse,
environment and assessment. These experiences should involve guidance and collaboration from mathematics educators in planning, analyzing, and evaluating the appropriateness and effectiveness of their teaching.

From these experiences, the Teaching Standards suggest preservice teachers should develop and revise their knowledge on research on how students learn mathematics. The experiences should also develop and revise interns' knowledge of and ability to use and evaluate "instructional materials and resources, including technology; ways to represent mathematics concepts and procedures; instructional strategies and organizational models; ways to promote discourse and foster a sense of mathematical community; and means for assessing student understanding of mathematics" (p. 151).

In short, these standards state that preservice teachers should be immersed in roles as students, observers, and teachers in Standards-based mathematical and pedagogical environments in order for them to be able to formulate those environments for their own students.

These recommendations for learning to teach are compatible with the Strike and Posner model for changing preservice teachers' beliefs. The Teaching Standards point out the need for interns to consider and change their assumptions about mathematics and its pedagogy through reflection on a variety of experiences that are in direct conflict with their traditional backgrounds. Also, like the strategies in the successful studies previously discussed, the Teaching Standards recommend that interns begin to take control and responsibility for their own learning as they grow.
Simon's Model for Preservice Elementary Teachers' Learning Processes Within Mathematics Education

Because the current reform movement in mathematics education, and, hence, mathematics teacher education, is in its infancy (Goldsmith & Schifter, 1993; Wilson & Ball, 1996), there has not been adequate time to formulate a number of theoretical models to guide the formation of programs with respect to the recommendations of the Teaching Standards as well as the mathematical learning processes and barriers to change of preservice teachers. Only one such model of preservice teachers' learning processes has emerged thus far: the one posited by Simon (1994).

Simon's (1994) model is a confluence between several learning models that already exist. First, he hypothesizes six goals for what preservice teachers need to develop in order for the five major shifts of the Teaching Standards (discussed in Chapter 1) to occur in elementary mathematics classrooms:

- Knowledge of mathematics (i.e., conceptual and procedural knowledge);
- Knowledge about mathematics (i.e., the nature of mathematics);
- Useful and personally meaningful theories of mathematics learning;
- Knowledge of students' development of particular mathematical ideas;
- The ability to plan instruction of this nature; and
- The ability to interact effectively with students (p. 72).

Next, he hypothesizes that learning to be a mathematics teacher is similar to learning mathematics. He justifies this conjecture by noting that both mathematics and mathematics teaching are problem-solving activities and that both involve conceptual understanding. Consequently, Simon (1994) utilizes a social constructivist theory of learning (Ernest, 1991) and places interns' constructions of knowledge of an object within
a recursive learning cycle in which a person explores the object, identifies key concepts about the object from reflection on those explorations, then applies the developed knowledge into a new exploration stage (Karplus et al., 1977).

Simon's theoretical framework for the mathematical and pedagogical learning processes of preservice teachers is thus the implementation of each of the six learning goals for interns that are listed above as the objects in the learning cycle model. In each case, the application phase of one goal (or cycle) serves as the exploration phase of subsequent goals.

Although it is too early to tell how well Simon's framework models appropriate learning processes for preservice teachers in accomplishing the goals of the Curriculum and Teaching Standards within preservice teacher education, it does point out the need for interns to reflect on experiences and consequently develop theoretical perspectives about the nature of mathematics, learning mathematics, and mathematical pedagogy.

Elementary Mathematics Methods Courses

The current study will examine the potential impact of an elementary mathematics methods course on three preservice teachers' beliefs about mathematics and its pedagogy. It will examine how the interns experienced the course, whether and how the interns' beliefs changed, and what factors in the course may have influenced the (non-) changes. The findings are intended to better define the roles, structure, and pedagogy of elementary mathematics methods courses within preservice teacher education in the face of mathematics education reform.
Roles of mathematics methods courses within teacher education. Subject-specific methods courses are eclectic islands in most preservice teacher education programs’ curricula. Within any one program, they may occur at various points and be connected or disconnected from other courses or experiences. They can also serve a number of purposes, depending on the goals of a program or even the whim of the course’s instructor (Stengel & Tom, 1996; Wilson, 1994).

Alternatively, mathematics methods courses may also be seen as a bridge between prior mathematical experiences of preservice teachers, general theoretical education courses (e.g., educational psychology) the interns take, and experiences in working with children. Ball (1989a) argues that mathematics methods courses face a tension not found in other education courses. She states that educational psychology courses can concentrate on general theories about learning, while mathematics courses can concentrate on the content and (perhaps) the nature of the discipline. But mathematics methods courses must "weave together" all of this knowledge. That is, the course must integrate interns' knowledge of and about mathematics, knowledge about children and how they learn mathematics, knowledge about the teacher’s role in that learning process, knowledge about the role of classroom environments on students’ mathematical learning, and knowledge about educational and mathematical values and goals. In short, Ball claims that mathematics methods courses play a, if not the, major role in accomplishing the goals of mathematics teacher education put forth by the Teaching Standards as well as a key component in the learning process model proposed by Simon (1994).
As a result, because preservice elementary teachers often enter these courses with a pattern of traditional prior mathematical experiences and beliefs, elementary mathematics methods courses have a major responsibility in breaking that pattern toward changing those beliefs about mathematics and its pedagogy (McDiarmid, Ball, & Anderson, 1988). Therefore, if the Strike and Posner model is accurate, a program's mathematics methods course(s) cannot solely cater to typical intern expectations for the course by simply presenting strategies to make mathematics fun or to survive in the classroom. Instead, these courses must make interns aware of their beliefs and question those beliefs through reflection on experiences contrary to their personal histories.

McDiarmid, Ball, and Anderson recommend that methods courses accomplish these goals by concentrating on mathematical representations of a few topics. They argue that teaching mathematics consists of making representations that are decided upon by connecting one's knowledge of and about mathematics and the topic, one's knowledge about children's learning in general and of the topic, and one's knowledge of teaching roles and strategies with respect to the topic and students. Thus, by concentrating on representations, the course would give interns opportunities to weave together mathematical and pedagogical knowledge and use the developed knowledge with children.

McDiarmid, Ball, and Anderson specifically list five responsibilities for methods instructors: (a) Confront interns' initial conceptions of what it means to do mathematics, learn mathematics, and teach mathematics; (b) Help interns develop their own understanding of the content and nature of mathematical topics; (c) Create opportunities to learn more about the knowledge, attitudes, and experiences students will bring to the
study of mathematics; (d) Develop a framework of criteria for and skill in evaluating mathematical representations; and (e) Develop processes for generating a wide range of representations for the same mathematical idea. (Note that this list of responsibilities places most of the burden of the six needed mathematical learning processes for preservice elementary teachers outlined in Simon's model (1994) on the mathematics methods course(s)).

This approach is an example of one that concentrates on developing what preservice teachers know and believe rather than on simply giving them a disparate collection of ideas for future use. McDiarmid, Ball, and Anderson argue that, through experiences in developing, selecting, or evaluating representations for teaching mathematical topics, interns are forced to consider and question what they really understand, what understanding means, and subsequently what learning and teaching mathematics might involve.

Research needs of mathematics methods courses. Unfortunately, the above is the only set of recommendations found that specifically addresses mathematics methods courses as change agents for preservice elementary teacher beliefs. There are still many unanswered questions about elementary mathematics methods courses' roles, structure, and pedagogy toward reconstructing interns' beliefs. These questions include, among others, (a) what content is needed; (b) what kinds of field experiences should be included; (c) how many credit hours should be required; (d) what evaluation procedures
should be employed in assessing interns' knowledge in a course; (e) how to go about establishing a learning environment conducive to perturbations; and (f) how the Standards will be addressed in a course (Vacc & Bright, 1994).

These questions remain unanswered because of a lack of a model addressing the role(s) that these courses should play in preservice teacher education toward changing interns' beliefs about mathematics and its pedagogy as well as addressing the structure and pedagogy of such courses. Such a model can be formed, but only by investigating and identifying (a) the learning environments of methods courses; (b) how interns' beliefs and expectations interact and change with those environments; and (c) factors of the environments and interns that influence (non-)changes (Brown & Borko, 1992; Cooney, 1994a; Feiman-Nemser & Remillard, 1996).

Unfortunately, despite many calls for such research (Brown & Cooney, 1982; Good & Biddle, 1988; Katz & Raths, 1992; Zeichner & Gore, 1990), few studies have been reported that involve all three needed points of information. Most of the studies involving methods courses only describe how preservice teachers' beliefs did or did not change along with generic factors that may have influenced such a change from the interns' point of view. Also, with the exceptions of the Learning to Teach Study (Borko et al, 1992; Eisenhart, et al, 1993), and Holt-Reynolds' (1991a, 1991b, 1993) and Anderson and Holt-Reynolds' (1995) accounts of secondary content-area reading courses, no studies were located that give a non-participant observer's account of the learning environment of a methods course in an effort to identify specific environmental factors influencing interns' beliefs. The few other studies that have reported the environment of
methods courses gathered the information through reports of the instructors or preservice teachers (e.g., Angell, 1991; Floden, McDiarmid, & Wiemers, 1990; Hill, 1997; Jantz, Weaver, Cirrincione, & Farrell, 1985; Steele, 1994).

Therefore, little is known about what actually occurs in methods courses (Goodlad, 1990). Consequently, little is known about how elementary mathematics methods courses influence or might influence preservice teachers' beliefs about mathematics and its pedagogy within teacher education.

The current study suggests a model that will guide the consideration of the roles, structure, and pedagogy that elementary mathematics methods courses might best play toward changing preservice teachers' mathematical and pedagogical beliefs. The study furthers the knowledge on all three of the points necessary for such a model by exploring an elementary mathematics methods course and interns' experiences in it in search for factors in both the course and interns in the restructuring of the interns' beliefs.

Significance of the Study

The purpose of the current study was to explore the content and activities of an elementary mathematics methods course and how the course and a concurrent field experience interact with and restructure three preservice teachers' beliefs about mathematics and its pedagogy. This research is valuable to mathematics teacher educators because:

1. It contributes to a theory of what messages about mathematics are sent to preservice elementary teachers through methods courses, how these messages are sent, and how these messages are interpreted by preservice teachers. This theory is important
because it can assist mathematics teacher educators in planning and implementing mathematics methods courses toward the goal of restructuring interns' beliefs in the direction of the NCTM Standards.

2. It contributes to a theory of how methods courses interact with other components of teacher education with respect to preservice teachers' beliefs about mathematics and the role(s) methods courses might take on to achieve the strongest intervention possible toward restructuring preservice teachers' beliefs.

3. It also helps to answer the claims of those who feel that methods courses have little impact on preservice teachers' beliefs and actions (Mardle & Walker, 1980; Ross, 1987).

4. In light of its conclusions, it addresses recommendations made by NCTM (1991) and others for the professional development of teachers.
CHAPTER 3

METHODOLOGY

Design and Procedures

This investigation was a case study of three preservice elementary teachers as they experienced their mathematics methods course and a concurrent field experience for the purpose of making general recommendations for such methods courses to alter interns' mathematical beliefs. The interns were selected to represent a range of mathematical backgrounds, of confidence to do mathematics, and of self-efficacy in teaching mathematics. They were interviewed at the beginning and end of the course to ascertain their personal histories and to detect changes in their beliefs about mathematics and its pedagogy. In order to discern possible influences toward those changes, the investigator observed the course and field experiences and interviewed the interns and other key informants about their perspectives on those events. The data were analyzed using analytic induction and constant comparative methods on the individual and then on the cross-case level.

Design

Case study research falls under the umbrella of interpretive research (Erickson, 1986). The goal of interpretive research is to discover concrete universals by studying
a case in detail and comparing it to other studies done in the same or more detail. The case study is the appropriate methodology for the purposes of this study because there is not much known about how interns change their beliefs during mathematics education courses and even less is known about the experiences in the courses that may influence those changes. The case study approach allows the researcher to focus on as many variables as possible within a bounded set of phenomena (Merriam, 1988). This focusing is not restricted to any set of predetermined variables that one would need in less exploratory studies where one is searching for true interpretations of the facts. Instead, the purpose of case study research is to be able to "weed out" erroneous conclusions so that one is left with the best possible interpretation (Bromley, 1986). Because of this approach, it was possible to describe and explain in a holistic manner the interaction of significant factors in the interns' experiences that seem to influence the restructuring of their beliefs.

The case study methodology also enables the researcher to get as close as possible to the personal world of meanings held by each intern, through both the interviews and experiencing firsthand the environment they are interpreting (Bromley, 1986).

**Population and Selection**

The population of the study consisted of preservice elementary teachers enrolled in a section of elementary math methods in a large midwestern university. Only those interns with traditional beliefs about mathematics and its pedagogy were considered for sample selection in order to maximize the possible extent of change of beliefs during the course.
Cases were selected to represent a range of variation in previous experiences and dispositions of doing and teaching mathematics. As Patton (1990) asserts, "by including in the sample individuals the evaluator determines have had quite different experiences, it is possible to more thoroughly describe the variation in the group and to understand variations in experiences while also investigating core elements and shared outcomes" (p. 172).

Participants were selected on the basis of their mathematical backgrounds, their confidence in doing mathematics, as well as their self-efficacy for teaching mathematics. Both mathematical background and confidence to do mathematics are strong predictors of mathematical success (Reyes, 1984; Welch, Anderson, & Harris, 1982). Teaching self-efficacy is a strong correlate of teaching practices (Kagan, 1992b).

Background was assessed from reports of high school and college coursework and grades. Confidence in doing mathematics was assessed by a portion of the Fennema-Sherman confidence subscale (Fennema & Sherman, 1976). Self-efficacy in teaching mathematics was assessed from a portion of an adaptation of the Science Teaching Efficiency Belief Instrument (STEBI) developed for preservice elementary teachers (Enochs & Riggs, 1990). Beliefs about mathematics and its pedagogy were assessed by a combination of two scales: (a) part of the scale measuring interns' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics used by NCTRL (Kennedy, Ball, McDiarmid, & Schmidt, 1991) and (b) part of the scale measuring beliefs about the nature of mathematics and the roles of teachers and students developed
for junior high school teachers by Feldt (1991). These scales were randomly mixed and
administered to the class through a mail survey approximately three weeks before the
course began (see Appendix A.1 for this scale).

From the background data, the interns with traditional beliefs who were willing to
participate in the study were partitioned into three groups: those with minimal
backgrounds, those with average backgrounds, and those with maximal backgrounds in
math. In each of these groups, interns were ranked according to their scores on each of
the confidence and self-efficacy scales. The ranks for each intern were added to give a
"combined rank." Then, three interns were selected in the following manner:

1. The intern in the minimal background group with the lowest combined rank.
2. The intern in the average background group with the median combined rank.
3. The intern in the maximal background group with the highest combined rank.

The selected intern from each of the above was then contacted before the course to
ascertain her ability as an interviewee and the evidentiality of her beliefs (see Appendix
A.2). Upon giving suitable responses, the intern was asked to participate in the in-depth
study. She was given a description of the data collection scheme, assured confidentiality,
and offered $100 in reimbursement for her time. The first choice in each of the first two
groups ("Carla" and "Becky," respectively) agreed to participate. The first choice in the
third group declined to participate; however, the second choice from that group
("Amanda") agreed to take part in the study.

By selecting three cases, the potential for subject attrition was protected to the extent
that if one subject dropped out, then there would be two subjects remaining with some
variation in the pre-study variables. As it happened, Carla was absent for one week of
the course (and, hence, one of the interviews during the quarter), but did not drop out.
No other absences occurred with the selected interns.

The data received from the three interns were compared for commonalities and
differences from which abstractions can be made across the cases to construct or extend
theory (Merriam, 1988; Patton, 1990).

Instrumentation

There were a total of seven interviews used in the proposed study: (a) a pre/post
quarter interview for each intern (see Appendix A.3), (b) a weekly interview for each
intern (see Appendix A.4), (c) a pre-quarter interviews for the instructor of the course
(see Appendix A.5), (d) a post-quarter interview for the instructor of the course (see
Appendix A.6), (e) a post-quarter interview for each field supervisor (see Appendix A.7),
(f) a post-quarter interview for each cooperating teacher (see Appendix A.8), and (g) a
pre-quarter interview with the strand director (see Appendix A.9). The purpose of each
interview is delineated in the description of the study's procedures (below).

Most of the interview protocols, with the exception of the weekly interviews for the
interns, were developed during the Winter Quarter of 1992, with the major pre- and post-
course interview for the interns adapted from the Teacher Education and Learning to
Teach study at NCRTL (Kennedy et al, 1991).

Pilot Study

A pilot study was performed during the Spring Quarter 1992 in an elementary
mathematics methods class with a concurrent field experience. All of the components of
the proposed study were implemented with the exception of the participant-observation and the weekly informant interview. The pre- and post-course interviews of the interns, the pre- and post-course instructor interviews, the field supervisor interviews, and the cooperating teacher interviews were tested and revised. All of the students enrolled in the course kept reflective journals throughout the quarter. Based on the analysis of the journals' contents and the infeasibility of responding to the journals during the course, it was decided that weekly interviews with the key informants would be more fruitful and controlled in terms of the data needed by the researcher. It was also decided that the researcher's own observation of the course's activities was needed to better ascertain the factors potentially influencing the interns' beliefs.

Procedures

Data Collection

The data collection took place in the following manner:

1. The three interns were selected as described above.

2. Each intern was interviewed at the beginning of the quarter to provide a baseline of (a) her previous experiences in mathematics (kindergarten through the present) and (b) her beliefs about the nature of mathematics, the curriculum of elementary school mathematics, and the teaching and learning of elementary school mathematics; as well as expectations for the methods course and field experience.

3. Each intern was interviewed at the end of the quarter using most of the same questions as in the pre-course interview (except for the biographical section).
4. Each intern was interviewed weekly for her descriptions and reflections of what occurred in the methods course and field experience. One interview with Becky and two interviews with Carla were canceled due to a school holiday and Carla's one-week absence.

5. The strand coordinator for the elementary teacher education program was interviewed at the beginning of the quarter about the goals for preservice teachers, the organization of the program, and the preparation for the upcoming quarter.

6. The instructor of the methods course was interviewed two times (at the beginning and end of the course) regarding the goals of the course, planned events, rationale for the events, and reflections of what occurred.

7. The field supervisors of the interns were interviewed about their goals and expectations for the interns, aspects of their observations, their beliefs about mathematics, and reflections about what occurred. These interviews took place at the end of the quarter.

8. The cooperating teachers of the interns were interviewed about their beliefs about mathematics and its pedagogy, how mathematics is dealt with in their classroom, as well as the goals, tasks, and reflections about the informants. These interviews occurred at the end of the quarter.

9. The written work of the interns (lesson plans, journals, etc.) was copied for further analysis.
10. The researcher observed the interns in their field experiences. He observed the manner in which mathematics was portrayed in the classroom by the cooperating teacher and students as well as the role of the intern.

11. The researcher served as a non-participant observer in the course setting. He observed the content and activities of the course, the roles taken on by the instructor and students, patterns of discourse among the participants, the role of the text and other materials, the physical organization of the class, along with other key factors that may be important with respect to the interns' beliefs (Lofland & Lofland, 1984).

12. All interviews and methods class time were audiotaped for transcribing and/or accuracy in recalling.

Analysis of Data

The data were transcribed and analyzed as much as was feasible during the period of data collection using analytic induction (Goetz & LeCompte, 1984) and the constant comparative method of analysis (Glaser & Strauss, 1967). These approaches involve a recursive process of searching for verifiable categories of meaning in the data from the points of view of the informants, other participants, and the researcher. These searches refocused further data collections and added further questions to explore. Disconfirming evidence was also searched for in order to insure as much internal validity of these categories as possible.

Out of necessity, due to the work and family schedule of the researcher, much of the data transcription and analysis were done the following quarter. During that time, further themes emerged and others were discounted.
At the first level of analysis, individual case studies were developed to ascertain the interns' beliefs about mathematics and its pedagogy, as well as their interpretations of their experiences throughout the course (Miles & Huberman, 1984).

The second level of analysis involved a cross-case analysis of all of the data in which patterns and themes were studied for commonalities (Miles & Huberman, 1984; Yin, 1989). These patterns and themes were the focus for the presentation of factors involving the interns and the course, as well as conclusions.

Internal validity of the findings was maximized through the triangulation of data presented above, consultation with sources for confirmation of the interpretations, and soliciting comments from colleagues (Merriam, 1988).

The generalizability of the study's findings was maximized by thick descriptions of the course's activities and the participants' interpretations of those activities (Merriam, 1988).

_delimitations_

1. This study generated theoretical categories through the inductive analysis of the data collected from the informants' realities rather than verifying predetermined categories or propositions, based on the assumption that legitimate categories of analysis can be generated from the data (Glaser & Strauss, 1967; Goetz & LeCompte, 1984).

2. The beliefs of the interns can be inferred and identified from the analysis of interview and written data (Erickson, 1986; Pajares, 1992). Also, interactions between
those beliefs and the goals and actions of the course can be inferred and identified from interviews with key informants and observations of the course (Lofland & Lofland, 1984; Yin, 1989).

3. The analysis of data was filtered through my own beliefs and knowledge (Glaser & Strauss, 1967), especially those relating to mathematics in the elementary school (see Appendix D.1 for a description of my personal history and motivation for the study). Bias was minimized as much as possible through conferences with colleagues, member checks, and searches for disconfirming evidence (Merriam, 1988).

4. The act of interviewing the interns as well as my presence in the class may have influenced their experiences in the course.

Limitations

1. This study did not explore the influences of other experiences of the interns during or after the quarter of investigation.

2. The hypothetical responses of action given by the interns during interviews may not have reflected what they would do in actual similar situations under the constraints of a school situation.
CHAPTER 4

RESULTS

The Setting

The study took place within the college of education at a large midwestern university. Undergraduate prospective elementary teachers who are accepted into the college select or are placed in a *strand*, which is a cohort of interns who enroll in the same classes and have their field experiences at the same schools. Some of these strands were set up around a certain philosophy or subject, while others were set up generically.

Statement of the Problem

The purpose of the current study was to construct a theory of the interactions of elementary mathematics methods courses with preservice teachers' beliefs about mathematics and its pedagogy. Specifically, the study explored the following questions:

1. What are three preservice elementary teachers' beliefs about the following at the beginning and end of an elementary mathematics methods course and field experience: (a) the nature of mathematics, (b) mathematics in the elementary school curriculum, (c) teaching elementary school mathematics, and (d) how children learn mathematics?

2. What differences exist between their beliefs at the beginning and end of the course/field experience?
3. How do the three interns describe and interpret their experiences in the course/field experience from the perspective of their beliefs?

4. How do the interns' descriptions and interpretations of their course and field experiences compare to the goals and descriptions of the course instructor, field supervisor, and cooperating teachers?

5. What factors of the course/field experience or of the interns seem to contribute to their beliefs and/or changes in their beliefs?

Toward answering questions #1 through #4, this chapter will describe the structure and key events of the program and course; potential messages the course sent to the interns about the nature, curriculum, learning, and teaching of elementary mathematics; and each intern's entering and exiting beliefs as well as experiences in the course and the field experience with respect to those variables. Finally, commonalities among the three cases will be discussed toward making hypotheses about factors contributing to the interns' beliefs and/or changes in their beliefs.

The Strand and Its Philosophy

The strand in which the study took place was one that, in the terminology of the strand director, emphasized informal education. That is, the strand was centered around the child-centered progressive philosophy of Dewey in which children experience an integrated curriculum centered on thematic units. The strand emphasized processes by which children learn and the questions they ask. Further, it emphasized how one can match those processes and questions to the development of a curriculum. Teaching was looked upon as a process of learning and reflection; and the strand emphasized
examining the role of teachers in a child’s learning process. According to the strand director, the major goal of the strand was to develop a "well-articulated theory of learning and what teaching is" (interview, October 8, 1992).

Because the strand emphasized a curriculum based on thematic units, mathematics was not, in theory, looked upon as a separate entity. Rather, it was to be integrated with, if possible, all curriculum areas into units that often were to be co-developed by children on topics meaningful to them.

In particular, with respect to the discipline of mathematics, the strand’s philosophy was to focus on the process of solving problems as opposed to the final answers to problems. Also, the cooperating teachers of the strand shared an interest in doing more with conceptual mathematics than with computational mathematics. However, because the cooperating teachers had, for the most part, more expertise and interest in the language arts disciplines, it appeared to the director that many of these thematic units were heavily based in those disciplines as opposed to a more equitable distribution of emphases. Despite this apparent slight of mathematics and the sciences, the strand director indicated that most of the cooperating teachers were involved in working toward developing more knowledge with respect to mathematics that was consistent with the strand’s pedagogical philosophy.

Strand’s Goals for Preservice Teachers

The strand held specific goals it wanted to accomplish with its preservice teachers. These goals were consistent with the strand’s pedagogical philosophy.
First, the strand wanted to make the interns life-long learners and to see teaching as learning. That is, it wanted the interns to get into the mode of being reflective practitioners. In particular, the interns were supposed to value the learning process, consider one’s role in the process, and as a result, set up occasions for learning. They were also expected to think of ways that children learn and the questions they ask through case studies with individual and groups of children.

With respect to mathematics, the strand wanted its graduates to value the need to continue to learn mathematics as well as language arts. In learning mathematics, interns should strive to know the nature of the discipline by thinking about what they need to know and how they know it in teaching as well as in the discipline itself. The strand director, pointed out, however, that this knowledge development should begin in their mathematics content courses that are taken before the interns enter the strand and should not be the responsibility of the strand to initiate.

_The Structure of the Strand_

The goals outlined above were to be accomplished through coordination of the education courses taken on campus with experiences in schools. The strand wanted its interns observing and reflecting about teachers and students in the field relative to the philosophy and methods discussed in the courses.

To begin the year, the interns, the instructors of the courses, a few cooperating teachers, and the strand director attended a three-day retreat. During this retreat, groups
of interns were sent to locations (e.g., a museum or fire department) throughout a city or town to learn what they could about the site (e.g., people, history, functions) and report back to the rest of the interns.

The purpose of this retreat was for the interns to see things as learners by having to generate their own questions, formulate impressions from a variety of curricular disciplines, communicate their ideas, and so on. They were then asked to reflect and discuss the learning process that they went through. Within that reflection, they were asked to think about the consequences an integrated curriculum would have on the learning process.

Following this experience, the formal three-quarter-long program began. In the first quarter, the interns took four courses: child development, children's literature, language arts methods, and mathematics methods. Also, the interns began their field experience at one of two schools designated as Professional Development Schools as part of the Holmes Group model adopted by the college. They worked with and observed a cooperating teacher for two full days each week. It was in this quarter that the study occurred.

In the second quarter, the interns took courses in science methods, social studies methods, and literacy across the curriculum. They also spent more time in their field experiences, this time with different cooperating teachers and more responsibilities.

In the third and final quarter, the interns devoted all of their time to their practicum experience, once again with different teachers.
The cooperating teachers were heavily involved with the strand. Many of them had graduated from a similar program, and they were aware of the theory of the strand and its goals for the interns. They were charged with taking a major part of the responsibility in supervising and in connecting theory and practice, particularly with respect to what was being discussed in the interns' courses during the quarter. According to the director, most of these teachers were highly reflective, hungry to learn, and looked to these experiences as an opportunity to extend their own professional development.

The strands' course instructors were graduate students in education. They were made aware of the learning philosophy and thematic basis of the strand and were encouraged to coordinate their syllabi and goals with the cooperating teachers. Also, the instructors met regularly throughout the quarter to discuss the philosophy, problems with students or courses, and so on. First-time instructors usually co-taught a course with an instructor experienced with the course and the strand.

The Mathematics Methods Course

The mathematics methods course met twice a week for 10 weeks. There were a total of 19 classes (one class was canceled due to a holiday) lasting 1.5 hours each. The 13th class was held off campus in a cooperating teacher's classroom.

The course was taught by Holly, a doctoral student in mathematics education. It was the first time she had taught an education course, having before taught middle school mathematics and more recently freshman and sophomore level mathematics at the university. Holly was called in to replace the instructor originally scheduled to teach the course about two weeks before the onset of the quarter. Because of the short notice on
replacing the instructor, Holly was assigned to teach the course without ever having co-taught the course with an experienced instructor as doctoral students normally do. Holly also taught another mathematics methods course for another strand during the quarter.

The Instructor's Goals

Judging from my interviews with her, Holly's goals for the course closely matched those of the strand. She felt that the course should strive to change the imprint that had been formed in the interns' minds of what a mathematics classroom could be like. She felt this needed to be done before the interns could move ahead with classrooms reflective of the NCTM Standards. Holly planned to challenge the interns' imprints through exposure to alternative models of classrooms as well as to give them alternative methods through various activities.

Holly also wanted the interns to develop pedagogical content knowledge (Shulman, 1986) through a growing repertoire of representations of mathematical concepts as well as the flexibility to use these representations to attack concepts from different angles. She wanted them to leave the course with a knowledge of outside resources for activities and the confidence and ability to select or develop sources for what they wanted to do. She stressed that the interns should be able to reflect on and defend these choices.

A third goal of the course was to show the interns "how wide" mathematics is by including topics such as patterns and data analysis. Holly felt that interns needed to see how these ideas can be taught at a lower level. She also thought that the interns should be made aware of the Standards' and the state curriculum's emphasis on these ideas.
Finally, Holly emphasized that the course should help interns become relaxed with themselves in teaching mathematics. She wanted the interns to know that there is not a blueprint for teaching mathematics, as some might expect. Instead, she wanted the interns to be themselves, build on their own mathematical personality, and be willing to go out and try different things.

The Instructor's Organization of the Course

Holly used the textbook (Reys, Suydam, & Lindquist, 1992) that had been selected by the original instructor of the course. She and her predecessors organized the syllabus according to the chapters in the book, although not in the order presented in the book (see Appendix B for original syllabus and actual day-by-day occurrences). Some of the chapters that were used dealt with particular issues in mathematics education (e.g., how children learn mathematics, use of technology); while others addressed particular topics in mathematics (e.g., computation, data analysis, fractions, geometry).

Because of her inexperience in teaching methods courses, Holly initially had a difficult time envisioning what the course would be like. She went "day-to-day" with how she addressed topics, trying out some things with one class that she did not use with the other class, and visa versa. Her basic plan was to cover part of the chapter reading on the day's topic or issue in the textbook and bring out ideas on how the reading related to an actual classroom. With respect to mathematical topics, she wanted to bring in different methods and activities for teaching the topics across the grades.
To plan a day, Holly read the chapter, looked at other sources, and picked out the two or three most important points. She then set an order that she felt was logical for the interns and built some connections between the key points for her presentations.

In selecting activities for addressing topics and issues in an actual classroom, Holly used a variety of sources, including the textbook, *Mathematics Their Way* (Baratta-Lorton, 1976), materials from Marilyn Burns (e.g., Burns, 1992; Burns & Tank, 1988), and *Used Numbers* (Russell, 1990). She tried to select activities that would be helpful for developing a unit from beginning to end. Holly used the following criteria when making her selections: "If I was a teacher, what would be helpful to me" (interview, December 11, 1992)?

The Observed Components of the In-Class Course

The observed day-to-day events in the 19 classes consisted primarily of presentations and discussions, activities, or videos.

Presentations and Discussions

Most of class time was spent with Holly either speaking to the class or holding a presentation/discussion with the interns. Holly indicated that she used these presentations to bring out the most important points of the topic for the day and to try to bring the interns into a discussion. She hoped that the discussions would ultimately "bring the preservice teachers' doubts to the forefront" (interview, October 22, 1992). My analysis of the transcripts of the class revealed that there appeared to be seven purposes or roles of presentations and discussions.
**Interns' goals.** Discussions of goals occurred twice during the quarter. During the first class, the interns were asked to meet in groups to discuss how they experienced mathematics and what they would improve about those experiences if they had the chance. Each group then described common findings to the whole class. Most descriptions centered on how boring and irrelevant math was, how their teachers were authoritarian lecturers in the classes, and how most assignments stressed drill and practice. Most suggestions for improvements were for math to be more relevant and for more hands-on activities to take place. In the second goals discussion, each intern was asked what her major goal would be with respect to math when she was a teacher. Their goals included that students should enjoy math, see math as relevant, find that problems are easy to solve without being frustrated, and use manipulatives.

**Theory presentations.** In three theory talks, Holly discussed theoretical aspects of how children develop mathematical knowledge. In the first class, Holly lectured on behaviorism and constructivism. She explained that in behaviorism, teachers define a certain behavior and work to get children to behave in that way. Holly implied that defining a behavior forces teachers into a lecture mode and into splitting the curriculum into small pieces. With constructivism, Holly’s major point was that children form "frames" for objects and that these frames are the key to how a child can develop his or her knowledge. Other theory presentations were a short categorization/pattern discussion and a short talk on Kamii’s philosophy of learning, which led to a discussion about whether manipulatives are needed.
Standards presentations. Several presentations focused on the NCTM Standards and the state curriculum. In the first two of this type of lecture, Holly summarized the history and the major points of the Standards by putting lists on the overhead for the interns to copy while Holly commented on them. During these lectures, Holly often alluded to the interns' background and how much better these guidelines are when compared to how they learned math. Other presentations were short summaries on how the state model curriculum and the Standards emphasize that particular topics (patterns, data analysis, and geometry) be included in the curriculum.

Teaching guidelines. These were the most frequent type of presentation and consisted of lists of actions suggested by the text or by Holly that teachers should take when addressing a topic or an issue. For example, in Holly's talk on teaching rational numbers, she listed important points for teaching, such as developing the concept first, using many models, developing number sense, and keeping the subject relevant. She interspersed her points with her own or interns' examples of activities and problems to use with children of different ages. Holly's lecture on guidelines for assessment was similar in structure. Other guidelines presentations focused on questioning, place value and computation, roles of calculators, roles of teachers, goals of questions, and planning.

Examples of model teachers. Four times during the quarter, Holly described the actions of "model teachers." For example, Holly described how Marilyn Burns (Burns, 1989a) had students explore patterns and describe their observations in journals with the expressed intent to encourage the interns to do and/or make assignments in mathematics involving writing, and thus, bring communication into the classroom. Holly also talked
three times about how a teacher allowed students to come up with their own solution methods to solve computational problems in order to show the interns that it is possible for children to do so. Two of the model teacher discussions, one involving Burns and the other Kamii, were followed by videos featuring those authors.

*Math presentations.* Occasionally, the central focus of the class was mathematics itself. Most of these sessions occurred when Holly became a "math teacher" in a traditional role. For example, after activities in which the interns developed general terms for patterns, Holly wanted to develop the concept of a function for interns who would be teaching algebra for sixth graders or beyond. Holly said, "I want to make sure you understand this" (class observation, November 25, 1992), and presented the key ideas with occasional questions from the interns.

*Resource presentations.* In several short talks, Holly made the interns aware of specific resources where they could locate a variety of activities. Holly provided the name of a book and sometimes described some of the activities in it. Among the resources listed were Payne (1990), Baratta-Lorton (1976), Kamii (1985) (both theory and games), and Anno’s books (e.g., Anno, 1983). Holly also listed (and sometimes read) children’s literature that involved a topic or issue under discussion. This especially happened in the class devoted to multicultural issues.

*Guest speakers.* Finally, in what might be described as a combination of a model teacher and a resource presentation, the class visited the classroom of Bob Cooper (a cooperating teacher in the strand) where he described some activities that he has borrowed or developed (e.g., tangrams, magic base two cards, Family Fun, geoboards). Bob used
the activities as examples of how he practices his beliefs that problem solving should be the driving force behind the curriculum and that children can develop their own strategies. He also critiqued resources on their strengths and weaknesses with respect to that theory.

Also, Nan Franklin, a doctoral student in language arts education, spoke to the interns about multicultural issues. In that presentation, she talked about being sensitive to how people from other cultures might act in a classroom situation and that activities in the classroom should accommodate those cultures. Little of the presentation was directed toward mathematics (except a few minor references to addition and subtraction).

Activities

The second most prominent portion of in-class events consisted of mathematical activities suitable for children that were either done by the interns in groups or by Holly leading the interns. Sometimes, an activity was followed by a discussion about the purpose of the activity and/or about actions performed by the interns during the activity.

Holly looked upon the activities as the bulk of the course and the biggest source of learning. She described the course itself as a "taster course" (interview, December 11, 1992), in which the interns can choose to take and try activities that they deem appropriate.

Holly held two major purposes for the activities. One was the general goal of challenging the interns' ideas about learning and teaching mathematics through exposure to ideas that were contrary to what they had had when they entered the course. In particular, Holly wanted the activities to show the interns how manipulatives were
important in learning mathematics. Her second purpose was part of her effort to provide
the interns with a repertoire of different ways to teach different topics across grade levels.

The activities, as observed in class, appeared to serve the two purposes given by
Holly. However, a third purpose was gleaned from some of the activities intended for
children: to engage the interns in mathematical problems of their own. This third
purpose was never articulated by Holly, but it was achieved because of the nature of the
discussions during and/or after the activities.

Illustrations and support of guidelines. Some of the activities experienced by the
interns reviewed or supported points made by Holly and/or the textbook. A notable
example of this was an activity that the interns did after Holly's suggestion that teachers
need to formulate worthwhile tasks for students. To illustrate what a worthwhile task
was, the interns were grouped and given two problems to solve. One was to find the
area of a rectangle given its length and width. The other was to find the dimensions of
a rectangular dog pen that would give the most running space (illustrated in the 1991
NCTM Teaching Standards). Following the exercise, the interns were asked to describe
the differences in their thought processes while they solved the two problems in order to
illustrate what a 'meaningful problem" was. Another example occurred when the interns
spent a class period peer-teaching each other. According to Holly, the purpose was for
the interns to spend time planning an activity described by Marilyn Burns and then
presenting the activity for their colleagues to do. Here, Holly was asking the interns to
act out points she had made about planning as well as to actually engage themselves in
activities involving probability, which had been the content emphasis in the previous
class. Other activities done in support of guidelines included the solving of problems in Bob Cooper's classroom and diagnosing computational errors.

*Activities to use with children.* Many of the activities were examples of ways to teach certain topics. After a short presentation, discussion, or video about the importance of the topic, activities were presented in a variety of ways: sometimes interspersed within talks, sometimes demonstrated by Holly and the interns in the roles of teachers and students, and sometimes performed in groups by the interns themselves. One example of a series of activities was during the class on data analysis. After a video (Garfunkel, 1988) to motivate the inclusion of data analysis in the curriculum, Holly led the interns through a series of activities and guidelines that dealt with collecting, presenting, and analyzing data from the publication *Used Numbers* (Russell, 1990). Another example was a series of activities to illustrate how calculators could be used for operation skills, estimation, and patterns.

*Activities for children that were problems for the interns.* Holly sometimes suggested activities that focused more on the mathematics rather than on the teaching and learning of mathematics. Usually, the interns worked in small groups to solve the problem and then discussed their answers or methods of solution. One example of this type of activity included the second day devoted to patterns. On this day, there was a short discussion on why patterns are important in the curriculum. Holly then gave an example of deriving an inductive pattern and split the interns into groups to do the same with different problems. When the class reassembled, Holly asked each group to describe how they discovered the pattern for their problem and its general term. Later, Holly described the
idea of a "function machine." Other examples of this kind of activity included calculator activities, geometry problems involving pentominoes and tangrams, and a geometry problem intended as an assessment activity.

The emphasis on the mathematics of the activities rather than the pedagogical implications of them appeared to be unintentional. Although one of Holly's criteria for a good mathematics teacher was that their subject matter knowledge was deep and true and that she was concerned about the interns' possible lack of subject matter knowledge, she did not feel that the role of the course was to develop that knowledge, but rather to take concepts already developed in the interns and put them into action in the classroom.

Videos

The third and final major component of the in-class portion of the course was videotapes. The class viewed six videos during the quarter, in all but one case having discussions before or after the video.

For four of the videos (Burns, 1989a, 1989b; Fennell, 1989; Kamii, 1989) there was one purpose, according to Holly: to challenge or replace the imprint of teaching mathematics held by prospective teachers through exposing them to alternative models and ideas.

Each of these four videos actually had its own specific purpose in illustrating alternative models of teaching and learning. The Fennell video was shown to exhibit various learning environments that support the four tenets of the Standards. The Kamii
video exhibited argumentative discourse within a class and the teacher's actions within it. The two Burns videos illustrated teachers' questioning techniques and making mathematical connections, respectively.

The other two videos (Corser & Gardner, 1989; Garfunkel, 1988) had purposes other than alternative models of teaching. The data analysis video (Garfunkel, 1988) was intended to supplement the *Standards* in convincing the interns to include data analysis in the elementary school curriculum. The video exhibiting Japanese and Chinese mathematics education (Corser & Gardner, 1989) was intended to illustrate how these cultures look at learning and teaching mathematics, with particular emphasis placed on the responsibilities placed on teachers in the United States as opposed to those placed on teachers in Japan and Taiwan. Following each video (except the second Burns video), there was a lecture/discussion of what the Holly and/or the interns saw as the most important points about the video.

*Textbook*

Holly explicitly discussed the textbook's (Reys, Suydam, & Lindquist, 1992) content only with respect to teaching computation and planning for instruction. She expected the interns to know the main ideas of a chapter before they came to the class involving that chapter and, in the first few classes, asked them to write five-minute summaries of what they read. But she felt that what the interns did as opposed to what they read was most important for their learning. Overall, Holly was disappointed in the book and was not sure how much the interns read for connections between the book's points and the activities presented in the book and class.
Assignments Given for the Course

There were specific assignments given to the interns for the determination of their grades. Two of the assignments were mandatory and the interns were to choose at least three of nine "optional" assignments.

The following is a brief description of each assignment (see Appendix B for the complete syllabus description):

Mandatory assignments.

1. Attendance and participation.

2. Lesson Plans and Teaching. The interns were to plan for and implement four mathematics lessons (two 2-day units) during their field experience.

Optional assignments.

1. Review of articles. The intern was to read, summarize, and comment on three journal articles about elementary or middle school mathematics.

2. Learning log. The intern was to keep a log of the development of her understanding of mathematics teaching and learning.

3. Math resource file. The intern was to collect at least 50 activities, games, and ideas from at least five journals and books.

4. Mathematics and literature project. The intern was to design, implement, and report on a lesson that used literature to approach mathematics. The intern was allowed to include this as one of her 2-day units.

5. Student case study. The intern was to select, observe, and interview a child and document his or her development of mathematical understanding.
6. Small group project. A group of interns was to prepare and engage the class in an activity to develop a skill or concept.

7. Learning center. The intern was to prepare and implement a learning center including at least five activities that contribute to the understanding of a concept or skill.

8. Classroom observation. The intern was to observe the mathematical activities students were engaged in in the field classroom, interview the cooperating teacher as to the rationale behind the activities, and report what the intern would maintain or change.

9. Reflective self-assessment. The intern was to have herself videotaped teaching one of the mini-units and note the strong points, what she would improve, and what her students thought they learned.

Holly developed these activities by reviewing what other math methods instructors in the strand had done. She wanted the interns to be able to choose what they wanted to do because she wanted the assignments to be as meaningful and beneficial to them as possible. She also wanted them to try different ideas in the field to give them experience and, perhaps, success to encourage them to try more things in the future.

Despite giving the interns options, Holly did have some assignments that she especially hoped the interns would select. She wanted them to do the resource file (to help accomplish the course goal of making them aware of resources), the mathematics-literature project (to connect to the literature-based strand), the small group project (to put interns' minds working together), and the learning center (to bring together several activities involving the same concept or skill).
The Course's Treatment of the Variables

Throughout the quarter, there were several messages about the areas of mathematical beliefs that the study assessed with the three interns: (the nature, curriculum, learning, and teaching of elementary mathematics). Some of these were explicitly intended by Holly while others were observed in the class by the researcher.

Instructor's Intentions for the Variables

In our interviews, Holly stated specific intentions with respect to the messages she wanted the course to give the interns with respect to the curriculum, learning, and teaching of elementary mathematics.

Because she did not feel the course's role was to teach mathematics, Holly did not intend the course to address the nature of mathematics. She felt that the course should instead address mathematics topically and try to show prospective teachers how broad elementary mathematics could be. Holly felt that the interns saw elementary mathematics as little more than arithmetic and she wanted to expand their ideas by making them aware of the importance of other areas of mathematics. She also hoped that the interns learned that there exists a deep basis of patterns in mathematics.

With respect to the curriculum of elementary mathematics, in addition to wanting to show the interns how broad mathematics is, Holly wanted to convince them that certain topics like geometry and data analysis should not only be taught, but emphasized in the elementary grades. She then wanted to give the interns ways to go about teaching those topics.
Holly had two major goals for the interns with respect to how children learn mathematics: that they see learning as a developmental process and that children must be given the opportunity to experience a concept in many different ways. Holly hoped these ideas would connect well with the "whole language" movement emphasized in the strand’s language arts philosophy. For example, she wanted to stress the environment presented in *Math Their Way* as well as the Burns and Kamii videos with respect to developing the whole child.

Holly held more course goals about the teaching of mathematics than about any of the other four variables. She indicated that she wanted the prospective teachers to have flexibility in teaching, know sources of activities, and, most importantly, change their imprint of what a mathematics classroom can be like.

Holly attempted to achieve these goals about teaching through both actual examples of alternative classroom environments with specific teacher actions and lectured guidelines on the role of the teacher.

*Observed Messages About the Nature of Mathematics*

Despite Holly’s intention that the nature of mathematics would not be dealt with, there were several messages about the nature of mathematics within the context of the course, although there were not as many messages as there were for the other three areas. These messages involved the definition of problem solving, the role of problem solving, the importance of strategies and community discourse, and the role of patterns in mathematics.
Messages about the definition of problem solving. There were several messages from the course that were consistent with the Standards' view that mathematics should be looked upon as a process of problem solving. That is, all of mathematics should be presented as situations that have no algorithmic method of solution.

With respect to the meaning of problem, Holly illustrated the difference between an exercise and a problem by having the interns work on two situations relating area and perimeter of rectangles. As was previously described, Holly asked the interns for their thought processes after each activity. The interns who participated responded differently with each situation ("memory of a formula" with the first situation and trial and error in relating area to perimeter in the second).

Messages about the role of problem solving. The best example of the message about mathematics as equivalent to problem solving was during Bob Cooper's lecture that problem solving should be at the heart of any mathematics the interns teach:

The main goal that you want to have is to start with problem solving. Don't worry if they can add and subtract - start with problems that they're able to understand what you're wanting them to do. Let the problems dictate the curriculum. When you and I were taught at the elementary level,....you didn't really have to use a lot of intelligence, just a lot of predictability - you had to add and subtract. My premise is that you start with problems. And lots of resources have them....Now they have a reason to learn adding and subtracting....Use it so they can be comfortable doing problems. (class observation, November 12, 1992)

Holly also advocated that problems be given to or developed by students that involve investigations involving many areas of mathematics to answer questions of interest. Holly
said in presentations on patterns and geometry that students should formulate their own questions and develop and put into action methods to go about answering those questions while teachers guide students in those actions.

Messages about the importance of strategies and community discourse. A related area where messages about the nature of mathematics were given involved the importance of the development of problem-solving strategies and the role of the community toward that end. For example, Bob Cooper, with several examples from his own class and from sources such as *The Problem Solver* (Hoogeboom & Goodnow, 1987), said that children learning to develop their own strategies for solving problems and communicating those strategies to each other should be the most important goal that teachers hold for mathematics.

This message was also made through the Kamii videotape. In it, the interns observed children communicating different strategies to solve the same arithmetic problem. The children often disagreed with one another's strategies and resolved those disagreements through reasoning. The interns also saw students communicating their strategies during the two Marilyn Burns tapes.

The idea that, through communication, there may be more than one method generated to solve a problem was explicitly talked about by Holly several times throughout the quarter. For example, Holly discussed the Standards' tenet about communication being an essential part of mathematics. She asked the interns why they thought communication was important. One intern gave a response that one can then look at mathematics from many different angles. Holly expanded on that response by pointing out that if only one
method (from an authority) is used to solve a problem, people would come to rely on that authority for their mathematical knowledge. Whereas if people "fought through [their] confusion" (class observation, October 1, 1992) and developed different methods of solution, then the people could gain different perspectives through the communication of those methods.

Messages about the role of patterns in mathematics. Finally, the course gave explicit messages about the importance of patterns in mathematics. Holly placed a strong emphasis on number patterns through both lectures and activities. Holly introduced patterns as being an important component of all mathematics:

The theme that is underlying mathematics. And a child sees as they are growing and observing the world - they begin to see repetition. Everyday they get up there's that wonderful babbydoll that they recognize or their mom. In the early days, people saw day and night... That's how they began to make order out of the world. We have patterns. They start looking at patterns. That's how we got control - at least if we can call it control - at least an understanding of science. It's like we see things that repeat and recur again and again... I was thinking, "Why is it that patterns are so important?" They give you a way to predict... You have the power of predictability - you have some control. (class observation, October 1, 1992)

In conclusion, the course gave many Standards-like views of the nature of mathematics with respect to what mathematics consists of (i.e., a holistic area involving patterns and problem solving) and how one does mathematics (i.e., reasoning about and communicating strategies in the process of solving problems).

Observed Messages about the Curriculum of Elementary Mathematics

As with the nature of mathematics, several Standards-like points were made to the interns regarding what the structure and topics of the elementary school mathematics curriculum should be.
Messages about the structure of the elementary curriculum. There were several messages from the course that were conducive to the view that the NCTM Standards has of the elementary school curriculum. First, as was previously stated with respect to the nature of mathematics, Holly tried to advocate a holistic curriculum, arguing in the first class that behavioristic outlooks by teachers bring about a curriculum that is split into pieces that students must master sequentially. On several occasions (e.g., discussions about the Standards, calculators, investigations using data analysis, and assessment guidelines; the second Burns video) she argued that, instead, students should learn mathematics through relevant problems that involve a number of mathematical ideas. For example, in that first class, she offered an example of a teacher who, like Kamii, had the class learn mathematics through events that occurred in the classroom.

Messages about topics to be included in the elementary curriculum. The course also emphasized including specific concepts and subjects in addition to the traditional arithmetic algorithms in the elementary curriculum. Even with respect to computation, throughout the quarter, Holly emphasized number sense, estimation, and mental arithmetic as curricular goals in a number of lectures and activities. These included number pattern activities, her lecture on Kamii's students and games, and calculator activities.

Also with respect to computation, Holly emphasized the need for children to understand place value concepts and indicated that one should consider place value as not something that should be easily learned early on, but rather as an ongoing developmental
process throughout the elementary curriculum. For example, she talked about research results indicating that children often know the semantics of place value, but not the concepts.

The course also featured subjects that are not usually emphasized in elementary school mathematics: data analysis and geometry. Holly used the statistics video to try to convince the interns of the importance of statistics and probability in elementary school. Then, she showed and/or involved the interns in activities involving descriptive statistics and probability. Holly also encouraged the interns to involve their students in investigations of their choosing involving data analysis and gave guidelines for such projects.

Holly later emphasized the inclusion of a significant amount of geometry in the curriculum. She had the interns come up with several geometrical concepts (e.g., attributes and names of two and three dimensional shapes, measurement, symmetry) while she gave them examples of several activities and books that pertain to the concepts. Then, over two classes, Holly had the interns do several problems (with respect to the interns) that developed spatial sense.

In conclusion, Holly made a significant effort to convince the interns to emphasize patterns, data analysis, and geometry in a holistic curriculum, along with treating the traditional topics conceptually.

**Observed Messages about Learning Mathematics**

The course presented theoretical and practical messages about how children learn mathematics and the nature of environments that should be established for learning.
Course's explicit theoretical message about learning mathematics. In the course, I observed only one explicit message with respect to a philosophy of how children learn mathematics. This occurred in the first class with the presentation on behaviorism versus constructivism. In it, Holly presented an argument that behaviorism drives instruction in the classroom by breaking up what we want children to learn into small procedural objectives. This splitting up of the curriculum then would lead teachers to teach math piece by piece by just lecturing a set of steps for performing each procedure to the students. From this line of reasoning, Holly implied that a behavioristic philosophy was the reason the interns experienced mathematics in the way they described.

With constructivism, Holly noted that it is in line with the mathematics education community's philosophy of learning. She brought up the notion of Davis's (1984) frame theory:

This says that you've got to look at teaching in another way. It's got to be more than clear; it's got to be more than telling them what to do. Because my saying it, my lecturing it might have nothing to do with their learning it. Because research is showing us that children construct their own knowledge - they construct their own understanding.....What we feel is happening now, what we in summary would say how children are learning math is that when they hear, when they get something new, especially some challenge, some question that you give them, they have to accommodate that new thing, that new insight. Now, if they have in their mind a place to hook on that learning, it'll probably stick;....if it doesn't connect with something that's real to them, it'll probably slip away. If they can't accommodate the new thing and it keeps coming at them and they've got to accept it, then there's an adaptation. This can cause an entire mind shift. (class observation, September 30, 1992)

Beyond this presentation, as well as a short noting of the progression toward recognizing patterns in classifying things, a short talk on Kamii's philosophy, and a short
discussion on manipulatives, there were no other explicit discussions about philosophies of how children learn mathematics. However, some messages about learning were recurrent throughout the course.

*Messages about mathematical learning environments.* The first theme that occurred often in the course was that students should be in an environment where they are given the opportunity to explore mathematical concepts and/or explain what they have found. For example, Holly encouraged the interns to allow students to investigate questions of their own making by devising how they were going to go about answering the questions. Other explicit inquiry-based messages were found in Holly's presentation on the need for data analysis and Bob Cooper's many examples of his students doing real problems and explaining their strategies. Still other examples came in lectures and discussions of environments that were shown in videos as well as the *Math Their Way* reading.

During the second pattern and second geometry classes, the interns experienced such environments as learners. While the problems were in progress, I observed the interns in what appeared to be excellent mathematical discourse: arguing why a particular way of looking at a problem modelled it well, showing different methods of attack, and so on.

*Messages about students' ability to solve problems on their own.* Another message that occurred frequently in the class was that if children are given the opportunity to explore problems, they will eventually come up with solutions. Sometimes Holly did this by real life classroom examples. One of these examples was a description of a friend's efforts with low ability children in working with circle models to develop the need to find a common denominator when adding fractions. The friend's students began to gain
confident in themselves to the point of asking their teacher not to tell them how to do problems. Still other examples were the many points given by Bob Cooper of not underestimating students' abilities to come up with different strategies for problems, such as inventing different figures with a given area.

At other times, Holly simply assured the interns that the students will figure problems out themselves. For example, while describing activities involving even and odd numbers, she told the interns that, as long as they give the students freedom to explore and guide them with good questioning, the children will be willing and able to explore number patterns and discover general rules for them.

*Non-recurrent messages.* Other messages given to the interns with respect to learning mathematics were not so recurrent, usually explicitly discussed only once. These messages included that children know a great deal of mathematics coming into school, that students should be exposed to a variety of modes of teaching, that one should teach conceptually, and that getting the right answer to a question does not necessarily imply that the student understands.

In conclusion, Holly and the course explicitly advocated a constructivist learning environment in which students are encouraged to investigate and solve problems among themselves.
Observed Messages about Teaching Mathematics

The course presented messages about the general role and specific actions teachers should take in a mathematics classroom. Holly attempted to present a Standards-like vision through both examples of alternative classroom environments and presented guidelines.

Messages about the general role of a teacher. Holly talked about the general role a teacher should take in a classroom three times during the quarter. The first was during the presentation on the Standards; the second during the talk on the goals of data analysis; and the third during the presentation of guidelines on assessment. All of these discussions emphasized the need for the teacher to provide opportunities for students to solve worthwhile problems on their own and foster the growth of a mathematical community by holding the role of a guide while students are solving the problems. Holly especially emphasized that teachers should not tell the students how to solve the problems. For example, she said during her talk on using data analysis in the classroom, "Your job is to... not decide for them, but guide them in deciding what data to collect and how to get it" (class observation, November 4, 1992). Within her guidelines on assessment, in addition to having teachers provide problem situations, Holly also noted that teachers should use multiple assessment techniques with students.

Messages about specific actions teachers should take. Holly's other messages regarding how one should be a teacher of mathematics involved specific actions that teachers can take within these roles. These actions were usually given as alternatives to the traditional role of transmitter of algorithms.
For example, Holly held a discussion following the Kamii tape about the teacher's actions. Holly appealed to the interns' background of having teachers only questioning an answer if it was incorrect. She then noted that the teacher in the tape was not leading the students toward the answer by performing steps on the board through leading questions, but, instead, it was the *children* doing all the thinking and reasoning to solve problems. Finally, Holly pointed out the teacher's use of wait time to allow students the opportunity to think and respond to each others' methods. Holly indicated to the interns that these actions lead to consideration of the question of what an expert teacher does: solving as many problems as possible during a class versus something closer to what was seen in the video. A similar discussion of teacher actions followed the first Burns tape.

Holly also emphasized the importance of the questioning a teacher does in the mathematics classroom. First, she described goals of asking questions (e.g., working together to make sense of mathematics) in order to engender the interns' thinking. Holly put a list of these goals on the overhead and went through each by supplying examples that would work toward accomplishing the goal. Second, Holly talked about the idea that the ways a teacher *states* questions can sway students away from their own thinking. Holly gave examples that illustrated how things such as inflection, leading questions, and yes-no questions can be debilitating to a teacher's intentions to get students to think.

Bob Cooper also had several messages for the interns involving what they should do and think when they are teachers in making problem solving the focus in the classroom. For example, he described how he allows his students to both practice strategies he has modelled for them and then allowing them to develop their own strategies in solving
problems. Bob suggested that the interns try problems themselves to decide what their students could both learn and handle. To illustrate this, he had the interns work with tangrams. He had them do problems with only four or five pieces first to point out, because the interns had trouble with the problems, their students may not learn as much with all seven pieces at first.

In summary, the course presented several messages about the nature, curriculum, learning, and teaching of elementary school mathematics. These messages, some intended by Holly and some observed through the course proceedings, appeared to concur with the perspective of the variables given in the Standards documents.
The Case of Amanda

*Personal History*

The intern interviewed from the group with the highest scores of confidence, self-efficacy, and mathematics background was Amanda. Amanda was a 21-year-old, newly married senior majoring in elementary education. She was a person who wanted everything from her clothes to her coursework neat, organized, and well-planned. For example, she often took notes in class and went home to rewrite and reflect on them, sometimes for the purpose of preparing for our interviews. She enjoyed doing the interviews and treated them as a further opportunity for growth.

Amanda's mathematical experiences prior to the course were very traditional in both curriculum and pedagogy. She learned mathematics as a sequential subject: mostly the basics in elementary school and junior high; and separate courses in algebra, geometry, and calculus in high school. She also took the two mathematics content courses for elementary teachers. Amanda described what she recalls about her elementary school curriculum:

> Addition, you know - you start out real basic. Well, I remember talking about sets and then like adding sets, subtracting sets, and then we’d go on to like multiplication, division, then long division....And then a lot of story problems....Each step, you know? (interview, September 21, 1992)

With the exception of her senior year calculus class, Amanda mostly learned mathematics through the teacher explaining how to do a type of a problem, her doing similar exercises on her own "to get used to the problems" (interview, September 21, 1992), and finally presenting the exercises on paper or at the board if called upon.
Amanda depended on her teachers or parents to show her how to do a problem. If she got stuck, she would put a question mark next to the problem and ask her teacher or parents later. However, after doing the same type of problem a number of times, Amanda usually did not need help. She prided herself on completing lengthy procedures correctly:

I loved long division....because I loved that one problem could take up this much space and you had a remainder....I was able to put all those numbers on a piece of paper and come up with the right answer. You know, because you had to keep on subtracting and then the next line, the next line, the next line. And you had to keep everything straight in each column. (interview, September 21, 1992)

Amanda’s comments about the effectiveness of her teachers centered around three attributes. First, Amanda felt that her best math teachers were those who could explain the material to students so they could understand it with minimal frustration. For example, she told of how wonderful her teaching assistant was for both content courses for elementary teachers because he explained every problem "step-by-step" (interview, September 21, 1992) until everyone in the class understood.

Second, Amanda also felt her best teachers were those who made the mathematics relevant. For example, she recalled her seventh grade teacher always made up stories about his car, making the students take information from the story and solve a problem. On the other hand, Amanda believed that high school mathematics was difficult to put in terms of real life. Therefore, she did not fault her teachers for not bringing relevance to those courses.
Finally, Amanda noted that her best teachers were in tune with students' feelings. For example, her second grade teacher was interested in knowing Amanda as a person rather than as a child.

Amanda felt that the only bad experience she had in mathematics was in her senior year calculus class because her teacher was poor on all three of the above guidelines. He expected students to understand concepts (such as integration) by reading the chapter. This was difficult for Amanda because she was not used to learning mathematics from textbooks and the material was not applicable to her life. She also thought that her teacher was cold and not concerned about her learning.

Despite this experience, Amanda would change little of her overall mathematical experiences with respect to curriculum, teaching, or learning because of her success in them. She indicated, however, that she would want to have more one-to-one interaction with her elementary teachers. She particularly wished her teachers would have circulated around to see how each student was doing on a problem and show him or her how to solve it if there was difficulty. She also wished there was more group work so she could have learned classmates' methods of solving problems (although she also thought it was good to just do problems the teacher's way because the teacher could then tell exactly where students made errors).

Beliefs

Parallel to her traditional personal history, Amanda entered the methods course with mostly traditional beliefs about the nature, curriculum, learning, and teaching of mathematics. She did seem to have some Standards-like beliefs about the learning and
teaching of mathematics, but her beliefs about the nature of mathematics seemed to be blocking the development of her pedagogical beliefs. These beliefs changed a little by the end of the quarter (see Table 4.1), particularly toward allowing students to attempt problems on their own before teacher intervention.

*The Nature of Mathematics*

**Definition of mathematics and problem.** Amanda entered the course believing that mathematics was a sequential subject in which one had to learn basic ideas and skills before tackling more advanced ideas. For example, she talked about her Math 105 course as being good because it was taught in sequence: "You just went through and started from the beginning at ground zero and just built up" (interview, September 21, 1992). Amanda also felt that mathematics was different than other disciplines, such as the social sciences, in that one needs to learn one skill before learning another.

Amanda's conception of the process of problem solving was like her conception of mathematics: sequential. She felt that problem solving meant being able to follow a predetermined process through its conclusion, with the more steps, the more difficult the problem:

> You're given a situation, whether it be a mathematical equation or any situation, and you work through it like the way that you know how. You know, if it’s like a certain sequence or procedure that you're supposed to follow and see if you get the right answer. And if you don't you go back to see what happened: what went wrong or where did you fall apart. (interview, September 21, 1992)

For example, Amanda stated that the most important thing to know in solving multiplication problems is the process of the traditional algorithm (e.g., knowing how to carry).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Entering Beliefs</th>
<th>Exiting Beliefs</th>
<th>Changes</th>
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| Nature of Mathematics            | 1. Math is sequential discipline.  
2. Solving problem = Following predetermined steps.  
3. Need external authority in doing math.  
4. Relevance essential.          | 1. Math is sequential discipline.  
2. Solving problem is solving puzzle or following predetermined steps.  
3. Need to try to solve first before consulting authority.  
4. Relevance essential.          | More open to trying to solve problems first before referring to authority.                                                                                                                                       |
2. Dominated by ASMD procedures taught in sequence.  
3. Other topics for diversion only. | 1. Preparation for everyday life.  
2. Dominated by ASMD procedures taught in sequence.  
3. Include more statistics and geometry.                                                                                                             | Would include more descriptive statistics and geometry as her field experience class did.                                                                                                                   |
| Learning and Teaching Mathematics | 1. "Hands-on."  
2. Learn sequentially by building on basic skills.  
3. Knowledge comes from teacher: need explanation if can't solve it right away.  
2. Learn sequentially by building on basic skills  
3. Teacher is problem solving model; students discover first before teacher steps in  
4. Affective variables dominate: No frustration; teacher enthusiastic and motivating. | Teacher acts as model for solving problems. Students try to discover on own before teacher steps in to explain. Teacher is reflective. Referred to her field experience. |

Table 4.1: *Amanda's Entering and Exiting Beliefs*
At the end of the quarter, Amanda appeared to enjoy the "puzzle" aspect of problem solving:

Researcher: What aspects of math do you like?

Amanda: The problem-solving parts. Like when we did those tangram things and we were trying to figure out all the different ways that you could put those together....That part is my favorite. (interview, December 10, 1992)

Although this may indicate that she showed signs that mathematics was now more of an open-ended problem-solving process, she also still felt that the problems one solves have predetermined steps that one knows or needs to find out. For example, she defined a person who understands mathematics "as being able to solve the problem that they're working on, and knowing the right steps to take to get to that point....I know that's very basic, but just that they know the right procedure to solve that problem" (interview, December 10, 1992). She also still thought that the most important things to learn about multiplication were the steps of the standard algorithm and basic facts.

The need for an external authority in doing mathematics. By the end of the course, Amanda changed slightly in her belief that if one does not know the steps to solve a problem or the reasons behind a concept, one should appeal to authority to find out. For example, at the start of the course, she indicated that someone good at mathematics was one who was knowledgeable in the skills, but knew where to look when the person cannot solve it right away. This belief in the need for an authority was also evident in her responses to hypothetical situations in which students notice a particular mathematical
phenomenon. First, she would assume the student was asking for an explanation. So, Amanda would try to reason it out herself. If this proved difficult, she then would refer to a book or someone who could explain it.

At the end of the quarter, Amanda still thought it was important for people who unsuccessfully attempt to solve a problem to turn to a source that can solve the problem for them. However, she now thought it was important for a person to try to solve the problem on their own first. For example, she still believed that someone who is good at mathematics knew what resources to turn to, but now would try what was familiar to him or her before referring to an authority; but a person who was not good at mathematics would only wait until someone exhibited steps toward a solution.

However, she also maintained her view that someone who does not know the steps to solve a problem should eventually seek help from one who could demonstrate a solution or restate the problem in different words. For example, Amanda herself continued to look for outside sources for solving problems when she was given the hypothetical situations of students noticing a phenomenon. She also still assumed the student wanted Amanda to explain why the phenomenon occurred and, if Amanda could not explain it, Amanda would try to go to a source for information.

*The need for relevance in mathematics.* Finally, Amanda consistently considered math to be worthless unless one can use their math skills in real life, which to her usually meant in using money or cooking. She indicated that a person who was doing math
outside of school was "figuring a tip at a restaurant...Or if you went to a store, figuring change at a cash register. Or balancing your checkbook. Those I see out of school, just banking in general" (interview, September 21, 1992).

In particular, Amanda exhibited this conviction for everyday relevance when she said that the most important thing that one should get out of elementary school math was the preparation for real life problems. These real-life problems, however, still only involved money for shopping, balancing checkbooks, and the like.

At the end of the quarter, Amanda appeared to have maintained this belief:

**Researcher:** What do you think are the most important reasons for including math in the elementary school?

**Amanda:** Because they need it.

**Researcher:** Why do they need it?

**Amanda:** Because they need to learn those problem-solving skills and they need to learn how to add and subtract.

**Researcher:** Why?

**Amanda:** Because they're going to add and subtract everyday. Like if they go to the grocery store or if they want to order something from a magazine or paying their bills....Remembering phone numbers - like chunking numbers together. Baking - they need to know how to double a recipe or cut a recipe in half or whatever. (interview, December 10, 1992)

In conclusion, Amanda's core beliefs about the nature of mathematics changed little from the beginning to the end of the quarter. She continued to believe that mathematics (and problem solving) is a sequential subject, that a mathematics problem could be something one already knows the steps to (or should appeal to an authority if stuck) and
that important mathematics consists of what is relevant to a person's everyday life. However, she did appear to begin to consider problem solving as an open-ended process, where one may try to attempt solutions before appealing to an authority.

The Curriculum of Elementary Mathematics

The dominance of traditional arithmetic. Both at the beginning and end of the quarter, Amanda's beliefs about the curriculum of elementary school mathematics fit well with her beliefs about the nature of mathematics. They were largely traditional, supporting her purpose of elementary school mathematics as a preparation for day-to-day life (i.e., money and baking). In line with this purpose, the basic skills of addition, subtraction, multiplication, and division (ASMD) dominated her curriculum, which she appeared to base on what she had experienced as a student:

Researcher: What do you feel are the MOST important topics there are to learn?

Amanda: Well, definitely addition and subtraction and multiplication and division. And like shapes...and I think we did things with angles, like if things are obtuse or acute. I think that helps in your perception, like things that are larger or things that are smaller. And so a little bit of geometry.

Researcher: What other topics do you think are important?

Amanda: It's hard to remember the subjects there are! Probably a lot of things about money....Also converting the measurements. You know, in baking....So I think it's important to start introducing those types of things: the different relationships between different systems of counting or money....Measuring like with a ruler and stuff like that. That would be another. (interview, September 21, 1992)

Within ASMD, Amanda's main goal of learning multiplication, for example, was to eventually learn the process of multiplying large numbers. She thought that it was the
foundation for learning other mathematics, "because if they don’t have that, they’re not
going to have any success for using it. If they don’t know the basics for how the
problem is done, then they’re not going to be able to do the rest" (interview, September
21, 1992).

In planning to teach multiplication, in line with her beliefs about the nature of
mathematics, Amanda would proceed in a sequence. She would begin with the basic
grouping concept of multiplication, and then develop the basic facts from the concept.
Then, she would go on to spend a great deal of time on multiplying two digits by one
digit, two by two, and so on. She would do most of this symbolically:

So I guess I would just want them to understand, like, the standard
process....like carrying the numbers and adding them on....because I think
that’s a very confusing step for a lot of students. So I would spend weeks
on it. (interview, December 10, 1992)

Finally, Amanda would then have the students do relevant "grouping" story
problems, with the amount of story problems growing as they became more comfortable
with the facts and procedure.

Inclusion of other topics. Amanda’s view of the role of other topics, such as
geometry and data analysis, in the curriculum was slightly altered by the end of the
quarter. At the outset of the course, Amanda had little to say about other topics that
should be included in the curriculum. For example, it appeared that the role of
probability and statistics had not occurred to her because of the curriculum she had
experienced. She didn’t think it should play a major role other than as a fun thing to
introduce beyond arithmetic and see how they grasp it. If her students were picking up
on it, she would expand; otherwise, she would stop.
By the end of the quarter, Amanda felt that some descriptive statistics should be included, with an emphasis on classifying, sorting, and representing data (with graphs). These beliefs also appeared to stem from her field experience in which the students were involved in such activities.

Her ideas of what geometry should be included changed from only knowing shape names to learning attributes of different shapes. This idea appeared to come from her experience in leading an activity in her field classroom in which students investigated attributes of three-dimensional objects.

Despite her emphasis on including geometry and statistics in her curriculum, Amanda still felt that arithmetic should dominate the elementary curriculum, although statistics should be emphasized more and more as the grade level increases.

In conclusion, it appeared that Amanda's beliefs about what should be included in the elementary school curriculum changed somewhat in that she was more willing to include probability and statistics as well as geometry in her classroom. This change probably resulted from her field experiences with these areas. However, she still maintained that arithmetic should dominate the curriculum with the major goal being computational efficiency in the standard operations.

*The Learning and Teaching of Mathematics*

*A mixture of discovery and transmission learning.* Amanda's experiences working in a preschool at a day-care center and her previous foundations of education and educational psychology courses led her to begin to look at learning as student-centered and open-ended experiences based on discovery. She indicated that she enjoyed seeing
children at the preschool being involved in new experiences learning things they haven't seen before, although sometimes this meant a teacher telling them information, such as where milk comes from.

Accordingly, at the beginning of the quarter, Amanda envisioned her future students learning mathematics through the use of hands-on activities such as:

- Tracing shapes, cutting them out, and taping them on a piece of paper where they go. Or imagining apples that have halves cut and you have to match the 2 parts to create a whole apple. So they can recognize shapes and create a whole one. (interview, September 21, 1992)

These beliefs about children learning in an active environment sounds like the beginning of a transformation from a traditional background to a Standards-like perspective. However, many core beliefs stood in the way of a completely constructivist point of view at the outset of the course. These beliefs appeared to stem from Amanda's beliefs about the nature of mathematics that mathematics is a sequential subject and thus it should be learned sequentially and that one should appeal to authority when one does not know how to solve a problem.

Amanda believed that mathematics should be learned in a sequential manner. She defined learning mathematics as "building on previous skills that they already have....Problems that incorporate the skills that they already have and add new ones and expose them to different types of situations" (interview, September 21, 1992). To her, this meant that, before any discovery experiences can be brought into play, students need to learn the basics first. That is, the first few years of elementary school should be
devoted to the teaching and learning of ASMD with some geometrical and measurement facts and skills: "(Students) need to have accumulated all of those skills and (understand) each step of the way" (interview, September 21, 1992).

Amanda evidenced her incoming belief that mathematical knowledge comes from the outside in her consistently stating that one needs to show students how to perform certain skills and that students pick up on the skills the teacher is trying to get across. She felt her own mathematics content courses as a whole emphasized the need for good explanations from a teacher, "trying to get us to find ways to explain it and innovative ways to, you know, help these kids find the answers" (interview, September 21, 1992). She indicated that students cannot discover certain mathematical skills on their own and that a teacher needs to motivate the need for and demonstrate the skills step-by-step so the students can see the process.

In particular hypothetical situations, Amanda leaned heavily toward the teacher in the role as the authority. For example, with multiplication, she expected to teach the traditional algorithm by showing students the steps in order. Then, while the students would be practicing the algorithm, Amanda would expect only procedural questions that pointed the role of mathematical authority to her. And she would keep that authority by repeating the steps to them without considering the possibility of allowing the student to reason out the process alone or together with her.

By the end of the quarter, Amanda still felt that her students should learn mostly through being actively involved in the learning environment. However, she appeared to have taken this more to heart than at the beginning of the quarter. She now felt that a
good teacher should be a good model in beginning an activity, then be supportive and approachable while allowing the students themselves to explore and discover what is to be learned through the activity (while the teacher walked around assessing their learning). Amanda also felt that a good teacher should reflect on what occurred in the classroom and how he or she can improve the environment in the future. Much of this sounded like a description of what she experienced in the field during the quarter as well as echoing some of what she said at the beginning of the term. Amanda evidenced this belief in the hypothetical situations. In them, she appeared to be more willing to allow students to think of methods or reasons for methods to solve problems themselves than before the quarter.

However, Amanda did not completely hold to this belief. She sometimes still thought that a major part of a teachers' job was to be there to explain how to do and justify procedures sometimes before (and sometimes after) the students had tried to solve a problem themselves. For example, in the situation where a student noticed that anything to the zero power was one, Amanda tried to (unsuccessfully) come up with an explanation on her own before giving way and allowing the student to try to come up with one. But if Amanda did find an explanation from a source, she would immediately tell the student. Also, she would eventually show the students a way to do a problem if she deemed they were having trouble. For example, when discussing how she would handle teaching students an algorithm for multiplying two digit numbers, Amanda indicated that she would allow the students to develop their own methods first, then, if no success was observed, show them the traditional algorithm.
The overriding importance of affective issues. Amanda’s belief that math should be relevant to students also contributed to her views on the learning and teaching of mathematics, particularly with respect to an affective point of view. For example, at the beginning of the quarter, she noted the most important attributes of a good teacher of mathematics were enthusiasm for the subject, interest in the subject, and the ability to motivate students to want to learn the subject. Further, she adamantly wanted her students to view her as open and approachable, "not someone who won't give them the time of day" (interview, September 21, 1992).

Further, Amanda did not want any frustration to occur among her students; and, if it did, her students would feel free to approach her with questions to quell the frustration. For example, she believed that her best math student would be someone:

Who doesn't give up. Tries hard and doesn't feel frustrated. And if they get to the point of frustration, they're able to come talk to me. Because a lot of students would feel intimidated to talk to a teacher or they just don't want to, like 'I don't need to know.' But I would want that person to approach me. (interview, September 21, 1992)

Amanda maintained that affect plays a vital role in one's learning mathematics at the end of the quarter. In particular, she still emphasized that one needs to be motivated and enjoy good experiences from teachers in order to be good at mathematics. She felt that high school students become poor at mathematics because teachers do not take the time to work with them one-on-one and repeat material they are having trouble with, thus frustrating the students.
Therefore, avoiding frustration within students was still a major goal with Amanda and probably one reason she did not change with respect to the need for students to be shown procedures if they don't find one on their own:

*Amanda:* That's not necessarily bad as long as it's not frustrating and long. Just as long as you're not spending a long time on it because you just can't get it. I mean, you could know all the steps but it just takes a long time because it does. Versus if you take a long time because you just sit there and stare at the paper.

*Researcher:* Is it Ok to be confused in mathematics?

*Amanda:* ...To a certain degree. I mean, I don't think you should be left in a confused state. I think that someone needs to be there to bail you out if you're confused for a long time....I maybe would let them be confused for five minutes. (interview, December 10, 1992)

In summary, Amanda appeared to change somewhat in her beliefs about how children should learn mathematics and the role a teacher should take in the learning process. She felt that teachers should usually allow students to learn mathematics by trying to solve problems on their own while the teacher plays the role of providing relevant experiences and being open-minded with students' methods. These changes appear to have been a result of her field experience during the quarter. However, Amanda did not change in her beliefs that teachers should, at some point, show the students a way to solve a problem in order to quell any frustration, especially that may be damaging a student's motivation to learn.

*Expectations for the Course*

Amanda came into the methods course with confidence in her own mathematical abilities, particularly for what she perceived to be the main components of the elementary
school mathematics curriculum. This confidence in her subject matter knowledge came, most likely, from the success she had enjoyed all the way through her schooling. However, Amanda was concerned about having the ability to come up with activities for children to learn mathematics as well as her ability to "think on her feet" and be spontaneous in coming up with another way for students to look at a particular aspect of mathematics, indicating that "it was hard to have all of these different ways in your head" (interview, September 21, 1992).

Amanda also had concerns about the curriculum in that she could not remember what it was from her own background and that she wanted to learn at what levels each grade began and ended. She had further concerns as to how to split up the curriculum throughout the school year.

Therefore, Amanda's concerns coming into the methods course with respect to pedagogical knowledge were to obtain more knowledge on: explanation, the curriculum for different grade levels, ways to approach a topic, how to start a topic at the right level, different activities and sources, and be able to immediately assess what students are doing wrong.

Amanda's expectations for the course prior to the quarter reflected these concerns. These expectations were to build resources to teach a variety of topics, especially hands-on and discovery activities. This was so that she could effectively introduce topics and be spontaneous in responding to students' problems. Amanda also was expecting the course to provide her with the levels and ages for topics and activities to refresh her memory of when those things occur in the curriculum.
Course-Related Assignments

Amanda chose two of the non-field related assignments: the resource file and the review of articles. She took opposite views when talking about them. She felt the resource file fit in well with her expectations for the course. However, she felt cheated in that the resource file was only to consist of xeroxed copies from sources to be handed in, rather than constructions by her peers.

Amanda did the article summary because it was easy and that she "could get it done and out of the way quickly" (interview, October 9, 1992) so she could spend more time on the resource file. She put a lot of time into all her assignments except for this one.

As with her beliefs about learning, Amanda felt that assessment of the course should coincide with how children were assessed in the field. However, she felt that she was not being assessed on her growth, but on a criterion based on non-reflective aspects of the assignments.

Amanda's Field Experience

Description of the Environment

From my observations, Amanda’s field experience in Alice’s combined first and second grade classroom was conducive to a Standards-like philosophy that Alice embodied in my interview with her. Most learning took place through a theme that required the need for children to develop and use mathematical (and other) ideas.

For example, one unit was on apples. Each student brought an apple to the class. They described each apple in terms of its color, size, roundness, etc. and made comparisons of these attributes through histograms. Then, the students had their apple
cut in half, where they were asked to describe the two halves (symmetry) and count and compare the number of seeds in each apple. They were then asked to draw their apple (cut or uncut) and write about it. Alice and Amanda assessed the students through questioning them on what they found.

*Description of the Cooperating Teacher*

Alice had taught for 18 years, with approximately the last nine years in the strand or in programs similar to it. Her teacher education was also similar to that of the strand, only with an emphasis on science.

Alice’s stated beliefs about mathematics and its pedagogy mirrored that of the Standards. With respect to the discipline of mathematics in her class, she felt that problem solving was the most important aspect of mathematics to learn. She defined a problem to be something "that you want to understand better and explain" (interview, December 16, 1992). Her curricular goals were for her students to be involved in learning different strategies for solving problems such as acting out, making a list or graph, and drawing a picture.

Alice wanted her students to see mathematics in a broader scope than just arithmetic. This was because one uses mathematics in many different ways in everyday life, such as in estimating quantities and using probabilities. She also wanted her students to develop number sense as well as to work with patterns, sorting, classifying, and recording information in different numerical and geometrical situations.

With respect to learning environment, Alice’s students learned mathematics through involvement and reflection of the thematic units, such as the apple unit described above.
Alice believed that learning mathematics was a developmental process that each child must experience in his or her own way and timetable. Therefore, she made the activities so that each child could express his or her own knowledge on an individual basis. Alice hoped that the students would eventually develop independence in working with mathematics.

Within each activity, Alice typically would describe or demonstrate the activity for the students and then let them work in pairs. Alice would then wander around the room, questioning students on their findings with an eye toward assessing what and how they are developing their knowledge.

_The Cooperating Teacher's Expectations for Amanda_

Alice looked at the field experience as an opportunity for Amanda to experience students' learning in a real classroom. She wanted Amanda to learn how to observe children learning and to learn how to select and organize appropriate activities designed to enhance particular learning experiences.

Consistent with her philosophy about children's learning of mathematics, Alice felt that preservice teachers should not learn according to a timetable. She felt that interns should learn like they will encourage students to learn in the future. She expected the experience to fit an intern's understanding, needs, and comfort level. Therefore, Alice provided many teaching models and strategies for an intern and plenty of opportunities for the intern to employ them. She also modelled how to observe children learning and pointed out things to look for through the real classroom.
Because Amanda had experience working with younger children at the day care center and Alice could see that Amanda was confident, Alice placed more demands on her than she would most interns in their first major field experience. Thus, Amanda worked with students from the first day. She involved them with activities (not related to her university coursework) with little interruption from Alice. Later, Amanda organized her own activities by examining what concepts were to be dealt with and attaching activities that fit those concepts.

Alice felt that her goals for Amanda were accomplished because Amanda followed her model of teaching well in providing avenues for children to express their knowledge. Alice also felt Amanda grew in being reflective about her actions and in using these reflections in providing meaningful experiences for the children (as opposed to just fun for the sake of fun).

*Methods Course Assignments for the Field*

Amanda did four activities with Alice's students that were course assignments. Her first mini-unit was one in which the students were to find the missing half of a pumpkin shape that contained the solution to a basic facts exercise. This activity was done early in the quarter. Her second mini-unit was *In the Hole*, in which students felt inside a bag to describe attributes of the three-dimensional object in it. This led to discussions of differences between two and three dimensions as well as to the students experimenting with the shapes' transformational attributes (roll, stack, or slide) and making a booklet of their findings. This activity was done late in the quarter. Amanda also did a math-
literature project: reading two books (*Ten Black Dots* (Crews, 1986) and *Rooster's Off to See the World* (Carle, 1987)) with accompanying activities involving students to total the number of dots or animals in the books.

*Amanda's Field Supervisor*

Amanda's field supervisor was Emily, who indicated in my interview with her that she did not do well in and hated math as a student, but had a different point of view when she became a kindergarten teacher. Emily used *Math Their Way* and saw that her traditional upbringing was unnecessary. She began to feel that students best learn math through exploration of problems and the use of manipulatives with the goal of building a connection between the concrete and abstract. Emily considered teaching in the same way by taking the role of a facilitator by providing experiences, stepping back so students can discover on their own, and then asking students if they could extend their findings.

However, because Emily's specialty was language arts, her expertise in mathematics education was limited to her teaching experiences and her traditional student background. She could not think of important mathematical ideas for early elementary school beyond those in *Math Their Way* (i.e., patterns, graphing, and addition and subtraction). However, Emily was aware of the *Standards* and their goals for learning and teaching.

Emily had several general goals for the interns. She felt that they need to move away from their natural expectations for specific activities and, instead, use their university coursework as a theoretical basis for their experiences in the field. In particular, she believed the interns need to begin to understand how children generally learn and
subsequently begin to take on the role of a facilitator as was described above. By doing this, Emily thought the interns could become good teachers in all disciplines.

However, she did not enact these goals with respect to mathematics. In addition to her supervisory role, Emily was the language arts methods instructor during the quarter of the study. Thus, when observing one of her students in the field, she tried to explicitly link the language arts theory of that course to what the intern had observed or participated in the classroom.

Although she did not concentrate on mathematics when supervising the interns (she was not aware of what Holly did in the math class), Emily did generically assess an intern’s actions by the role she took (i.e., facilitator versus lecturer). She also discussed completed lessons with the interns by discussing that role as well as other general pedagogical issues (e.g., questioning, the intern’s opinion of the lesson, areas for improvement).

Emily did observe the final moments of Amanda’s geometry lesson in Alice’s class. She said that the process Amanda took students through was well thought out and that Amanda facilitated active involvement by allowing rich conversations regarding the attributes of shapes. However, Emily did not assess Amanda in any way specific to mathematics or mathematical pedagogy.
How Amanda Experienced the Course and Field with Respect to the Variables

The Nature of Mathematics

The course. Amanda appeared to view the course as reaffirmation of her traditional beliefs about the nature of mathematics. When some new concept of the nature would show itself, Amanda either ignored it or misinterpreted it.

Amanda perceived that the course reaffirmed her belief in mathematics as a separated, sequential subject. She noted this through her reading of the book, the course's separation of computational exercises, and in the syllabus for the course.

Amanda also misinterpreted or unintentionally missed some messages that were conducive with respect to her beliefs about the nature of math. For example, she misinterpreted the intention of the problem versus exercise activity, looking at the "dog pen" problem as good because of its relevance and the way it was written, despite Holly's major emphasis during the preceding talk on why the problem was given.

Even when Amanda appeared to change her beliefs through the course about a particular aspect of the nature of math, she would later change back to her previous point of view. For example, she saw the Kamii tape and pointed out that the traditional algorithms were not important to include in the elementary school curriculum because students could make up their own. However, later in the quarter, when discussing important aspects about computation, she pointed out that the most important thing to know to compute 507-258 was borrowing in the process.
At the end of the quarter, Amanda indicated that the course only influenced her with respect to the nature of math in that it reminded her about how broad math was (through the activities) as well as in the importance of language in mathematics when explaining answers (from the videos). However, she also indicated that the course portrayed math as "tedious and boring" (interview, December 10, 1992) as opposed to how her field portrayed it.

The field. In the field, Amanda saw math being portrayed as a subject that revolved around active problem solving where students needed to explain their own solutions. She saw a community of mathematical explorers as opposed to the course's presentations and discussions. She noted that Alice showed how easy it was to integrate math in the curriculum because one could always record numerical information about what children were finding, analyze it, and report it using graphs.

The Curriculum of Elementary School Mathematics

The course. Amanda felt she learned little from the course about the elementary school curriculum with respect to her concern about what students need to do at each grade level. Instead, when discussing curriculum in interviews, she seemed to assume that it consisted of the sequence of topics she experienced in elementary school, junior high, and high school. Amanda consistently pointed out the importance of traditional topics such as place value and the four operations while downplaying the role of non-traditional topics such as data analysis. At many times, Amanda implied that the course reaffirmed her belief in that curriculum and she appeared to maintain this belief despite messages to the contrary from the course.
Amanda did indicate that some course activities changed her perspective on the breadth of the elementary curriculum. However, from the interviews, it appeared she only grew with respect to geometry. This growth did not become evident until after she had done her three-dimensional activity in the field. Even after the classes on geometry that discussed curricular ideas, her beliefs about the important concepts to be dealt with in geometry were limited to that which she dealt with in that activity and the specific geometry activities done in the course.

The field. Amanda noted that, although mathematics was not emphasized as much in the field as Holly encouraged in the class, the students experienced a variety of mathematical concepts, including measurement, representing and analyzing data, and different strategies for computing basic facts. However, Amanda was not sure whether the curriculum she saw in the field was normal. Thus, she did not appear to use her integrated field experience (beyond her geometry activity) toward altering her beliefs about curriculum.

Learning Mathematics

The course and field. Amanda did not perceive that the course addressed much about how children learn mathematics. But, when Amanda would discuss a certain feature of the course or field experience, she would talk about learning in a Standards-like manner. However, some events in the two venues appeared to lead Amanda to revert back to a more traditional view.

Amanda would describe learning in a Standards-like manner most often when we discussed her field experience. She often would describe how the kids learned by
"discovering like scientists" with curiosity and how she could see "24 different learning styles" in the field where the kids "want to explain things" (interview, October 9, 1992).

Amanda would also point out the differences between how children learned in the field and how she and her colleagues were learning in the methods class. She felt there was little exploration in the course and the interns weren't assessed on how they grew.

However, despite these feelings, there were aspects of the course that drew constructivist-like responses from her when discussing learning. These incidents consisted mostly of videos and Bob Cooper's classroom. With the Kamii and Burns videos, Amanda discussed how children approached problems in different ways of their own and how they wanted to explain their processes. When discussing Bob's classroom, Amanda pointed out Bob's philosophy of having kids explore, problem solve, and think critically. In all of these cases, Amanda also related these course messages to her field experience.

Despite these constructivist views in relating field and course experiences, Amanda, when discussing happenings other than the videos and Bob Cooper, reverted back to talking about children learning by receiving sequenced knowledge. For example, she discussed how it made sense that the book and the course talked about how one had to start up somewhere and build up skills. Also, when talking about an incident when Alice showed the students a method for solving a problem before the kids tried it, Amanda agreed with Alice's strategy because "some kids need an example of how to do something" (interview, November 12, 1992) because of their learning style. She argued further that some kids need to be lectured to and cannot learn through experimentation.
Along the same lines, Amanda kept her view that children should not be frustrated when learning mathematics. For example, while agreeing with Bob's philosophy of experimentation, she indicated that if a child could not get it, he or she should be shown a method to avoid frustration.

Amanda also maintained her belief throughout the quarter that children must be motivated about and enjoy math in order to learn it. This was especially evident when discussing the multicultural video. Amanda stated then that the biggest problem facing mathematics education in this country is that children are not motivated to learn mathematics. She felt that motivation needed to be improved in order to have any hope of improving children's learning of math. (Note: Math, in this case, as in most other cases, was procedural mathematics.)

In summary, it appeared the course and Amanda's field experience led her in some ways to reconsider her beliefs about how children should learn mathematics. Alice's learning environment, the visit to Bob Cooper's classroom, and the Burns and Kamii videos all appeared to lead Amanda to believe that children can and should learn mathematics through problem solving. However, other incidents possibly led Amanda to endorse a more traditional, teacher-centered, learning environment.

This overall ambiguous experience with respect to learning mathematics might explain some of the ambiguity in Amanda's beliefs about learning at the end of the quarter (with leanings toward a more Standards-like view than she started the quarter with).
Teaching Mathematics

The field. Amanda felt her field experience left her more prepared to be a teacher of mathematics than the course did. She looked at the field as an opportunity to learn through experience because Alice gave her ample chances to work on her own with the students. She would usually work with one group of students while Alice worked with another. She spent most of the activities making sure they were on task, asking them questions relating to their findings, and helping when a student couldn’t physically perform something. She rarely, if ever, came out and told a student an answer or what he or she should have found.

Amanda did not look to the assigned field activities from the course as an opportunity to learn about teaching and learning mathematics. Instead, she was more concerned about how to organize activities and the need to be detailed in what she wanted to do. She was glad to be making activities, as this was her expectation for the course.

Despite these claims, it appears that Amanda did learn about allowing students to become immersed in their own and the community’s learning from the assignments. This was evident in her actions before and during the activities. She planned activities in light of what she wanted the children to learn as opposed to just looking for a cute activity to do. For example, she took time to think of questions that she could ask to guide students to the goal set out for the activity. In presenting each assignment activity, she described what actions needed to be performed with the materials; then let the students on their own in groups to develop or work out problems while she went around the room questioning the students on their findings.
This mode of activity on assignments was particularly evident in Amanda's work on her geometry activity. Originally suggested by Alice for the students to explore shapes for a quilt, Amanda adjusted so the students could explore the characteristics of three-dimensional objects and their characteristics, rather than just their names. She allowed the students to go as far as they could in exploring attributes of the objects and in expressing what they found.

The course. In the course, Amanda felt she saw the importance of language when teaching mathematics, to be spontaneous, allow for discovery, and to consider questioning as a source for children's learning.

Most of these ideas about teaching mathematics came, as with learning mathematics, by watching the videos. Amanda particularly saw the illustration of informal discussions held among students and teachers about students' solution processes as the key message in the Fennell, Kamii, Burns, and multicultural videos. She felt the environments portrayed in these tapes helped her see where she "wanted to go" as a teacher. She especially saw this in the Kamii tape, where Kamii's illustrations of questioning and children's eagerness to explain their answers were congruent to what Amanda observed in her field experience. However, Amanda also noted that the perspective of the teacher in front leading the class in all the tapes went against the strand philosophy.

Amanda also felt the videos re-emphasized Holly's suggestions of wanting teachers to allow discussions in the class and that this point would not have been brought home had the videos not been shown.
Amanda did not explicitly feel that she gained much in terms of teaching from other aspects of the course. In particular, she did the in-class activities as a mathematics student with little thought toward their worth in teaching or learning mathematics. Instead, she only looked at them as ideas and materials to put into an activity list.

Amanda felt that the course sometimes presented a teacher-centered view of learning in the participants' (and the videos') actions and words. Despite these feelings, Amanda often echoed these traditional views of teaching as her own when discussing particular incidents in class. For example, when describing the mirror activity (from the second day for geometry), Amanda was concerned because she did not understand why a geometrical phenomenon occurred. Her concern arose because she wanted to be able to explain to the students why it was happening but didn't know how. She also partially interpreted the geometry classes as pointing to the need to tell children formulas.

These results, when put together with Amanda's maintaining a belief at the end of the quarter that students should eventually be shown how to solve problems to avoid frustration, suggests that the course did not do much more than accentuate her entering beliefs and that opportunities (e.g., videos and activities) in which more constructivist views could have confronted the traditional views were not used to their potential. Instead, it appears that only Amanda's reflection on Alice's role in the field learning environment gave rise to any change in Amanda's beliefs about teaching mathematics.
The Case of Becky

Personal History

The intern interviewed from the middle group with respect to confidence, self-efficacy, and mathematics background was Becky. Becky was a lively and talkative 21 year old senior who, when given an assignment, would work toward completing it to get it out of the way. Her desire to teach came as a result of her experiences as a gymnastics instructor where she felt rewarded when children would successfully complete what Becky had taught them.

Becky’s background in mathematics could best be described as traditional. She recalled elementary school as learning how to do computational and word exercises involving addition, subtraction, multiplication, and division. In high school, she had two years of algebra and one year of geometry, where the emphasis continued to be on learning procedures that she could not explicitly recall a few years later.

Becky learned mathematics by listening to her teachers give her the steps to solve the problems, perhaps reading the textbook examples of the problems, then working similar homework exercises to the point that she could do them quickly for the purpose of receiving a good grade on an test. She felt comfortable learning math this way, and, because it gave her good grades, considered math to be her favorite subject in elementary school.
In seventh and eighth grade algebra, Becky hated math because she could not "whip it off" as well as she used to. However, in ninth grade, her teacher was clearer in giving explanations to the point that Becky could learn to do problems quickly again (and hence, improve her attitude).

In college, two events changed Becky's outlook on her abilities in mathematics. First, she did poorly on the placement test. Although she claimed that this was because she was rushed before the test, it was the main factor in her decision to take as few math courses as possible in college. As a result of the test, she was placed in an intermediate algebra course, which, to her, was a repeat of her algebra courses in high school in both content and method of learning.

The second event that changed her view of her abilities in mathematics was her experience in the two content courses designed for elementary teachers. There, despite receiving good grades in the courses, she felt confused because the textbook and the professors "took something simple...like learning how to add or something... and made it so complex" (interview, October 1, 1992). She indicated that the professors and teaching assistants would often approach problems in different ways, which would confuse her as to which way she should approach them. She also felt it was unfair that the exams included problems that she was not shown how to do in class.

Although she felt the purpose of the content courses was to get interns to understand why basic mathematics works and to put them in the place of children learning it, Becky felt that the emphasis on telling children why was not necessary because of her own previous success in mathematics without it and because the reasons only confused her.
Despite her confusion in the courses, the experiences did not disturb Becky because, once the courses were over, she did not consider them again:

It didn't hurt me because if I didn't agree or if I was confused, I just pushed it out of my mind and forgot about it....When 106 was over, that's it - it never crossed my mind again. (interview, October 1, 1992)

Beliefs

Becky’s beliefs changed little from the beginning to the end of the quarter (see Table 4.2). Her beliefs remained traditional in nature, although she appeared to be slightly more open to allowing new topics in a minor role as well as student exploration before a teacher intervenes with correct processes.

The Nature of Mathematics

Before the quarter started, Becky had a view that mathematics was a sequential subject consisting of computational procedures to be performed by following steps obtained from an external source until one became proficient at those steps. By the end of the quarter, she had changed somewhat in that she wanted people to know not just the steps, but also why those steps are performed. This knowledge, however, would also be given by an external source.

Definitions of mathematics and problem. At the beginning of the course, whenever Becky talked about mathematics, it was almost always in reference to the steps involved in performing computations. Becky’s considered that doing mathematics consists of:

Computing. They probably have a calculator beside them, trying to think of the steps involved, maybe looking up some of the steps involved because they don’t have them memorized, adding in their head, and that’s about it. (interview, October 1, 1992)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Entering Beliefs</th>
<th>Exiting Beliefs</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Mathematics</td>
<td>1. Math is sequential discipline of computing.</td>
<td>1. Math is sequential discipline of computing.</td>
<td>None except good to understand predetermined steps to solve problem.</td>
</tr>
<tr>
<td></td>
<td>2. Solving problem is following predetermined steps.</td>
<td>2. Solving problem is following predetermined steps.</td>
<td></td>
</tr>
<tr>
<td>Curriculum of Elementary Mathematics</td>
<td>1. ASMD procedures dominate.</td>
<td>1. ASMD procedures dominate along with explanation of steps.</td>
<td>None except explaining ASMD procedural steps; geometry/data analysis in minor roles.</td>
</tr>
<tr>
<td></td>
<td>2. No other topics if not in official curriculum.</td>
<td>2. No other topics if not in official curriculum.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Affective variables dominate: Math needs to be made enjoyable through activities with caring teacher.</td>
<td>3. Affective variables dominate: Math needs to be made enjoyable through activities with caring teacher.</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2: Becky's Entering and Exiting Beliefs
For example, when she specifically discussed important ideas she would like her students to learn about multiplication, she talked about the repeated addition concept of the operation and properties of multiplication. However, her ultimate goal for learning multiplication was to become proficient at the traditional multiplication algorithm, with solving advanced multiplication exercises consisting of performing the same procedure, in multiplying larger and larger numbers. Becky's general view of a problem consisted of either an algorithm or a one-step word problem in which a solution method is already known.

At the end of the quarter, Becky still looked at mathematics as being a procedural subject. When asked what makes math difficult, she responded, "It's dealing with numbers and they're just computing and going through steps and processes and everything has to be exactly right or they aren't going to come out with the right answer" (interview, December 8, 1992).

Specifically, when describing important elements of knowing multiplication, she again emphasized the procedural rather than the conceptual aspects of the operation. For example, she felt that those who knew multiplication could be identified as those who knew "how to multiply the largest numbers all the way down to the smallest numbers" (interview, December 8, 1992).

Although she still emphasized the importance of procedural knowledge over conceptual knowledge, she now indicated that it was important for one to know the reasons behind the steps one was performing. For example, she described those who are good at mathematics as people who can visualize each step they're taking in their minds.
Becky also did not change on her view of what a problem is. She arbitrarily used the term whether a person knew the process beforehand or not. For example, she still believed that she was a good problem solver in high school because she could perform multi-step procedures that her teacher had outlined and get the right answer. Becky also still based the difficulty of a problem on the number of steps and whether or not one knew them beforehand.

*The need for an external authority to do mathematics.* At the outset of the course, Becky not only thought that mathematical knowledge consisted of the steps to perform procedures, but that this knowledge came from external sources, such as a book or a teacher (unless one was a genius). For example, when asked to define what it means to understand mathematics, she said,

Maybe, like after a teacher has gone through and explained something and maybe did a couple examples or something, you would get the paper or the assignment and go home and do it yourself. And if you could, you understood it; if you couldn't, you didn't. You'd have to go back in and get more help....Just getting the answer, understanding it and knowing how to do it. (interview, October 1, 1992)

Becky personally re-emphasized this dependency on others for mathematical knowledge when responding to the hypothetical situations. If she did not know why a certain phenomenon occurred, she would either just say "you're right" or go to a textbook and look up the reasons without trying to figure them out herself.

At the end of the quarter, Becky's belief that mathematical knowledge comes from an external source had not changed. When describing learning and teaching mathematics, she expressed some guilt at saying that one learns by "listening to someone teach to them" and that a teaching includes "teaching on the board and going through the steps of
a problem" (interview, December 8, 1992). Also, once again, when she was given hypothetical situations, Becky would either tell the student that she was right, go and look up the information needed, or state, "That's what the answer is! We don't know why" (interview, December 8, 1992)!

The need for relevance. Finally, Becky believed that mathematics is worthless unless one can use it in everyday life, especially with money. She felt that mathematics beyond that traditionally taught in the elementary school (e.g., algebra) could not be justified for inclusion in a curriculum because it had fewer connections to real life than addition, subtraction, multiplication, and division. Becky maintained this view after the course, noting that mathematics is valuable only because of monetary considerations, such as balancing a checkbook and "how to shop in general" (interview, December 8, 1992). She also noted that every career uses math; but she only mentioned financially-based careers such as accounting and realty.

Therefore, it appears that there was little discernable change in Becky's beliefs about the nature of mathematics from the beginning of the course until the end. She maintained her belief that mathematics is a procedure-driven area that is used by people by relying to external sources for information, although she placed more emphasis on knowing the reasons for steps in the procedures by the end of the course.
The Curriculum of Elementary Mathematics

Throughout the course, Becky had a view of the curriculum of elementary school mathematics that mirrored her views of the nature of mathematics as well as her own experiences. In particular, she felt that relevant procedures should dominate the mathematics that children learn.

The dominance of traditional arithmetic. Throughout the quarter, Becky felt that the basics (skills with ASMD, word problems, and money) should dominate the curriculum with the goal of functioning in everyday life. She believed that the traditional algorithms, as opposed to concepts and models, were the ultimate goal of learning about ASMD. At the end of the quarter, Becky added that students should eventually be able to add and subtract with manipulatives (in explaining the steps) and calculators.

Inclusion of other topics if allowed by experts and subject matter knowledge. Before and after the course, when asked about what mathematics should be included in the curriculum of elementary school mathematics, Becky was initially at a loss to say anything. She felt that she would obtain what she was supposed to teach from the school that hires her and that her job would be to obtain activities for that curriculum that would be interesting to students.

At the beginning of the quarter, in addition to her beliefs that the official curriculum would probably consist mostly of ASMD, Becky indicated that probability should also be included. This was the only non-arithmetic topic she mentioned. However, it appears that she mentioned this area only because the interview occurred the day the Fennell
video was shown. This claim can be justified by her enthusiasm for the activity-based learning (and apparent lack of specific knowledge about probability), as well as her lack of recall in the previous interview about what probability involved.

After the course, Becky did include topics beyond ASMD (e.g., geometry and probability). However, these were relegated to a minor role. She had little knowledge of these areas beyond activities from the course. However, she was not concerned about this lack of subject matter knowledge because she thought that a teacher only needed to know basic arithmetic, shapes, and fractions. If she was to teach something that she knew little about, she, consistent with her lack of concern of what the curriculum should contain, was confident that there would be "a million resources" (interview, December 8, 1992) that she could refer to for activities.

Finally, Becky did not change in her belief that topics that were not included in the official curriculum of the school should be minimally (if at all) discussed within her classroom, even if a student suggests such a topic. For example, when asked what she would do if a student asked what -2 meant on a calculator, Becky said that she would just tell the student that it was a negative two, give a brief lecture on what it meant, and continue what she originally was doing in the mainstream curriculum. Part of Becky's rationale for this stance was that she felt that it was not within her power or knowledge to deviate from a curriculum that was set up by experts who knew more than she did about what students should learn.
The Learning and Teaching of Mathematics

A transmission view of learning. It was argued before that Becky held a constant belief that mathematical knowledge comes from external sources. This belief was accentuated when she talked about how people learn and teach mathematics:

Becky: Sitting at a desk with the teacher at the board explaining a new concept and just going through, doing an example on the board or maybe introducing the steps, the process.

Researcher: I'm talking about the person who's learning, not the teacher.

Becky: Well, the person who's learning is sitting there watching the teacher do all that! But they're probably just watching him and taking notes and...that's it. (interview, October 1, 1992)

Although she made this statement at the beginning of the quarter, little had changed by the time the course ended with the exception that she felt guilty for holding that point of view within a strand emphasizing informal learning environments.

At the outset of the course, Becky did theoretically advocate students learning through group activities; however, she never suggested that students learn in this way when she addressed specific situations and topics. Instead, true to her definition and personal history, Becky consistently said that she would have her students learn by listening to her describe concepts and procedures and then practice what she showed them before moving on to the next level of skills. In the hypothetical situations, Becky always took the stance that a student has to be verbally shown how to do mathematics in order to understand.

She maintained this view at the end of the quarter, although now she more often mentioned the need to allow children to explore on their own. But Becky still returned to the notion that they still eventually need to be shown how to do something. When
asked how her students would generally learn mathematics, she stated, "Through each other, through myself, through working with actual objects, manipulatives... by exploring. I guess they're going to learn through activities and problem sheets" (interview, December 8, 1992). But she also went on to say, "They're going to learn from me because there will probably come to a point in time where I would actually be doing problems and showing them, you know, how I do them" (interview, December 8, 1992).

Specifically, when discussing children learning multiplication algorithms, she stated:

I might let them, when introducing it, I might let them try it on their own and see if anybody can come up with it.... maybe how they would think that it is to be done. And then go through and show them. (interview, December 8, 1992)

Also, with each hypothetical situation where students come to her with conjectures or confusion, Becky would either tell the student why or appeal to another authority for an answer or reason.

The overriding importance of affective issues. Affective issues dominated Becky's outlook on what good teachers do in having their students experience mathematics. Both at the beginning and end of the quarter, she placed an emphasis on a teacher needing to make mathematics enjoyable for students through the use of activities because of the structured and boring nature of the discipline. In particular, she felt that the most important attributes of good teachers of mathematics were "(to be) enjoyable, fun, organized, clear, and motivated" (interview, October 1, 1992) and that she wanted to be looked upon as "fun, motivated, enthusiastic, knowledgeable, caring, [and] understanding" (interview, December 8, 1992).
Becky consistently advocated the use of manipulatives in learning mathematics but only because of affective matters, based on the lack of use of manipulatives in her own education. Like with her beliefs about the value of activity-based learning at the beginning of the quarter, Becky felt that methods course activities with manipulatives mostly provide students with an alternative to sitting at their desks and being bored. In addition, with the use of manipulatives, Becky felt that the teacher needs to show them the process with the manipulatives before the students can do the same thing themselves.

In summary, Becky essentially maintained her beliefs that a teacher needs to be an authoritarian transmitter of mathematical knowledge who fulfills this role by being interesting and fun for students.

Expectations for the Course

Becky’s expectations for the course reflected her theoretical view that mathematics should be taught with activities for the purpose of making it interesting and enjoyable while they are learning. She looked at the course as an opportunity to gather activities and sources for activities. Her only other expectation was to learn how to teach mathematics in an informal environment. She felt unfamiliar with the idea of such an environment because she had not yet experienced one.

Course-Related Assignments

Becky’s perspective on the course assignments not involving her field experience centered on two themes: finishing them quickly and receiving a good grade. For example, when considering doing the review of articles, her intent centered on gaining points toward a grade:
We also have to, besides getting ideas to be an effective teacher,...we also are getting a grade for this course. And I want to keep my GPA up and I think I've done well with critiquing articles in the past and pleased my instructors with my writing, I think. (interview, October 9, 1992)

Becky did not choose to do the review of articles; but she would have if she "needed extra points" (interview, December 8, 1992).

Becky chose to do only one assignment that was not to be performed in her field experience: the resource file. Becky treated the assignment in a manner consistent with her expectations: only collecting the articles without considering their worthwhileness with respect to learning, curriculum, or mathematics itself. For example, she once indicated that she had copied 75 articles with a goal of 100 for not only a resource for her first year of teaching, but to please Holly and receive a good grade.

*Becky's Field Experience*

*Description of the Environment*

Becky's field experience took place in the third and fourth grade classroom of Brenda. From my observations, Brenda's classroom was one in which students usually worked on individual assignments in particular subject areas or on group projects (e.g., on thematic topics such as spiders) that integrated subjects.

Overall, mathematics played a secondary role in Brenda's classroom. Most of the work in the classroom was based on language arts (reading books, writing stories, and communicating points of view). It appeared to me that mathematics was forced into these scenarios (e.g., writing the story problems in the projects, but little else) and was otherwise treated as a separate subject.
Description of the Cooperating Teacher

From my interview with her, I learned that Brenda graduated from the same program that Becky was enrolled in, although, at the time, Brenda's mathematics methods course was not part of the program. Therefore, she did not learn much about teaching mathematics in the program. She called what she did learn an "abstract type of approach" (interview, January 8, 1993) that did not emphasize the use of manipulative materials.

From graduation on, Brenda never felt comfortable teaching mathematics. She felt that she needed more preparation time for teaching mathematics than any other subject. However, she always tried to improve by finding sources for activities and manipulatives and regularly attending inservice programs run by Bob Cooper to learn more about problem solving and ways to employ it in her curriculum.

Brenda considered mathematics as something that is taught because it is useful in the real world. Brenda also saw problem solving as important. She considered good mathematics students in her class as people who are flexible in their thinking such that they feel free to try different approaches to solving problems.

However, her emphasis in mathematics usually centered around skills and concepts involving numeration, the four operations, as well as applications involving money. She specifically named numerals, number names, equations, place value, regrouping, money, multiplication, and, later, fractions. For example, the project that she felt mathematics was used the most was one on currency, in which the students organized a checking account to add and subtract from. Also, although problems from the Dinamath newsletter
were required of the students to solve; I only observed students attempting the problems once and the students treated them as extra activities beyond what they had to do.

Students' learning of the traditional computational skills differed from their learning of conceptual mathematics. Pencil and paper arithmetic was relegated to the individual worksheets in the students' math folders, while conceptual mathematics (e.g., computational decision-making, problems from Dinamath, and projects) was experienced through group activities. Brenda briefly introduced the activity and then the students performed it individually or in groups that were mixed in student ability. Brenda sometimes met with those she deemed in need of remedial help so they could successfully complete the activity with respect to the mathematics involved.

No matter what mathematics her students were engaged in, Brenda encouraged the use of manipulatives. Brenda felt strongly that manipulatives helped students see and touch the mathematical concepts and skills as well as to tie the two realms together.

Finally, Brenda placed a great deal of emphasis on her assessment of students with respect to what their deficiencies and strengths were. In my observations of her class, Brenda (and/or Becky) could usually be seen wandering around the room asking and answering questions of students. She felt that observations of her students and her reflections on them were a stronger indicator of her students' abilities than tests.

In summary, it appeared that Brenda attempted to provide a constructivist environment for learning the limited amount of mathematical concepts that were involved in her curriculum. That is, she attempted to force students to learn mathematics more or less on their own and to make their own conclusions from their work, while the
teacher played a guidance role. However, it also appeared that, despite the use of manipulative materials, students' learning of algorithmic skills was done in a more traditional manner, with the teacher transmitting the information to the students.

The Cooperating Teacher's Expectations for Becky

Brenda wanted Becky's first experience in an informal environment to involve developing an understanding of the parts to the whole of the environment, such as organization, planning, and teacher-student interactions. Above all, Brenda wanted Becky to consider the thinking behind Brenda's decisions and actions.

Toward those ends, Brenda saw herself in a guidance role in that she should suggest activities as well as discuss and approve Becky's ideas. For example, Brenda helped Becky select an activity for one of her mini-units for the math methods course. Brenda suggested a place value activity and asked Becky to consider it in terms of what and how students will learn the desired concepts. She also wanted Becky to consider what items would be required, how to group the students, and so on. When Becky got stuck in these considerations, Brenda took it upon herself to describe her own thinking in planning such an activity.

Brenda wanted Becky to become more involved and independent in the decision-making as the quarter went on. She especially wanted Becky to move from perceiving an activity as "neat" toward seeing it in terms of where the activity will lead the learning.
Brenda felt that most of her goals for Becky were accomplished during the quarter. She felt that Becky got acclimated to the environment and began to see the details behind the decision-making process, although Brenda wished there was time to discuss assessment issues with her.

Methods Course Assignments for the Field

Most of Becky’s perceived learning of mathematical pedagogy took place through her methods course assignments in the field. Becky’s chosen assignments were a math and literature project, a learning center on multiplication, and a mini-unit using calculators.

In the math and literature project, Becky used two activities involving place value that Brenda had suggested. One was an activity in which different-colored chips representing different place values were placed in a bag and students were questioned about the largest and smallest possible numbers that could be pulled from the bag if one chip was taken out at a time. The second activity involved different-colored cubes representing different place values that were rolled onto a target which contained the numerals 1 through 9. The students were then asked what number was represented by their roll. After each roll a team of two would add that number to their previous number. The winner was the team that had the largest value at the end of the activity. Becky also read a book at the beginning of the second activity that "sort of tied into the activity" (interview, October 22, 1992).

The first place value activity, more than any of the three mathematics assignments she did in the field, appeared to involve meaningful mathematical discourse among the students with Becky attempting to take on the role of explainer so that the students
understood what they were doing. The second place value activity was not as much of a learning experience for the students to Becky because the activity itself lent itself to an immediate winner after the first rolls were completed (because the largest place value occurred first).

Becky's second assignment in the field was a learning center on multiplication. She chose this assignment because of the success a previous cooperating teacher in another education course had with learning centers and because they encourage active learning with stimulating activities. Becky made the learning center using activities that she collected for her resource file.

Becky's third and final field assignment was her second mini-unit. In a small group setting, students were given a sheet with operation signs on it and asked to place selected single-digit numbers between the signs in order to generate the largest and smallest possible numbers from the operations. The students were to use a calculator to perform the operations. This activity was given to Becky by Brenda as a way to get the students to use the calculator as a tool to learn the varied effects of operations.

**Becky's Field Supervisor**

Becky's field supervisor was Diane, a doctoral candidate in language arts education. In my interview with her, I learned that, despite her specialty, Diane had previously tutored traditional algebra to middle school students. Her beliefs about mathematics centered around decision-making and problem solving; but her curricular beliefs were
traditional. With respect to teaching and learning, Diane held strong constructivist views that students should learn mathematics through situations that generated a need within the students to develop a concept or skill.

In general, Diane believed that preservice elementary teachers needed to develop strong mathematical knowledge through not only basic skills, but also through experiencing problem-solving situations. However, Diane’s subject matter goals for interns in this particular strand centered around developing language arts pedagogy. She had only a few generic goals for the interns with respect to mathematics. These involved doing whole-group lessons, gaining experience in planning lessons, and obtaining and/or developing curricular materials that fit with the philosophy of the math methods course.

In her supervisory role, Diane only observed the interns with respect to generic pedagogical issues such as knowledge of the material, clarity, lesson plan structure, and the nature of the interactions with students. She also provided emotional support to the interns.

Diane did not observe Becky do anything with respect to mathematics. However, in general, she thought that Becky worked well with Brenda and the students. She felt that Becky’s confidence in working with individual students and in an informal environment left her with an excellent introduction to such environments.
How Becky Experienced the Course and Field with Respect to the Variables

The Nature of Mathematics

The course. Becky considered the messages from the course about the nature of mathematics, particularly the role held by problem solving, but sometimes misinterpreted them or decided that they were minor when compared to her original beliefs of what is important in mathematics.

Becky often agreed with what the course said about students becoming problem solvers and the use of problem solving in the classroom. For example, while discussing the multicultural video, she stated that she felt the goals of school mathematics should be for students to know the basics and the steps for each problem, but also to be able to try to solve problems without teacher intervention.

However, Becky usually reverted back to traditional outlooks when discussing events in the class. For example, while she praised (for affective reasons) the environments in the Kamii and Burns videos for promoting active learning and reasoning, she indicated that she would not deviate from the actions she took in hypothetical situations in her pre-quarter interview. For example, after viewing the Kamii video, she maintained that the traditional algorithm should still be taught to children through the teacher's explanations. She thought the traditional algorithm was important because it is both the method most people use as well as the quickest way. Also, following the Bob Cooper class, Becky
agreed with the message of allowing students to develop their own strategies; but felt that the teacher should step in with a strategy if the student(s) do not develop one right away.

**The field.** Becky did not perceive that there was much mathematics done in Brenda's classroom. Also, she did not take time to think about what mathematics the students were learning in her assignments or how they were learning it (beyond being generically active).

At the beginning of her experiences, Becky did feel that it was good that the students were experiencing math through thematic units because it was more relevant to them. However, as the quarter went on, Becky became more convinced that mathematics should be one of the subjects that demands a separate learning time, particularly because she observed mathematics playing a secondary role in the thematic units.

With respect to the Dinamath problems, Becky noted that they were treated separately as a fun activity after the students' folder work was completed. Becky thought the students found the sheets interesting and, thus, were an incentive to complete their real work.

Becky treated the problems from the sheets differently from the folder work when going around helping the students. With the math folder work, Becky would answer any procedural questions. But with the problems, Becky was not so quick to reveal a solution method.

In summary, it appears that Becky took the course and field messages about the nature of mathematics and interpreted them with respect to her beliefs. In the course, the
messages seemed to be understood by Becky; but they did not budge her away from her belief that mathematical knowledge should ultimately come from an authority. In the field, she interpreted the mathematics that was played out as not being mathematics because the thematic units were not congruent to her own familiar background experiences.

*The Curriculum of Elementary Mathematics*

*The course.* Becky felt that the course reintroduced her to other areas of mathematics that she previously did not consider as possibilities for the curriculum, such as geometry and statistics.

Becky felt that curricular issues were not of her concern during the quarter because the curriculum was something made up by experts to be given to her when she was hired at a school. This curriculum would then be followed by her, even if it conflicted with her beliefs, because the experts know more than her.

Becky also appeared to make the assumption that the curriculum she had in school (developed by experts) was the curriculum that she would be teaching. For example, when we discussed the class involving rational number division, I asked Becky if such a topic should be included in the curriculum at all if she could not come up with any applications for it. She replied, "For some reason, it needs to be taught because that's what everybody is saying and that's what I was taught and that's what people are teaching. So it must be important somewhere" (interview, November 19, 1992).

The course provided Becky with her only pedagogical experiences with some topics for which she had little subject matter knowledge. For example, she did not know any
other aspect of geometry for students to learn except for the specific activities that were done in the two geometry classes. However, she was not concerned because, if forced to teach it, trusted that she could locate sources that would see her through. Becky felt similarly about data analysis.

*The field.* As was previously discussed, Becky felt that, while the course emphasized the importance of including different areas of mathematics in the curriculum, her field experience did not give her that message. Becky felt that the students in Brenda's class needed to experience more mathematics as a separate subject and that mathematics should involve traditional topics that are taught at that level. For example, she commented that Holly talked about introducing rational numbers in second grade; but she saw no fractions being taught by Brenda in the field.

*Learning Mathematics*

*The course.* Becky used the course to gather ideas for students to learn mathematics in an active (fun) manner. Thus, she thought the various activities of the course were good ideas because they promoted active engagement. Becky also promoted active learning during interview discussions of a theoretical nature or when discussing videos that illustrated such learning.

However, Becky gave little thought to any general cognitive philosophy as to how children learn in the environments of the activities or as portrayed in the tapes. For example, she felt that it was interesting that the videos showed teachers having students reason and explain what they are doing. However, this did not sway her from her belief that the teacher should be the authority in the classroom. When Becky discussed the
Kamii video, she felt it was neat that the students participated, but only because it was not as boring from what she had experienced. Becky still felt after the video that the teacher should ultimately present the traditional algorithm for addition to the students. Also, when asked how she would introduce a topic she had little knowledge of, she responded by saying that she would look up activities in a book by Marilyn Burns and "just do what she does" (interview, December 3, 1992) with little regard for the philosophy on which they are based.

*The field.* Becky relied on her incoming beliefs when interpreting how students learned mathematics in her field experience. As was stated previously, she thought that learning through group work in the thematic units encouraged learning because it was relevant, stimulating, and better than what she experienced during her own education. However, she did not try to envision how the students were learning mathematics because she did not learn that way. She felt that they were not really learning math in the class because she did not see Brenda explain to them how to do the work on the worksheets. Becky thought that the students must have been "exceptionally smart" (interview, November 19, 1992) to do the math on the worksheets and in the small groups because they were not receiving any teaching of mathematics.

Finally, Becky used her beliefs about learning mathematics in the field when interacting with students. She usually walked around the room answering students' questions from worksheets by either telling them how to perform an operation or by telling them if they were right or wrong. She also assessed their work in this manner while grading papers.
In summary, it appears that Becky used her established beliefs and course expectations as guidelines when interpreting and acting on messages about learning mathematics in both the course and the field.

Teaching Mathematics

The course. Despite messages from the course that a teacher should take the role of a guide in allowing students to learn mathematics through problem solving, Becky consistently reiterated her belief that, either before or after students attempt a problem, the teacher should show the students the correct steps or answer. For example, when teaching operations with fractions, instead of considering Holly's message of allowing the students to develop methods for operating on two fractions, Becky said that she would show students the operations with manipulatives and then tell them the easy (written) way to do it.

One event in the class encouraged Becky's belief in traditional teacher role. She looked upon the peer teaching class as one of the most useful of the course because it gave the interns a chance to experience getting "in front of a group and actually teach(ing) a lesson...and talking in front of them and having all eyes on you while you were talking" (interview, November 5, 1992). Further, she felt the day gave them a chance to practice explaining to students when they did not understand something.

Finally, Becky used the activities and videos in the course only to compile a list of ideas to teach different topics. She never considered the role a teacher should take during the activities other than getting the students involved and letting them use manipulatives.
The field. During the first couple of visits to the classroom, Becky was impressed by Brenda's handling of mathematics in the group activities, the students making their own problems within the projects, as well as the students' individual work on the problem solving and the math folder. She felt that Brenda was promoting a good environment for mathematics because it was different from what Becky had experienced in her own education.

However, as the quarter transpired, Becky, in her opinion, saw little mathematics teaching being done while she was there. She thought that too much of the mathematics was incorporated into the thematic units with little or no explanation being done for the students to know the steps to follow. Becky believed that Brenda should have spent more time in whole group situations because the math on the worksheets had to be done in a certain way and the students would learn more mathematics through whole group work than through the projects.

Becky was especially disappointed with Brenda's teaching of mathematics after having seen Bob Cooper and his descriptions of what he does in his classroom. She felt Bob had a real understanding of the mathematical concepts for elementary school. On the other hand, she felt the same way about Brenda, only with respect to "language and literature and writing and reading" (interview, November 19, 1992), with little or no time set aside for mathematics.
Becky learned little about teaching mathematics through her course assignments in the field. Instead, she used her activities only to get more experience in planning, organizing, and implementing activities in an informal environment while making sure to not "mess up" anything that the students had already learned.

For example, with her learning center on multiplication, Becky did not consider assessing what the students were learning to be an important aspect of doing the assignment. When asked what she thought the students learned, she replied:

To tell you the truth, the main thing that I was really thinking about when I did this learning center was just getting something together, you know, and trying to make it similar to what they've been doing in multiplication. I'm not really trying to, like, introduce anything new.... I was really worried about getting the center done and having them having something to work on. (interview, October 30, 1992)

In forming the center, Becky looked for activities that involved multiplication in some way at their level and kept the students active in learning by being "interesting and exciting" (interview, October 16, 1992). The activities that she ended up using were based only on procedural knowledge. In particular, they consisted of activities where recall of the basic facts was paramount. Becky did assess the students, but only on what activities they chose and on which activities were their favorites.

Also, during the third assignment activity involving operations using calculators, Becky assumed a traditional role by standing in front of the students and directing them on the instructions and monitoring them as they worked individually on the problem. She did not assess the students in any way except for monitoring that they were understanding what the problem was asking and telling a student who developed a good strategy that he
was right. With respect to this activity, Brenda felt that Becky took too much of a traditional authoritarian role that left her students in a role that they were not used to.

In summary, Becky interpreted the messages about teaching mathematics with respect to her established beliefs rather than reformulating her beliefs by thinking about the messages. It appeared that, perhaps because of her traditional background, Becky knew no other way to rely on when considering what she should do as a teacher in the field or the future; and she subsequently took contrary messages about teaching as extras to use for supplementing traditional practices.
The Case of Carla

Personal History

The intern interviewed from the group with the lowest scores of confidence, self-efficacy, and mathematics background was Carla. Carla was a quiet 21-year-old senior who often found it difficult to express what she felt or meant. She often kept to herself when the class was involved in activities.

Carla’s mathematical background was highly traditional. From all of school, she only recalled learning procedures for the four operations through the teacher telling her how to do it and her subsequent practicing and memorizing. Learning the four operations was the only relevant mathematical experience in her life because of its perceived usefulness when compared to other topics in mathematics, such as factoring and trigonometry in junior and high school. She wished that she could have instead taken high school courses that would have taught necessary life-skills such as balancing checkbooks. Finally, she never felt that she was a success in mathematics because, despite "trying hard" (interview, September 29, 1992), her grades that were lower than in other subjects.

In college, Carla took only the two math content courses designed for prospective elementary teachers. She thought they were more difficult than ones she took previous to college because she had to think more about how to get answers to problems, rather than memorize procedures. Carla did not attribute this difference to the courses, but to being in college, where teachers are not supposed to give explanations.
She felt that the courses' content had little to do with the elementary school mathematics curriculum. She did feel that the purpose of the courses may have been to understand the thought processes toward solving a problem so that she could explain it to a child.

Beliefs

Carla's beliefs changed little over the course of the quarter (see Table 4.3). Before and after the quarter, she held beliefs that important mathematics consists solely of computational techniques of ASMD given by a teacher to be practiced and memorized.

The Nature of Mathematics

Mathematics is ASMD. Carla's view of mathematics at the outset of the quarter was limited to skills involving the four operations of addition, subtraction, multiplication, and division. She neglected to consider any other aspect of mathematics because she did not "catch on" to the "other stuff" and learned it only for the "two weeks" (interview, September 29, 1992) that she needed to know it for an examination.

Her view of the four operations was a procedural one. She defined doing mathematics in terms of a person computing using either paper and pencil or a calculator, depending on the sizes of the numbers involved in the computation and the incentive of the person doing it. She also felt that once a person knows the basic facts and procedures to add, subtract, multiply, and divide, they are ready to do any kind of mathematics and that not knowing these basics was at the center of people "getting lost" (interview, September 29, 1992) in mathematics in junior high school and beyond.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Entering Beliefs</th>
<th>Exiting Beliefs</th>
<th>Changes</th>
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| Nature of Mathematics                   | 1. Math is ASMD procedures.  
Procedural knowledge over Conceptual knowledge.  
2. Knowledge from external authority, who judges work's validity.  
3. Relevance essential.            | 1. Math is ASMD procedures.  
Procedural knowledge over conceptual knowledge.  
2. Knowledge from external authority, who judges work's validity.  
3. Relevance essential.            | None                                                                                   |
2. Concept first, then all procedures without reference to concept.  
3. Include only topics she has subject matter knowledge for. | 1. Only ASMD procedures;  
2. Concept first, then all procedures without reference to concept.  
3. Include only topics she has subject matter knowledge for.  
Geometry and data analysis only as amusing sidelights. | None, except include data analysis and geometry as amusing sidelights. |
| Learning and Teaching Mathematics       | 1. Learn only through transmission of information from teacher; practicing, memorizing.  
2. Affective variables dominate: Need to make math fun through activities with manipulatives after explanation. | 1. Learn only through transmission of information from teacher; practicing, memorizing.  
2. Affective variables dominate: Must make math fun through activities with manipulatives after explanation. | None                                                                                   |

Table 4.3: Carla’s Entering and Exiting Beliefs
At the end of the course, Carla would occasionally mention geometry and statistics when discussing mathematics. However, she appeared to have maintained her strong belief that mathematics consisted of only the basics and that all other mathematics were frills. For example, in the course, she felt that patterns were "cute and all," but they did not "connect" (interview, December 8, 1992) with her in what she perceived mathematics to be. Instead, she felt that being able to compute in the four operations was the most important mathematics for people to know, because it was the only relevant mathematics to her.

Also, although she did indicate the importance for people to be able to understand the concepts of the four operations, Carla continued to feel that people who understood the basics were the ones who knew how to perform the skills. In particular, she also felt that the only misconceptions about multiplication were procedural in nature, such as not knowing their basic facts or skipping steps in the traditional algorithm.

In general, it appeared Carla wanted to say the right things with respect to the course's explicit view of what was important in doing mathematics; but her traditional beliefs about the nature of mathematics being rooted in those skills remained strong. For example, although Carla occasionally mentioned critical thinking or problem solving as important for students to be able to do at the end of the quarter, she did not believe it was as important as knowing how to perform skills; nor did it seem that she had a good comprehension of what was meant by those terms. For example, after describing the background her entering third grade students should have (adding, subtracting,
multiplying, some fractions, and shape names), she indicated that they need not have any background in topics such as "statistics, probability, and problem solving" (interview, December 8, 1992).

The need for an external authority to do mathematics. Carla felt at the beginning and end of the course that mathematical knowledge comes from external authorities. She argued that, although it may be possible for someone to develop how to do addition and subtraction (and, after the course, even more), it is usually necessary to have someone such as a teacher to judge the validity of one's work and to correct work that is wrong.

Also, when asked to address the hypothetical situations, Carla consistently stated that she would need to look in a book to explain the fixed rule or answer to the student. For example, during her response to a student's inquiry about division by zero, she had difficulty reconciling the idea herself. She found herself forced to either look it up in a book or to claim that it's zero "because that's just how math is" (interview, September 29, 1992). After the course, although Carla did try to reason it out and even allowed students to try to reason it out, she stated that if none of the explanations were convincing enough to her, then she and the students would be forced to look in a book "where it might really explain what the answer is" (interview, December 8, 1992).

The need for relevance. Throughout the quarter, Carla believed that mathematics was only good for limited real life concerns that involved money, such as grocery bills and balancing checkbooks. She thought that someone good at mathematics was one who saw a purpose in math and could relate it to real life. Carla thought that high school mathematics was worthless when compared to elementary school computations. She
praised one-step word problems (one-step exercises involving the four operations) as something she likes because they are not just "numbers on a paper" (interview, December 8, 1992). However, Carla also held that one needed to know computational skills before they can do those word problems.

The Curriculum of Elementary School Mathematics

A traditional curriculum of ASMD. From the beginning to the end of the course, Carla's beliefs about what should be included in the elementary school curriculum complemented her belief that the only worthwhile mathematics was the basics: traditional computational skills involving whole number addition, subtraction, multiplication, and division. Her reason for including only those things was that they were the only mathematics that she saw day-to-day use for. However, when I pressed her, she also considered standard ideas of fractions and measurement as possible topics because of their relevance to daily life if they are kept simple enough. At the end of the quarter, she included other topics (including geometry, probability, statistics, and problem solving); but these were given less emphasis and were treated as amusing sidelights.

Within the basics, most of the mathematics her students would learn consisted of learning the concept of the operation (e.g., multiplication), the basic facts, the algorithm, and word problems in the following order: She would begin by telling the students about multiplication's relationship with addition. Then, she would spend the bulk of the time developing a times table, beginning with the zeroes, ones, twos and fives so the students "can see that it is not hard" (interview, September 29, 1992). Finally, she would show the students the steps of the traditional algorithm. Carla stated that she would also
include one-step word problems throughout once the students got used to computations because of their relevance to real life. This sequence was no different at the end of the quarter, with Carla only adding that she would tell students why the steps of the algorithm work.

Carla did not consider her beliefs of what the curriculum should be to be unusual. Instead, she felt that what she experienced in elementary school was the only curriculum. When describing her goals, she did so through trying to remember what she experienced.

*Inclusion of topics based on subject matter knowledge.* Although the perceived relevance of a topic played the key role in deciding whether or not it should be included in her curriculum, Carla also gave the impression at the beginning and end of the course that she may not include a topic in the curriculum if a topic was too difficult for her to learn (Carla felt she was strongest at the basics and weak at geometry, probability, and statistics). For example, when discussing the inclusion of probability and statistics in her content courses, she considered that they were there to make her think about problems she had not seen before because, if they only dealt with the basics, she would not have to think as much. However, that was the only reason Carla saw probability and statistics being included in the courses because these topics were not part of her vision for elementary school mathematics. Later, when specifically asked if she would consider including those topics in her own curriculum, she said she would, but only as a fun diversion that was not too difficult for her students as it was for her in the content.
courses. She felt that, because she did not experience those topics in elementary school and still "did fine" (interview, December 8, 1992), there was no reason to include them for her future students.

In summary, Carla maintained her beliefs in the dominance of arithmetical computations in what elementary students should learn in mathematics. This belief was brought about through her own experiences in mathematics, what she perceived as being relevant in her daily life, and what she felt comfortable with respect to her own subject matter knowledge. Ways of doing mathematics beyond computing and areas of mathematics beyond arithmetic were considered to be fringes to Carla and were to be treated as such in elementary school.

The Learning and Teaching of Mathematics

_A transmission view of learning and teaching._ Carla entered and exited the course with strong beliefs that children can only learn mathematics by having the information transmitted to them by teachers, practicing the mathematics, and then finally memorizing the steps needed. When asked to define what it means for someone to learn mathematics, she said, "I just basically see someone sitting there while the teacher is explaining what to do" (interview, September 29, 1992). She also perceived someone who understands mathematics as someone who has received the transmission well:

I can just visualize one person looking confused and another person, like, shaking their head, you know, and going on with what the teacher is saying. That's the difference between one person learning and another person not catching on to it. (interview, September 29, 1992)
Carla's beliefs about the role of the teacher in the learning process complemented her view that students need to learn mathematics from explanations. When asked what she saw when she thought of somebody teaching mathematics, she replied,

The teacher is just standing there doling out information to the kids. You know, giving them information....Not really doing much with their hands or whatever. Just basically sitting there and telling the kids what to do. (interview, September 29, 1992)

These beliefs likely were a result of how she went about learning mathematics from elementary school until college. She had no complaints about this treatment, saying that students need to have a set procedure given to them in order for them to get the right answers.

Carla saw as vital the need for clear-cut explanations from teachers in the learning of mathematics. She did not consider thinking or reasoning about the mathematics as important, especially for mathematics learned before college. For example, she said that she hoped she could explain the material well enough to her students so that they could then work in a learning center.

At the end of the quarter, Carla still saw explanation as being the primary way by which her students would learn mathematics, with the use of manipulative materials playing a role only after they have understood what she said. Overall, Carla would judge her overall effectiveness as a teacher by how well her students grasp her clear explanations. Accordingly, she saw becoming a better explainer the only thing she needed to learn about teaching.

Carla also still felt that her role in the classroom would be that of an authority to whom her students would turn both for initial explanations of a concept and if they were
having trouble with performing algorithms. For example, she indicated the following as types of questions she might expect from her students about multiplication:

I don't know... 'how do you get the answer?' I explain it right, then, you know, they shouldn't have any major problems besides, you know, just learning the answers, you know? If I explain it and they understand the concept, then they shouldn't really have too many questions besides, you know, 'What's the answer to 9x6?' or 'What's that answer?' or 'Did I do this right?' or 'Is that the right way to come up with the right answer?..'
(interview, December 8, 1992)

The overriding importance of affective issues. Carla did see needs for improvement in how people learn mathematics. However, these improvements did not involve changing the role of the learner away from a receiver of information. Instead, throughout the quarter, Carla thought that mathematics must be taught so the subject appears more fun and interesting to the students. This belief was related to her belief that the only good mathematics was relevant mathematics.

She saw the affective side of learning mathematics as playing a key role in how she saw her future students going about learning mathematics. Her main emphasis would be on having her students learn in a variety of ways as opposed to only doing worksheets and being bored with mathematics. She indicated that she would want her students to consider her to be "interesting, stimulating, and as someone who gives them a variety of things to do" (interview, September 29, 1992).

In particular, Carla emphasized the need for the use of manipulatives in learning mathematics. However, her reasons were that they were a specific fun alternative to boring worksheets. For example, she looked upon Marilyn Burns as a person who made math fun rather than meaningful because she allowed her students to use manipulatives.
In summary, Carla held strong beliefs at the beginning and end of the course that mathematics consists mostly of procedural information to be transmitted from an authority to the person learning it. The means of transmission should primarily consist of verbal explanations; however, in order to teach the mathematics effectively, the authority must make the mathematics interesting and fun by encouraging the use of manipulatives, word problems, activities, and the like.

**Expectations for the Course**

Carla’s expectations for the course complemented her perceived need to be able to explain mathematics better to children and to use manipulatives so students can visualize what she is saying: "I’m hoping that this math class will teach me ways to clearly explain myself, to give me ideas of how to show them- you know, with the manipulatives and everything" (interview, September 29, 1992).

**Course-Related Assignments**

Carla chose her assignments by considering how easily she could accomplish them as well as if it gave her ideas for teaching a classroom. For example, at the beginning of the quarter, she chose not to do the review of articles "because it’ll probably be too much typing" (interview, October 9, 1992). She chose the resource file because it would be useful to her later. (Note: Carla did end up doing the review of articles because she later thought that doing them would result in "easy points" (interview, December 8, 1992).)

Carla only gave the effort required of her when doing the assignments. For example, when selecting sources for her resource file, she did not consider what students would
learn from the activities. Instead, she took what she thought "looked fun" (interview, November 5, 1992) and copied them to get the credit. Most of the materials in the file were worksheets where students perform standard algorithms as part of a game.

Carla's Field Experience

Description of the Environment

Carla's field experience took place in Cheri's fourth and fifth grade classroom. Cheri was absent for much of the quarter because of jury duty. Therefore, much of what occurred in the classroom may not have been reflective of Cheri's philosophy or actions in teaching. Nevertheless, the environment I did see was the most traditional with respect to the four variables studied.

I observed the classroom during the time students usually did mathematics. At this time, students had a choice of what to do. If they chose mathematics, they worked on a set of assigned exercises from a textbook. The students were shown how to do the exercises by either the textbook or the teacher. Then, if students required help, they referred to the teacher, who corrected them. This homework was usually done by the students with the goal of completing it by the due date, with several comments from the teacher to students who were behind to get caught up in the book. Homework exercises were graded right or wrong.

Occasionally students could work out of the Dinamath problem solving newsletter. But this occurred only if their textbook assignments were complete.
Description of the Cooperating Teacher

Although Cheri was not present for much of the quarter, it appeared that much of what I observed was conducive to her practical philosophy of mathematics and its pedagogy, although not to her theoretical philosophy. In my interview with her, Cheri said her handling of mathematics was stronger than what was done in most of the strands' field classrooms because of her emphasis on mathematics as opposed to language arts. She attributed part of this strength to her background in mathematics.

However, Cheri gave an ambiguous view of what she considered to be important mathematical experiences her students should have in the classroom. On one hand, she appeared to want to present mathematics as a problem-solving process in which the students develop their own strategies and learn concepts. Cheri discussed how she used a variety of sources in developing problem-solving activities for her students, and used manipulatives to help students develop concepts for themselves. For example, she talked about how her students engaged themselves in tangram and pentominoe activities from a source book to develop spatial sense.

On the other hand, it appeared that she emphasized that mathematics is a set of skills to be learned from her or the textbook, to be practiced on a few exercises, and then assessed by her to see where the students may have broken down. She indicated that the usual mode of operation was her introducing the procedure, having the students do a few examples, and any students having trouble come back to her so she can locate and point out their errors. This mode was the only way I observed mathematics being portrayed.
Cheri felt that mathematics was a subject that needed to be treated separately from the other topics because it the students would not learn enough mathematics by only doing the integrated units taught in the informal environment. She also felt that she needed to concentrate more on mathematics in her class because of the students' already strong language arts base.

The curriculum Cheri's students followed during the quarter primarily consisted of traditional skills. During the fall, she wanted her students to be comfortable with multiple-digit addition, subtraction, and multiplication so that they could study long division, fractions, and decimals in the winter. Also, I observed the students learning the traditional algorithm for multiplying decimals as well as estimation of the products (done with an algorithm given to the students).

*The Cooperating Teacher's Expectations for Carla*

Cheri held few preconceived expectations for any preservice teacher that would work in her classroom. She indicated that her goals were to give opportunities to experience working with students and reflect on those experiences to improve in the future. Cheri usually put those goals into practice in tandem with what the intern had to do with university classes as well as with what individual goals they would like to accomplish, if any. Therefore, it was up to Carla to take the opportunities Cheri provided for her in the classroom environment and use them for as much as she wanted.

*Methods Course Assignments for the Field*

Carla did two mini-units in the field, with the first one accounting for credit for a math and literature unit. The first one was an unit in which she read a book about a man
selling toothpaste and then gave the students a ditto in which they needed to decide at what price to set cookies to make a profit. The other mini-unit involved the students using clues to build a mystery shape with cubes.

*Carla's Field Supervisor*

Carla’s field supervisor was Diane, who was also Becky’s supervisor (See description in the section on Becky).

Like with Becky, Diane did not observe Carla with respect to math; but did think that Carla and Cheri’s students had become comfortable with each other. However, she also noted, like Cheri, that Carla did not strive to improve herself even when explicit suggestions were made to her.

*How Carla Experienced the Course and Field with Respect to the Variables*

*The Nature of Mathematics*

*The course.* As was previously described, Carla did not change in her beliefs about what mathematics is and what it means to do mathematics, but, instead, appeared to interpret the course’s messages with respect to her own beliefs. This was especially evident with respect to the course’s treatment of patterns and problem solving.

Carla’s beliefs were that mathematics consisted of the basic skills. Because patterns and problem solving were not part of those basics, she looked upon them as frills that can be done for fun once the basic skills were learned. For example, she looked upon the
calculator activities that utilized patterns to solve problems as cute activities that should not supplant the major part of mathematics. In particular, she felt calculators should only be used as checking tools after the basics are mastered.

Carla was confused as to how patterns are important in mathematics from the beginning to the end of the course. She could not connect patterns to "any other part of math" (interview, December 8, 1992). Thus, she thought that the classes about patterns were worthless.

With respect to the role of problem solving, many of the activities (e.g., the geometry, the patterns, problem vs. exercise activity) were true problems to Carla. However, as was indicated above, Carla only thought of the activities as specific ideas she could use for fun. During or after the activities, she did not consider their (and problem solving's) role in mathematics unless I specifically asked her during interviews. For example, we discussed a pattern activity involving painted cubes done early in the quarter. She did the activity in the role of a student in finding a pattern; but did not think about it beyond that point. Instead, once the problem was solved, Carla and her group talked about unrelated matters. She did not consider the activity again until I asked her about it in an interview.

The field. Because of the traditional nature of Cheri's classroom with respect to mathematics, Carla did not observe students experiencing mathematics in a different way than in her own elementary school experience. Carla viewed the field experience as being different from the methods class with respect to problem solving, with the only problem solving done in the field being the Dinamath activities, which Carla referred to
as an extra. Carla preferred the authoritarian method of experiencing mathematics in the field, and, in fact, wished Cheri would spend more time explaining skills to the students.

The Curriculum of Elementary Mathematics

The course. Carla felt that the methods course influenced her to change her views only with respect to what should be included in the elementary school curriculum. Carla still believed, however, that the basics were the most important mathematics that students should experience. She often wondered why Holly put so much emphasis on areas such as patterns, data analysis and problem solving because they were not strongly emphasized in her own education. Carla also filtered a number of messages about the curriculum through her prior beliefs, assuming that what was said in the messages agreed with what she believed.

With respect to what should be included in the curriculum, she maintained her belief that the basics were the most important topics to be covered; but she did change with respect to what other areas of math could be dealt with. For example, Holly’s ideas for activities in the topic led her to think that she would now "hit a little more on" (interview, December 8, 1992) statistics than she did at the beginning of the quarter.

Carla felt that other areas of mathematics such as data analysis, geometry, and patterns could be taught by her, if she was required to. However, she gave these areas low priority when it came to compare against arithmetic’s importance in the curriculum, despite contrary messages in the course. For example, she reacted to Holly’s talk on the importance of involving students in investigative data analysis activities:
I'm sure I would teach some of it; but I don't think I would go into any great detail. You know, I think I would teach it as like it was sort of a fun sort of math activity or something....It just wouldn't be a major focus. 'Cause...some of the things she did seemed sort of fun....like the raisins and all that sort of stuff....I think that there's so many other parts of math that needs to be dealt with before you start going into probability and statistics....like adding and subtracting - you know, there's so many kids that can't add and can't subtract and can't multiply. You know, can't do all that stuff. And, you know, that's something that you have to learn how to do. (interview, November 4, 1992)

Part of the reason for Carla not wanting to emphasize such topics was her lack of subject matter knowledge, and, even more, her lack of pedagogical content knowledge involving these areas. For example, after the classes devoted to statistics, she admittedly did not know what important concepts of statistics were herself (except random selection), let alone what would be important concepts for students to learn. She also felt she could not teach rational number division because of her lack of subject matter knowledge and her fear of a student asking a question.

Overall, Carla did not feel that all of the emphasis placed on mathematics in the course was necessary because of her assumptions about the curriculum and her personal dislike for the subject. She felt that mathematics really didn't need to be emphasized as much in elementary school because if she hated it, then most other students would hate it too; and if there was more mathematics beyond the basics in the curriculum, students will hate it even more.

The field. Cheri's mathematics curriculum, as was previously stated, consisted mostly of traditional topics to prepare the students for middle school. Therefore, there was little in the field that would do anything but strengthen Carla's traditional curricular
beliefs. Carla rarely noted much about the field topics, except to occasionally state what students were doing for a particular week. She never noted (like she had with the course) that the field's curriculum was unusual.

Carla did notice that there was little relation between the curriculum emphasized in the course and the curriculum she observed in the field. For example, she noted that, while probability, statistics, and patterns were heavily advocated by Holly, students in Cheri's class experienced none of those topics.

*Learning Mathematics*

*The course.* Carla's core beliefs about how children should learn mathematics changed little from the beginning to the end of the quarter. In particular, she maintained throughout the quarter that children need to learn the steps to solve a problem from an authority and that math needs to made relevant and fun in order to learn it well. These beliefs held no matter what contrary evidence was given in the class.

For example, Carla was impressed with the Kamii and Burns videos where the students were able to explain how they got an answer. She thought that it was important that students be able to explain their steps to show they understand them and are not just blindly performing them.

However, Carla also felt that being able to explain on one's own was good because the kids may not understand the *teacher's explanation* that was done in the first place. For example, she noted that the students' explanations in the first Burns video pointed out to her that she should allow her students to explain in their own words only because they may not understand what she told them.
Further, despite messages to the contrary, Carla felt that, even if students are first given a chance to explore, the teacher must eventually explain the steps to the students. She said this was because some of them will get stuck, some will be doing it wrong, and some students will never be able to explain their own steps.

When responding to specific situations brought up in class or in the interviews, Carla always sided with the traditional beliefs that students should learn from teachers who try to make the math as easy as possible. She never voluntarily suggested that students be allowed to explore a problem on their own. For example, after the area/perimeter activity, Carla still felt that one must learn the formula for area from a teacher before being able to solve any problem involving area.

Overall, Carla felt that she learned little from the methods course about children learning mathematics. She thought the course had one message about learning: children should use manipulatives. However, Carla felt she already knew this as a part of her beliefs about the need to make mathematics fun. Therefore, she thought the course only added to this knowledge by giving her specific uses of manipulatives.

*The field.* Cheri’s classroom’s learning environment was conducive to Carla’s beliefs about how students should learn mathematics. Therefore, it is not surprising that Carla had few disagreements with the learning environment there, whether it be with respect to grading papers right or wrong, walking around answering students’ questions as to whether they are performing a skill correctly, or the goal of only trying to get the assignments done that pervaded the classroom.
When I presented an alternative environment to the one she experienced in the field, Carla would tried to bring it back to the one that existed. For example, we hypothetically discussed the students in the field developing their own algorithms instead of relying on the book. Carla thought the students would eventually get used to doing it. However, when they would complete the problem, they would "probably just ask the teacher if this was the right way to get it" (interview, October 16, 1992).

The only disagreements she had with Cheri was that she would like to see more introductory examples given to the class. Carla also wished that Cheri would allow the students to use manipulatives and games more, which also was in line with her beliefs.

Overall, Carla saw different strengths and weaknesses with respect to how she saw children learning mathematics in the field and in the methods course. She felt that there was not much about learning mathematics in either venue. She did not recall Holly talking about children learning mathematics in the course. Also, because she mostly saw students in the field working out of a textbook, she did not think about how they went about "catching on" (interview, December 8, 1992) to the mathematics. Carla preferred her field experience over the course because it gave her an opportunity to work with real students.

Teaching Mathematics

The course. Carla felt that the course partially satisfied her need to learn about teaching mathematics because of the activities that Holly presented. However, she felt
that Holly should have also given her a "whole new way" (interview, December 8, 1992) of teaching mathematics that Carla could take directly to her classroom and use in her first year to make mathematics fun for her students.

Carla either did not consider the course's messages about teaching at all or thought of them as reiterations of what she already knew. For example, when Holly discussed what roles a teacher should play, Carla only copied down what was on the overhead and put it aside for later use.

Carla claimed that most of the course's messages about teaching made sense because they were what she already believed. However, Carla appeared to only consider or reinterpret messages that she saw as teachers showing mathematics to be fun and/or easy with manipulatives. For example, Carla saw Holly's guidelines of teaching fractions as showing students how to do the operations with visuals so that it's easy for the students to later do on their own. Also, Carla considered the Marilyn Burns videos to be useful because it showed how a teacher could generate interest in mathematics and make it fun for the students. Carla felt that, with a few years' of practice, she could be like Burns in this manner without consideration of philosophical issues.

Carla did not appear to consider course messages that portrayed teachers in non-authoritarian roles. For example, Carla felt that the Kamii video gave a good example of having students explain their reasoning so that teachers can understand what they're doing and thinking. However, Carla also thought that the traditional algorithm was what
the students were explaining and that the teacher was and should still be the mathematical authority in the class by telling students if they are right or wrong. Carla perceived the Marilyn Burns tapes in a similar way.

*The field.* In the field, Carla felt comfortable with the authoritarian manner in which mathematics was taught to the students either by the teacher or through the book. Carla herself enacted similar roles throughout the quarter, usually in working with one or a few students. The only exception to her playing the role of authority was during her field assignment activity of finding a mystery shape. There, she had the students solve the problem using the clues she gave them.

Overall, however, it appears that Carla did not experience the teaching of mathematics in any new manner. Thus, the field experience could have only strengthened her beliefs about what a teacher's role should be in the classroom.
Potential Factors Toward (the Lack of) Changing Beliefs

Despite entering with different levels of confidence, self-efficacy, and mathematics course histories, all three interns in this study entered the course with roughly the same traditional backgrounds and beliefs with respect to the nature, curriculum, learning, and teaching of mathematics (see Tables 4.1-4.3). These beliefs did vary somewhat, with Carla’s being more traditional than Becky’s, whose were more traditional than Amanda’s. Amanda’s beliefs about teaching and learning appeared to change the most, with minor changes occurring in Becky’s and Carla’s beliefs (see Table 4.4).

With respect to the nature of mathematics, all three maintained their belief that mathematics is a series of established algorithms received from an authority. All emphasized the need for mathematics to be relevant in day-to-day life, particularly in the realm of money or baking. Amanda and Becky appeared to change slightly toward allowing one to attempt a problem first; but if the person could not solve the problem in a short amount of time, that person needed to be shown the traditional method of solution.

With respect to the curriculum of elementary school mathematics, all three continued to believe that the procedural knowledge of the traditional arithmetic algorithms and solving relevant story problems should be the major goals for children. Amanda and Becky changed slightly toward some emphasis on the concepts behind the algorithms. Although the methods course seemed to influence them to include topics such as geometry and data analysis in their hypothetical curricula, these topics were relegated to a minor role when compared to arithmetic.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Changes in Amanda's Beliefs</th>
<th>Changes in Becky's Beliefs</th>
<th>Changes in Carla's Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Mathematics</td>
<td>More open to trying to solve problems first before referring to authority.</td>
<td>None except good to understand predetermined steps to solve a problem.</td>
<td>None</td>
</tr>
<tr>
<td>Curriculum of Elementary Mathematics</td>
<td>Would include more descriptive statistics and geometry like her field did.</td>
<td>None except includes more explanation of ASMD procedural steps; geometry/data analysis in minor roles.</td>
<td>None except include data analysis and geometry as amusing sidelights.</td>
</tr>
<tr>
<td>Learning and Teaching Mathematics</td>
<td>Teacher acts more as a model for solving problems. Students try more to discover on own before teacher steps in to explain. Teacher is reflective. Referred to her field experience on each of these.</td>
<td>None except now sometimes allows for quick exploration before teacher steps in with explanation.</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 4.4: Changes in the Interns' Beliefs as Described in the Case Studies
With respect to learning and teaching mathematics, all three continued to emphasize the role of affective variables by promoting an active learning environment managed by a caring and enthusiastic teacher. Amanda was the only one of the three who did not consider the sole purpose of manipulatives in an active environment to be the promotion of affective traits of her students, although those variables were still her major concern. The three interns continued to believe that the teacher should be the ultimate authority for knowledge in demonstrating the required skills. Although Amanda, drawing on her field experience, became an advocate for allowing more exploration and invention in solving a problem, she too felt that the teacher should eventually demonstrate the solution to avoid frustration.

Why did the interns' beliefs not appreciably change with respect to their methods course? One might argue that one mathematics methods course that lasted ten weeks would not be long enough for any discernible change to occur. This may be so; however, it was apparent that *some* change occurred in Amanda's belief structures of learning and teaching over the course of the quarter.

Even if lack of time was a predominant factor in the non-changes, there were factors about the course that hindered the reconstruction of the interns' beliefs. Most of these factors can be explained by the Strike and Posner theoretical model that states one must (a) be made aware of his or her beliefs; (b) be aware of the important role beliefs play; (c) be confronted with experiences that cannot be reconciled with existing beliefs; and (d) reflect on those experiences to the point of a felt need to replace existing beliefs with a intelligible, plausible, and worthwhile paradigm contrary to those beliefs. According
to this theory, it is apparent that the interns' beliefs did not change largely because the course did not utilize the interns' beliefs; nor did it encourage the active reflection upon the intended, Standards paradigmatic messages about the nature, curriculum, and pedagogy of elementary school mathematics. Instead, the course allowed the interns to filter their experiences through their existing beliefs rather than challenging those beliefs. Also, while the course offered messages that were contrary to the interns' beliefs, it and the field experiences may have reduced the messages' intelligibility, plausibility, and worthwhileness through contradictory implicit messages and a lack of connection within and outside the course.

*Interns' Filtering and Lack of Reflection on Experiences*

As will be seen in this section, the interns did not think very deeply about the messages the course conveyed about the nature, curriculum, and pedagogy of elementary school mathematics (see Tables 4.5–4.8 for summary of their experiences with respect to those variables). Each intern appeared first to decide whether a message was important enough to pay attention to with respect to her perceived needs and expectations. Those messages that the intern did consider were interpreted with her existing beliefs acting as guidelines for what the messages meant to her.

*Interns' Filtering Experiences Through Their Perceived Needs and Expectations*

All three interns used their perceived needs and expectations as arbitrators in deciding what course experiences were important enough to consider. Each intern expressed the
<table>
<thead>
<tr>
<th>Intern</th>
<th>Math Methods Course</th>
<th>Field Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>1. Noted breadth of math (activities, syllabus) and solution justification (videos).&lt;br&gt;2. Agreed with some explicit messages when brought up in interviews; returned to beliefs otherwise.&lt;br&gt;3. Ignored or misinterpreted some messages through expectations and beliefs - especially relevance (e.g., problem vs. exercise activity is relevant area activity) and sequential (e.g., textbook's treatment of computation).</td>
<td>1. Saw math as active problem solving.&lt;br&gt;2. Students need to explain own solutions. Noted differences from course (exploratory vs. presentation).</td>
</tr>
<tr>
<td>Becky</td>
<td>1. Agreed with use of problem solving and student actions in such environments (especially in videos, Bob Cooper); but only for affective purposes with external authority still present.</td>
<td>1. At outset, group thematic activities good because of relevance.&lt;br&gt;2. After a few weeks, changed mind toward teaching math separately.&lt;br&gt;3. Problem solving done for fun/relevance.&lt;br&gt;4. Treated conceptual and procedural student questions differently.</td>
</tr>
<tr>
<td>Carla</td>
<td>1. Interpreted explicit messages with respect to beliefs (e.g., patterns and problem solving are fun supplements).&lt;br&gt;2. All activities interpreted only as specific ideas.</td>
<td>1. Not different from background: Preferred to course messages.&lt;br&gt;2. Agreed with need/role of external authority in classroom.&lt;br&gt;3. Problem solving done as fun supplement.</td>
</tr>
</tbody>
</table>

Table 4.5: Interns' Experiences with Respect to the Nature of Mathematics as Described in the Case Studies
<table>
<thead>
<tr>
<th>Intern</th>
<th>Math Methods Course</th>
<th>Field Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>1. Downplayed topics beyond what she previously experienced. Consistently placed emphasis on traditional topics.</td>
<td>1. Math not emphasized like course recommended. 2. Saw variety of concepts: measurement, representing and analyzing data, different strategies for basic facts. 3. Only grew on geometry concepts from her activity.</td>
</tr>
<tr>
<td>Becky</td>
<td>1. Did not consider course messages because experts will provide curriculum upon employment. 2. Consistently assumed childhood curriculum. 3. Was personally reintroduced to possible topics and provided with only pedagogical experiences in topics of little subject matter knowledge: geometry and data analysis.</td>
<td>1. Felt math was largely ignored. 2. Needed more coverage of traditional topics.</td>
</tr>
<tr>
<td>Carla</td>
<td>1. Questioned emphasis on patterns, data analysis, problem solving. Not as necessary as teaching needed basics. 2. Presentations and activities led to consideration of additional coverage of statistics, but only as minor supplement.</td>
<td>1. Did not note anything wrong with curriculum - similar to childhood's. 2. Did notice difference in topics recommended in course versus those in field.</td>
</tr>
</tbody>
</table>

Table 4.6: Interns' Experiences with Respect to the Curriculum of Elementary Mathematics as Described in the Case Studies
<table>
<thead>
<tr>
<th>Intern</th>
<th>Math Methods Course</th>
<th>Field Experience</th>
</tr>
</thead>
</table>
| Amanda  | 1. Course did not address learning mathematics.  
2. Saw field-like exploratory environments only in videos, Bob Cooper.  
3. Video and Bob Cooper messages filtered through beliefs (e.g., Bob Cooper should not allow frustration; book advocates sequenced learning). | 1. Students discover like scientists using 24 different learning styles.  
2. Noted difference with course: independence and cooperation in field; little in course.  
3. Agreed with cooperating teacher's strategy of showing solution method before one activity. |
| Becky   | 1. Used course only to gather activities promoting active engagement; but no consideration of rationale.  
2. Agreed with active learning portrayed in videos when discussed in interviews but did not consider theoretical underpinnings; returned to transmission beliefs otherwise. | 1. Group activities good because relevant and stimulating.  
2. Did not envision how the children learn math; felt students are smart because little explanation given by cooperating teacher.  
3. When requested, told students how to perform algorithm and graded worksheet exercises right or wrong. |
| Carla   | 1. Maintained transmission beliefs throughout.  
2. Agreed with allowing students to explain in videos; but only to assess if they understood teacher's explanation.  
3. Valued activities with manipulatives; but only because they are fun. | 1. Little deviation from childhood environment.  
2. Students need more explanation than what was provided.  
3. Could envision field students developing own algorithms only if they ask the teacher to verify correctness. |

Table 4.7: Interns' Experiences with Respect to Learning Mathematics as Described in the Case Studies

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<table>
<thead>
<tr>
<th>Intern</th>
<th>Math Methods Course</th>
<th>Field Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>1. Saw importance of language, spontaneity, allowing for discovery, and questioning from videos. 2. Did not consider activities with respect to teaching (did as student and for expectations of ideas). 3. Noted some course events promoted teacher-centered actions and words. 4. Sometimes interpreted activities through beliefs (e.g., had concern of how to explain a discovery to students).</td>
<td>1. Field environment and cooperating teacher dominated her preparation to teach because could work directly with students. 2. Spent most activities in role of a guide. 3. Course assignments used only to experience organization and not for teaching math. 4. Did plan course assignment activities with an eye toward what students would learn (e.g., planning questions).</td>
</tr>
<tr>
<td>Becky</td>
<td>1. Ignored course messages about guidance role of teachers in favor of beliefs in an authoritarian role. 2. Peer teaching was valuable because explained in front of people. 3. Used videos and activities primarily for fulfilling needs of specific ideas.</td>
<td>1. Noted little real teaching by cooperating teacher. 2. Thought cooperating teacher should address whole class more often. 3. Did course assignments only for experience in planning, organizing, and implementing activities.</td>
</tr>
<tr>
<td>Carla</td>
<td>1. Course partially satisfied teaching needs because of fun activities. 2. Still needed new way to take directly to classroom and make math fun. 3. Ignored or interpreted course messages through beliefs (e.g., Burns encouraged manipulative use for affective purposes).</td>
<td>1. Comfortable with cooperating teacher's and book's authoritarian role. 2. Enacted similar role when working with students.</td>
</tr>
</tbody>
</table>

Table 4.8: Interns' Experiences with Respect to Teaching Mathematics as Described in the Case Studies
same basic expectation for the course: to provide a set of sources for activities that each
could implement in an active manner. Each also had similar reactions to what actually
transpired in the course.

*Activities treated as the only worthwhile course events.* First, each intern considered
the course activities and sources for activities as the only worthwhile portions of the
course. Other parts of the course, particularly presentations, were looked upon as taking
time away from what they wanted to do: developing or learning activities.

Amanda always pointed out that the most significant aspect of the course was when
the class was involved in an activity. She was consistently disappointed with the amount
of time listening to presentations or watching videos in the class when compared to the
time formulating activities. For example, when discussing the active, exploration-based
learning environment of the second pattern and second geometry classes, she stated she
wished all the classes were like that. Also, when reading the textbook, Amanda skimmed
over the theoretical concepts and only concentrated on activity ideas the book presented.
Because of her overall disenchantment with the course with respect to her expectations
of developing and testing activities, Amanda decided to satisfy her expectations herself
by forming an unassigned database of activities.

Becky mentioned the activities as the only significant events of the course, never
referring to anything else that happened as important, even forgetting that certain non-
activity events occurred. In particular, Becky felt that the only worthwhile presentations
were those in which Holly gave the interns specific activities. She described Holly's role
in the class as:
Somebody who gives us ideas of how to teach certain areas and things - and gives us resources and where to go and games to get us started. Mainly survival for, like, the first year of teaching! (interview, November 19, 1992)

To Becky, presentations involving theory or guidelines were considered a waste of time.

Becky thought that her colleagues also utilized the course only for gathering ideas:

Most people treat (the course) like a blow-off. They're just getting what they can, you know, for their own benefit. They're getting resources, they're getting a few games here and there, and they're trying to get a few ideas. But nobody really takes it, like, real seriously. (interview, November 19, 1992)

Like her two peers, Carla spent most of the class with an eye out only for specific ideas and sources. She did not pay attention to presentations or videos except those giving ideas for using manipulatives. For example, she stated that the only major issues addressed in the course were the activity books that Holly shared with the class. Carla was somewhat disappointed by the amount of time spent on patterns and topics such as data analysis. Carla wanted to be spending time on what she felt was important: survival in the first year in teaching the basics.

In addition to the statements made in their interviews (see case studies), another indication that these three interns used their expectations for activities to decide on what was important in the course was found in their notes from classes. Beyond simply copying guidelines that Holly had on the overhead, all three interns wrote little in their notes besides specific activities that were done or sources for activities recommended in class.
Misinterpreting course events as only satisfying needs. The interns often interpreted the purpose of course events as only providing them with specific activities for use as future teachers, even if the experience was done with an alternative (and sometimes stated) purpose.

For example, each of the interns did not consider the purpose of the problem vs. exercise activity as illustrating what a true mathematics problem was and was not. Instead, each considered the activity only as an idea to use with students to illustrate perimeter and area. Also, each used the textbook only as a source for activities.

Other examples of misinterpreting events as ways of satisfying the interns' needs include their treating the peer teaching day as only a set of data analysis activities as well as an opportunity to practice teaching in a traditional manner, their perception of the objective of the data analysis video as an example of how one can use media with students, Becky's and Carla's treatment of the guidelines for teaching rational numbers conceptually as only another group of activities, and Becky's view of Bob Cooper's talk about problem solving in the classroom as only a set of "neat and creative ways to teach math" (interview, November 19, 1992).

Selection and treatment of assignments for fulfilling needs. Finally, as was noted in the individual cases, each intern appeared to select her assignments on the basis of her needs for collecting activities and practicing organizational skills, as well as the immediate need to get things done quickly for a good grade.

Parallel to their expectation of the course to provide activities, each intern elected to develop a resource file. However, Becky and Carla's files appeared to be generated in
the spirit of getting a good grade with both files containing more than the required number of resources and consisting largely of fun worksheets requiring only fact or procedural knowledge.

Amanda and Carla chose to do a review of articles for the sole reason of getting easy points quickly. Becky indicated that she would have done a review had she "needed extra points" (interview, December 8, 1992).

Amanda and Becky looked to the field assignments not as opportunities to learn about how children learn, what roles a teacher should take, what should be included in the curriculum, or what doing mathematics means. Rather, each considered the assignments as occasions for learning how to organize and implement generic activities, although Amanda also learned mathematical pedagogy from the lessons. Carla, given a choice of activities by Cheri, her mentor teacher, selected those that could combine as many assignment options as possible (for points) and involved mathematics that she understood. Carla even relied on Cheri to select and retrieve materials needed for these lessons.

In summary, the interns considered the messages and events of the course with respect to their expectations. These expectations, driven by their perceived needs to have specific ideas to teach mathematical topics, were used to decide both on an event's importance and purpose. Because the interns' expectations for the course were different from Holly's, many events were ignored or misinterpreted.

*Interns' Filtering Messages Through Their Existing Beliefs*

Rather than taking potentially conflicting messages from many events in the course and reflecting upon them, together with their existing beliefs in order to formulate new
beliefs, the three interns appeared to unconsciously assume their beliefs were fixed guidelines through which to interpret the messages. In particular, if a message conflicted with their beliefs, the interns either ignored the message or translated it so that the message agreed with their beliefs.

I did not notice as much filtering on Amanda's part as I did with Becky and Carla. Perhaps this was a result of her being the only intern who prepared to comment on class events in our interviews. Also, perhaps she was more aware of her beliefs and could more consciously compare them to the messages than the others.

Videos' and Bob Cooper's messages. The interns took the videos' and Bob Cooper's messages of the importance of problem solving in the curriculum and the Standards-like roles of teachers in the classroom and either temporarily agreed with them before reverting back to their old beliefs or misinterpreted their meaning altogether with respect to those beliefs.

For example, Amanda interpreted messages from Bob Cooper's class as being common sense. Yet, for example, contrary to Bob's emphasis on students going as far as they are able, Amanda felt that a teacher should step in at the first sign of frustration and take the role of authority in telling students what to do.

Becky also filtered the messages made by Bob Cooper and the Kamii video. In particular, she paid attention only to the affective aspects of the active and hands-on learning that took place in those classrooms. For example, Becky thought she could incorporate the teaching style on the Kamii video as one of many so that her own students do not become bored. However, Becky ignored the major point made by Kamii and a
main point of Bob Cooper's about the goal of autonomous learning for students. Within the same interview, Becky talked about how she would handle a student who performed a different algorithm to solve a problem. If the student's method was correct, Becky wouldn't mind. But if the student was wrong, Becky would correct him or her.

As was described in the case study, Carla felt that the Kamii and Burns videos emphasized the need for students to explain their reasoning. However, she also thought that the students were reexplaining what the teacher had already told them and that teachers in the videos were determining students' correctness in performing traditional algorithms. Carla did not attend the Bob Cooper talk.

Messages from the textbook. In addition to using the textbook primarily as a source for activities, the interns also interpreted messages from the book as agreeing with their entering traditional viewpoints. For example, with respect to the chapters involving computation, which recommended the development of various situational strategies, Amanda's major impression was that it was common sense that the book emphasized that one must learn mathematics in a sequential manner because it was a sequential subject. When discussing the chapter on technology, which espoused many roles for calculators and computers in learning mathematics through problem solving, Becky appeared to think the chapter said that the major roles for calculators were to check answers and perform operations on large numbers. Carla read the chapter on technology and, despite agreeing with what the book said about the role of technology ("it said basically what I already
know" (interview, October 30, 1992)), she claimed that the book emphasized technology for the same uses she espoused, such as checking, drill and practice tutorials, and fun games.

Messages from presentations and activities. The interns often ignored or reinterpreted course messages that were contrary to their beliefs.

For example, Amanda ignored course messages about geometry and instead relied on her personal history beliefs about geometry in the curriculum as well as on the geometry activity she did in the field. She claimed she forgot what was done in class and answered my questions about the geometry curriculum with only her beliefs and field activity in mind.

Becky, as described in the case study, viewed the peer teaching activity through the lenses of her beliefs about what is meant by teaching. She valued the activity because it was the only one of the quarter that had the interns in positions of real teachers: in front of the class explaining to students. She felt that:

(Holly) probably did it so we could get experience with teaching activities and learning how to be clear when we are teaching. Because we could practice with these guys, you know? If we weren't clear with our own students one day in the classroom as a real teacher, then you're going to run into problems. (interview, November 5, 1992)

Carla never completely disagreed with anything said or done in the class, yet she maintained her traditional beliefs. She appeared to go through the course by only paying attention to those things that fit her existing beliefs and sometimes noticing, but not worrying, about the rest. For example, she was concerned about the emphasis put on data analysis, partly due to her lack of subject matter knowledge. However, she brushed
the emphasis aside by stating that she would include it only as an easy fun sidelight to the core curriculum she already had in mind. Her rationale was her belief that students need to learn how to add, subtract, and multiply first. And, because many children cannot perform those skills, little emphasis should be placed on topics one does not really have to learn.

Messages from the field experiences. Two of the three interns interpreted messages about teaching in the field with respect to their traditional beliefs. Becky consistently claimed that there was no real teaching of mathematics being done in Brenda’s class because Brenda rarely lectured. On the other hand, Carla felt that Cheri did a fine job teaching mathematics because the environment resembled her own background: students learning mathematics from Cheri or the book and assessment based on the correctness of answers.

In summary, the three interns took many of the intended messages about the four variables and reinterpreted them so they fit the interns' existing belief structures. This filtering occurred in varying degrees, with Amanda filtering less than Becky and Carla.

Interns' Lack of Reflection on Experiences

Perhaps the major factor contributing to the interns' filtering of the course's messages was that they often did not make the effort to think deeply about those messages they listened to. In essence, once a class ended, the interns did not think about the nature, curriculum, or the pedagogy of mathematics. Instead, beyond our interviews, they apparently considered nothing about the course until the next class convened.
Amanda's reflection on learning and teaching. The only possible exception to this phenomenon was Amanda. She paid attention to and took notes on what was said and done during class time, then went home to rewrite and think about her notes. She did this partly for our interviews, but also because she considered reflection an attribute of a good teacher. She agreed with Holly's occasional recalling of her thoughts about teaching from her career by saying, "I think that helps us to see that you're always going to grow and develop and reflect back on what you did and see that you weren't perfect and could always improve" (interview, November 19, 1992).

Often, the thoughts she had about class discussions were made with her reflections about her field experience in mind. For example, she looked upon the book reading and class discussion about planning with respect to her planning details about a lesson on fast tens and nines:

I kept thinking when I read this chapter, it reminded me....I did a lesson with the second graders on fast 10s and I was using the overhead. And there were ten second graders. And I could not....decide where I was going to have them sit....I couldn't decide if I wanted them....in the front of the overhead or off to the side. Because....I wanted to have contact with them. And it was like the little things, you know, that you really need to think through and plan ahead. So that just like reemphasized that when I read the chapter. (interview, October 22, 1992)

Alice felt that Amanda was reflective in planning, implementing, and evaluating activities in her classroom whether the activity was a course assignment or one Alice wanted her to do:

She was very thoughtful and reflective in terms of introducing and giving them meaningful experiences and lots of opportunities to express their knowledge. And also...having them demonstrate what they knew. She was very good at providing different kinds of activities for them. (interview, December 16, 1992)
Amanda also reflected on events that happened in the class with respect to her own experiences in elementary school. For example, when discussing the tile pattern activity done as a class, Amanda recalled similar thoughts and experiences she had had as a student. She noticed that the intern next to her had a different idea from hers on what the next structure in the pattern would be. This reminded her of being an elementary school student when a classmate would not understand something the teacher said when Amanda understood.

*Amanda's lack of reflection on nature and curriculum.* However, Amanda did not reflect as much about messages that did not directly involve actions of teaching and learning. When *Standards*-like messages were made about the nature of mathematics or the significance of including topics in the curriculum, Amanda either did not evidence much thought about or forgot the message. For example, she thought the data analysis video was a waste of time and did not think about the reason Holly stated for showing it. She also claimed that she did not remember when Holly asked the class (and provided answers) for justifications for including data analysis in the elementary curriculum.

Therefore, overall, Amanda did try to consider messages from the course about teaching and learning mathematics. She purposely compared the messages with her own experiences as a student as well as with her reflections on her field experiences that differed from her personal history, yet which were perceived by Amanda to be plausible and worthwhile alternatives for children's learning of mathematics. Perhaps her changes in beliefs about teaching and learning mathematics could be attributed to these reflections and her awareness of her previous beliefs. Similarly, her lack of change in her beliefs
about the nature and curriculum of elementary mathematics may be attributed to her not taking the opportunity to reflect on such issues when they were examined in the class.

**Becky's and Carla's silence.** Becky and Carla did not exhibit any thought about issues brought up in the class on any of the four variables. When I asked them a question regarding issues or events from class, each of their verbal and physical responses were like those of someone who had never considered the question before. These responses included silence, stating that they had forgotten about the event, and not being concerned if an issue was contrary to their thoughts.

Becky never tried to think of anything about the course except with respect to her expectations and the assignments she was required to do. She never mentioned anything about the class as notable except specific activity ideas. Her response to interview questions was often sustained silence, a request to repeat the question, or to detail events that she had forgotten about. Examples of this lack of careful thought abound throughout the transcripts of Becky's interviews. For example, when I asked her why she thought an activity was done in the class or for what purpose it could be used with students, Becky usually had given no thought to the issue before the question was asked and responded with a shallow answer or stammering. When I asked her what she considered the purpose of the calculator activities, she responded:

(Silence) I don't know - Maybe to give us ideas of how to incorporate calculators into the class, I don't know. I have no clue, really....I don't know. (Silence) I don't know. They were interesting. (interview, October 30, 1992)

Carla also did not take the course with the idea that she would think about issues brought up in the class. Like Becky, she wanted to do only what was required of her as
well as collect ideas and activities to use in her future class. During interviews, Carla usually responded to a question about an issue with silence while she thought about the question followed by either "I don't know" or a restatement of her beliefs relating to the issue. With respect to activities, Carla appeared to never reflect on the purpose of an activity beyond putting it on her list of ideas. For example, when discussing the probability activity led by the two interns, Carla had to stop and think why it was included in the course. Her response began with a series of "I don't know"'s before she finally concluded it was another activity for her resource file. Carla treated course presentations and discussions in the same manner. For example, when I asked Carla to discuss her opinions of Holly's talk on the goals of including data analysis in the curriculum, Carla said, "What do I think about teaching it? Mmm...I don't know. I mean, I haven't really thought about it" (interview, November 4, 1992).

_Becky's and Carla's forgetting events._ Many times, when discussing an important course event (usually a presentation), Becky and Carla evidenced their lack of reflection by stating they forgot the event occurred. This was usually within a few days of the event and after the intern had discussed what she considered to be important events and issues from the past one or two classes. For example, both Becky and Carla forgot the occurrences of the presentation on the importance of allowing students to develop algorithms for operations with fractions on their own as well as the talk on behaviorism and constructivism. Even upon examining notes that had been taken at the talk on behaviorism and constructivism, both Becky and Carla could not recall anything about the event, let alone discuss what they learned from it. With respect to Holly's discussion
of rational number operations, Carla was able to recount what was recommended regarding addition; but she could not recall anything about Holly's detailed discussion on division, referring instead to her knowledge of the traditional algorithm.

Becky's and Carla's lack of concern if messages disagreed with beliefs. Finally, neither Becky or Carla showed concern over issues that were dealt with in class that they were confused about or disagreed with. For example, during each interview, I asked the intern if there was anything in the class that she was concerned about. If there was a response, it always consisted of procedural matters (e.g., getting assignments done or getting to lunch between classes). Becky addressed why she did not consider issues that obviously contradicted her beliefs:

If you take [the course], like, real literal or real serious....because there are going to be some things that you disagree with, things that you get real confused about, things that aren't going smooth for you - you just have to push some of those things aside. You can't let everything get to you because you will just totally drive yourself nuts. (interview, November 19, 1992)

Carla made no attempt to resolve difficulties that were not required to be resolved. For example, from the beginning to the end of the course, she did not understand the course's motives for spending time on patterns. She also made no attempt to learn what had happened at the Bob Cooper seminar she missed.

When given explicit opportunities to reflect on important issues, Carla did not. For example, when preparing to summarize the major points for a chapter in the textbook, Carla only skimmed the headings within the chapter so that she would have enough to write. Also, when given the assignment to describe attributes of a learning community,
Carla attended the related seminar, wrote down what the speaker said, and copied them down to turn in. She could not remember what else the speaker had said beyond those points.

In summary, the interns showed little evidence of reflection on the messages from the course about the nature, curriculum, learning, and teaching of elementary mathematics. If the interns did not reflect about the messages brought about in the course toward reconsidering their beliefs, there would be little chance for the course to have an impact on the reconstruction of their beliefs because if the following requirements for change of the Strike and Posner model: reflective disposition, awareness of and valuing beliefs, and cognitive actions toward becoming dissatisfied with current beliefs. Therefore, it may be that the lack of reflective thought on the part of the interns is a, if not the, major factor in the interns' lack of change in their beliefs. But the question remains: What factors in the course and in the interns themselves may have discouraged such reflection?

Factors Toward the Interns' Filtering and Lack of Reflection

There were at least two factors in the interns' not reflecting on course messages. The first lay within the interns themselves: their perception of their own traditional subject matter knowledge and pedagogical content knowledge as both adequate and the only possible perception of mathematics and its pedagogy. The second stemmed from the course's lack of action on the interns' entering beliefs. These factors were the course's not requiring the interns to consider what their beliefs were and not requiring the interns to reflect on potentially conflicting messages that were conveyed.
Interns' Perceptions of Their Subject Matter Knowledge and Learning to Teach

Throughout school, each intern had experienced mathematics only as a sequential collection of procedures to be practiced and memorized. That collection of procedures was the same, usually consisting of numerical or symbolic manipulations in arithmetic, algebra, and (for Amanda) calculus. Outside of school, they used mathematics only for monetary and measurement purposes. Therefore, it is not surprising that their beliefs about the nature and curriculum of elementary mathematics were similar and mirrored those previous experiences.

With respect to learning and teaching, the interns also experienced mathematics in the same way: a teacher modelling the procedure to be learned so that the students can mimic his or her actions repeatedly on exercises in a book. If the students had trouble, they could ask the teacher for help in performing the procedure for them. The interns then were assessed on whether they could perform the procedures correctly. Therefore, it is not surprising that the interns had similar beliefs about how one could best learn mathematics and what role a teacher should play in the process. If there were alternatives to this in their beliefs, they were usually to negate poor affective views among students; but the teacher still ultimately held the role of mathematical authority in the classroom.

Because of these similar experiences, the three interns had only a limited view of the nature, curriculum, learning, and teaching of elementary mathematics. After twelve or more years of this view with few, if any, experiences that gave a different perspective, the interns were probably not aware that there could be alternative viewpoints on what mathematics is, what constitutes important mathematics, and how mathematics is learned.
and taught. Thus, it is not surprising that the interns appeared certain that the mathematics their future students would experience would be largely the same that they experienced as children and that those students would learn mathematics largely in the same manner that they did, with the exception that the learning might take place in the informal environment that their strand advocated.

As a result of their one-sided point of view of mathematics and its pedagogy, the interns felt confident in their subject matter knowledge of what they perceived to be elementary school mathematics as well as in their ideas of how mathematics should be taught and learned. Thus, they looked upon the methods course as only an opportunity to gather tools to implement their existing knowledge and beliefs rather than as an opportunity to examine and possibly change those cognitive structures. That is, they wanted to learn actions, not philosophies.

*Interns' perceptions of their subject matter knowledge.* With respect to their perception of their subject matter knowledge, all three interns were sure that they could teach mathematics in elementary school. However, their comfortable perception of their subject matter knowledge was restricted to the traditional curriculum and a procedural view of mathematics. As Becky indicated:

*Becky:* I feel I have the knowledge fine for that grade level.

*Researcher:* What does a teacher need to know?

*Becky:* (Silence) Arithmetic. They do everything from addition and subtraction to multiplication and division. They do word problem solving. They do working with geometry and shapes, tangrams, and pentominoes - what other shapes? I can't remember. (Silence) ...They don't do fractions in the class that I'm in but I think they should be doing fractions. (interview, December 8, 1992)
Carla was the one intern who was somewhat underconfident of her mathematical abilities. She did not feel that she was good in mathematics in general. She felt that she was only able to memorize procedures for a short period of time and then forget them. However, she felt her subject matter knowledge of elementary school mathematics was adequate enough to teach young children, relying on her beliefs that the elementary curriculum consisted of only a collection of simple computational facts and procedures to be practiced and memorized:

I mean basically, they're just learning about, I mean, between third and fifth grade, they're still learning about basics and everything. And I'm pretty good at that, you know! So, I think I'm qualified to teach it. I mean, just about everything they did while I was in the (field) class, I knew how to do it. (interview, December 8, 1992)

However, when confronted with conceptual questions in both the class and our interviews, however, it was clear that each intern lacked conceptual knowledge, despite claims to have experienced conceptual thinking in their content courses. For example, when asked about hypothetical students discussing why 5^0 (five to the zero power) should be defined as one, their lack of conceptual knowledge was evident as each tried to raise five to several powers before finally asking to appeal to a textbook or another authority.

Yet, when incidents like this were not at the forefront of our conversations, each went back to her belief that her subject matter knowledge was adequate for elementary school mathematics. For example, during the same interview in which she struggled with defining 5^0, Amanda felt that, with respect to subject matter knowledge, she was:
Amanda: Very qualified.

Researcher: Why?

Amanda: Just because I think I have a really good understanding of math at that level. I understand the geometry types of things that they'd be doing; I understand addition and money relationships they get into. I just feel that I would have a really good background. (interview, December 10, 1992)

Therefore, because the interns believed they did not need to learn anything more about mathematics to teach elementary school, they were not motivated to try to learn any more. Thus, each concentrated her efforts in the class toward learning about how to teach mathematics.

Interns' perceptions of their pedagogical content knowledge and learning to teach. Amanda, Becky, and Carla all felt that they knew enough about the learning and teaching of elementary mathematics that they needed only a set of activities to enact that knowledge in their future classrooms. Their confidence in their pedagogical knowledge was especially assertive with respect to pedagogical theories. Amanda felt that she already knew enough about theories of learning and teaching and that she only needed some real life tools to apply that theory with. When specifically asked what more she felt she needed to know about learning and teaching mathematics, Amanda reacted with responses concerning how teachers act in the classroom, such as how to explain better and how to introduce and proceed through a topic, particularly when students have difficulty. Amanda believed that to gain this knowledge, she only needed a store of activities and more experience in the field interacting with children.
Becky also felt comfortable with her theoretical knowledge of how children learn mathematics by the time she took the methods course. She claimed that she learned this mostly from previous courses, saying:

We studied all of that. I know all those stages that they go through and all that. It's, like, in the educational psychology classes and also with the child development class that we're taking right now - we're just reiterating what we've already learned in 450 and 451. (interview, October 1, 1992)

Becky not only believed that her knowledge about learning came as textbook knowledge, she also felt that this knowledge, as well as her knowledge of the mathematics curriculum, must be taken from experts in the field. Throughout the quarter, she would rationalize her beliefs or any perceived lack of knowledge by appealing to experts. For example, she responded to my question of whether students should quickly move from manipulatives to the abstract by saying:

They say you're not supposed to; they say it's better to stay on manipulatives as long as possible. So I probably would do that, because math experts or the math authorities are saying it! They know more than I do! (interview, December 8, 1992)

Carla also felt reasonably confident in her knowledge about how children should learn mathematics. She did not look to the course for anything that might add to or change that knowledge. Instead, she looked upon the course to supplement her beliefs that mathematics needs to be made fun for students with ideas and activities, especially those involving manipulatives. Carla felt that one becomes a good mathematics teacher only through practice (She looked to the course only to help her explain steps to exercises so
that she would appear knowledgeable to her students). Not once did Carla mention the role of one's beliefs or one's reflection on those beliefs in how one teaches or learns to teach. When discussing a Marilyn Burns video, she noted:

I think if the teacher, you know, can generate interest in the class, you know, that the kids can really get into it, I think I could teach like Marilyn Burns. (Silence) It seemed like it could really happen to me, you know? 'Cause I think if the teacher knows what she's doing and she knows all those neat ways to incorporate math so the kids will enjoy it, I think it could happen...with practice....I don't think it could happen next year; but, you know, with practice, maybe in about two years. (interview, December 2, 1992)

In summary, it appears that one contributing factor in the interns' not reflecting upon their methods class, and thus, not changing their beliefs, was their comfort with (or unawareness of) their own subject matter knowledge, pedagogical content knowledge, and their beliefs about how one learns to teach. Thus, they were only concerned with gathering a store of ideas with which they could enact their (conscious or unconscious) personal agendas of mathematics and its pedagogy in their own classrooms. Therefore, they did not look upon their methods course as an opportunity to reexamine what they thought about mathematics as a subject or how one learns it because they had already experienced what they considered to be mathematics and its pedagogy. They were in the course only to improve upon those experiences for their future students, not change the philosophy and nature of those experiences. Therefore, the Strike and Posner model's requirements of being aware of one's beliefs, valuing the importance of those beliefs, having a reflective disposition, and engaging in cognitive actions about anomalous experiences were violated in part by this complacency.
The Lack of Required Reflection in the Course

The strand's philosophy emphasized the interns' considering their beliefs and knowledge during the courses and field experiences toward becoming reflective practitioners. The strand's director had this as one of the most important goals of the strand's experience:

In this strand, one of the things that I'm really working toward is to have a really well-articulated theory of learning and a concept of what teaching is and to have them at least think about what it is they need to know and how they need to know it in teaching - and then in the disciplines - what disciplinary knowledge they need to know. (interview, October 8, 1992)

Holly also felt that it was important for the interns to work on changing their imprint of what a mathematics class should be like and that this imprint should be modified as soon as possible. She felt that the interns needed to believe in how they were going to run their classrooms to the point that they could defend their philosophy and actions to those who may not share those beliefs, such as parents and principals.

However, the course's methods toward changing that imprint emphasized pedagogical actions rather than reflections on the part of the interns. It was as though it was assumed that having the interns simply exposed to stated messages (e.g., guidelines presentations), alternative classrooms (e.g., the videos and Bob Cooper), and specific ideas (e.g., the activities and sources), followed by taking these ideas and trying them out with real students would enact such a change in their beliefs. Further, it appeared to have been assumed that the interns would change their imprint by taking the ideas from the course and adapting them according to their own personalities without the benefit of reflection. That is, the interns only needed to take what they found to be useful in the course and
try it with students in their own way. It was thought that if students reacted well to the interns’ attempts, then the interns would be fired up to try them again. As Holly said to the class during the second meeting:

You won’t know exactly how to teach math in every grade from K-8. That’s like, not possible and how you’re going to do it will depend on your personality. I’ve been in a lot of schools in the last few weeks and I’ve seen at least three or four excellent primary grade math classes. Each one with different personalities, different ways of handling it. Some use the textbook, some have thrown out the textbook, some using Math Their Way, some using pure games and puzzle solving. So how you eventually solve the problem is up to you. What I’ll try to do is to bring out some main themes that you should be building into your math program in the way that you choose.... And I hope your background would have some books that you could go to, some resources and places with which to build lessons. (class observation, October 1, 1992)

As part of this outlook Holly felt that reflection should be a general aim of teaching; but did not emphasize it as a method toward changing the imprints. This was evident because the interns were not required to share their thoughts on their beliefs with respect to readings from the book, discussions in class, activities in class, videos in class, or most of the assignments out of class. The only place where reflection on course-related material was required was on the mini-units, where the interns were asked to respond briefly with what they felt went right or wrong on the activity and what they would do differently if they were to use the activity again.

Within the class, Holly did explicitly suggest that the interns reflect on issues that were brought up in the class; but not as a requirement. For example, at the beginning of the course, Holly told the interns:
Listen to yourself. Don’t shut yourself up. If you hear something here and you see something else out in the classrooms that seems to work, and here we’ve said 'that’s not the way we do things,' let that doubt come up in your mind. Don’t try to squash it and make things fit a mold. Bring it up. Let’s talk about it. Let’s look at these different ways. So do listen to yourself.

(class observation, September 30, 1992)

A few other times during the quarter, Holly suggested that the interns think about their beliefs in how they teach. These came in talks in which Holly noted that the interns need to be sure of what they believe so that those beliefs can drive their decisions and actions and so they can defend those actions to parents and principals. However, the interns were given no suggestions on how this could be done or opportunities to practice this idea during the quarter.

Holly did ask the interns to fill out an evaluation sheet at the end of the quarter in which they were given several terms that described their prior traditional mathematical experiences and asked, "Give your ideas of how you want your math classroom to function." However, Holly also asked the interns for their name on that sheet. Therefore, the responses - which usually emphasized the importance of the use of manipulatives, group work, and making math enjoyable - may not have reflected the interns' true beliefs. Nevertheless, Holly felt their responses indicated that the course had an impact on their beliefs:

From the papers that they gave in, I think they did have their old idea about 'This is the way to teach math, you know, we have to look at the book and do the page in the book and then give homework,' that routine, I think, was challenged. And I think that they had a different idea of what they could do and how they could get things across. (interview, December 11, 1992)
Aside from these minor events, the interns were not otherwise assessed on their thoughts of what happened in the course despite ample opportunities for reflection (e.g., after problem activities in which outstanding mathematical discourse occurred).

There appeared to be three reasons for the lack of assessment of their thoughts and beliefs with respect to the course. They were Holly's unfounded hopes that the interns were reflecting on their experiences in the course, her lack of experience in assessing their thoughts, and her hesitancy to embarrass the interns.

Holly confidently hoped that, once an activity or discussion took place in the class, the interns would think about the issues brought up with respect to their beliefs. For example, a few weeks into the course, she was sure that any Standards-like responses she was receiving from the interns during discussions were currently not their real thoughts but that future discussions would begin to confront their existing beliefs. Holly appeared to think that the interns considered everything in the course as relevant to their real teaching and that they made decisions on whether they agreed with a point or on whether to include an activity or not in the future "in their mind anyway as [they're] sitting there" (interview, December 11, 1992).

Despite Holly's beliefs that the course did challenge the interns' imprints and that the interns did consider the course to be mostly worthwhile, she admitted that she did not have any formal or informal evidence to back up those claims. Holly lamented many times during the interviews that she did not truly know the impact the course had on the interns' beliefs. First, she wished she had more of an idea of what the interns' backgrounds were before the course so the impact could be measured. Second, she felt
she could only guess about the impact the course was having on the interns by looking at their faces, listening to their words, and just getting a general feeling of how successful a particular class had been. Holly thought, because the class was "a quiet group," the interns were "very hard to read" whether something she said "registered with them" (interview, December 11, 1992). Thus, Holly had little evidence for her hunch that the course was or was not having an impact on their beliefs. She consistently said things such as, "I wanted them to have a chance to process what they had seen....their own reasoning because I'm sure they got conclusions out of that, but I'll never know [italics added]" (interview, October 22, 1992).

These regrets appear, at least in part, to have sprung from Holly's own inexperience with employing alternative assessment methods. Despite her admonitions to the interns (in the last class meeting) to assess their students' thoughts as much as possible and Holly's own desires to probe what impact the course was having on their beliefs, the interns were assessed only on variables that had little to do with their reflections on their own beliefs. The variables assessed included only if the work that was required on an assignment was completed and if a reasonable amount of effort was invested. Also, the success of an activity done during the class was assessed only through the involvement and excitement shown by the interns.

These criteria (and assignments) were developed by other instructors who had taught the course before Holly. Because Holly had been thrust into the position of teaching the
course for the first time with only two weeks notice, she did not have time to develop her own assessment schemes. Thus, she was forced to use ready-made ideas to assess (and derive a grade) for the interns.

Holly was also somewhat hesitant about explicitly asking the interns to reflect on what they had learned from the course, partly because of the course's pace and partly because she did not want to embarrass people:

_Holly:_ Sometimes I wish I'd taken more time to call on different ones and to say "what do you think?!" But it's very fast-moving.

_Researcher:_ There were several times in the class when you would ask a question and there would be almost no response.

_Holly:_ Yeah. That doesn't, that didn't, like, disappoint me or something. Umm...I could understand where you would have a blank mind on some of those things....maybe I should have been more insistent on getting an answer; but I hate to put people on the spot. (interview, December 11, 1992)

Therefore it appears that despite the strand's and instructor's valuing changing the interns' beliefs, the interns were not assessed in ways that required them to be made aware of their mathematical beliefs or to reflect on course and field events with respect to those beliefs. The consequences of not forcing the interns to reflect were far-reaching, however. As with almost any other educational situation (Doyle, 1983), the interns valued most the criteria they were being assessed on. And, because they themselves did not see the need to reflect on their beliefs, and the course was not requiring them to reflect on issues and activities experienced in the course, the interns (at best) put reflection on the back burner while they concentrated on their immediate expectations for the course and on earning points on the assignments that determined their grade.
In summary, it appears that the three interns did not change their beliefs about the nature, curriculum, learning, and teaching of elementary school mathematics in large part because they did not reflect on the Standards-like messages about those variables that the course was encouraging through the lectures, activities, and videos. This lack of reflection on and/or lack of awareness of their unilateral beliefs was because (a) the interns were comfortable with and thus were not personally motivated to change their conscious or unconscious beliefs, and (b) the course itself did not require the interns to consider their own beliefs and reflect on the messages of the course with respect to those beliefs. Thus, the interns were free to filter the course’s messages through their expectations for the course as well as their conscious or unconscious belief systems.

With respect to the Strike and Posner model of belief change in preservice teachers, the course hurt the interns’ opportunities to change their beliefs. As noted, the course did not emphasize that the interns be aware of or value their beliefs and did not require them to reflect upon their beliefs with respect to the anomalous messages in the course. By virtue of this lack of emphasis and requirements, except for three minor verbal entreaties by Holly, the interns may have been implicitly told that their beliefs and reflections upon them were not significant components of teaching, thus hindering the development of reflective dispositions. As a result, possible cognitive actions toward being dissatisfied with their entering beliefs and toward considering the intelligibility of the Standards-like messages may have been obstructed.
Other Factors Potentially Contributing to the Lack of Changing Beliefs

Although the lack of forced awareness and reflection was probably the most significant contributor to the lack of change in the interns' beliefs about the four variables, there were other factors in the course that may have supported a non-change. These factors were the contradiction between the explicit and implicit messages in the course and the lack of connections between the course and the interns' field experiences. Although there is less evidence of the nature of the impact these factors had, it is evident that if they did have an impact, it would have been to the detriment of changing the interns' traditional beliefs. This is because all of these factors had something in common: They might have weakened the impact of the course's messages that advocated a Standards-like learning environment and which were contrary to the interns' traditional beliefs.

Course's Implicit Messages

Although the course, on the surface, treated mathematics and its pedagogy as the Standards do, there were definite messages in the actions, words, and omissions of the course's participants that assumed a more traditional and behavioristic approach of treating and teaching mathematics. These messages contradicted many of the messages intended for the interns (see Table 4.9). Thus, the course did not speak in one coherent voice about the direction that elementary mathematics education should take. Instead, it appeared there were two directions: one marching away from and one marching back toward the current state of affairs.

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<table>
<thead>
<tr>
<th>Variable</th>
<th>Explicit Messages</th>
<th>Implicit Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Mathematics</td>
<td>1. <em>Problem</em> differs from <em>exercise</em> with problems having no direct solution.</td>
<td>1. Problem is same as exercise.</td>
</tr>
<tr>
<td></td>
<td>2. Problem solving permeates mathematics.</td>
<td>2. Problem solving is a separate topic.</td>
</tr>
<tr>
<td></td>
<td>3. Strategy development and community discourse are the most important goals.</td>
<td>3. Only answers reported to single authority; one algorithm for computation.</td>
</tr>
<tr>
<td></td>
<td>4. Patterns are important component of all math.</td>
<td>4. Patterns are a separate topic consisting of fun number patterns.</td>
</tr>
<tr>
<td>Curriculum of Elementary Mathematics</td>
<td>1. Curriculum should be holistic consisting of relevant problems involving variety of concepts.</td>
<td>1. Separate topics were discussed only on specified days with few &quot;real-life&quot; problems mentioned.</td>
</tr>
<tr>
<td></td>
<td>2. Curriculum should emphasize deep ideas involving number sense, data analysis, geometry.</td>
<td>2. Other than specified days, curriculum is traditional arithmetic.</td>
</tr>
<tr>
<td>Learning Mathematics</td>
<td>1. First class: Behaviorism is reason for fractured curriculum; constructivism discussed through &quot;frames.&quot;</td>
<td>1. Theory/research never again mentioned as support.</td>
</tr>
<tr>
<td></td>
<td>2. Environments based on student investigation and communication.</td>
<td>2. Justification of solutions in problem activities encouraged but interns reported only answers; traditional field reports; behavioristic language.</td>
</tr>
<tr>
<td></td>
<td>3. Give students opportunities to solve and they'll do it; don't underestimate students.</td>
<td>3. If student makes computational error, show and correct it for student.</td>
</tr>
<tr>
<td>Teaching Mathematics</td>
<td>1. Teacher role: providing tasks, fostering community.</td>
<td>1. Class fall into traditional roles in discussions; transmission language; peer teaching in traditional roles.</td>
</tr>
<tr>
<td></td>
<td>2. Actions include modelling strategies, allowing reasoning, wait time, goals/techniques of questioning, multiple assessment techniques.</td>
<td>2. No actions modelled or discussed during activities; short-response questions with no explanation.</td>
</tr>
</tbody>
</table>

Table 4.9: *Explicit and Implicit Course Messages About the Variables*
Implicit messages about the nature of mathematics. With respect to the nature of mathematics, the course presented mathematics as a subject centered around problem solving and patterns that is learned through investigation and community discourse. However, these messages were often ignored or contradicted through the class' structure, actions, and words.

Messages about the definition of problem solving. Despite the contrast made through the area activity between the words "problem" and "exercise," the class was not consistent in maintaining the distinction. For example, during the "goals for the year" discussion, despite a good start in keeping with the Standards’ view, some interns used the words problem solving to mean something that should be made easy to students so that no frustration occurs.

In addition to sometimes allowing the term problem solving to go unchecked, many other words that could have different meanings were not explicitly defined. Words such as understanding, pattern, creative thinking, connections, and reasoning were treated as though everyone had a common definition for each term.

Messages about the role of problem solving. The messages of Holly and Bob Cooper presenting the view of mathematics as a holistic subject centered around problem solving was contradicted by interns’ stating that problem solving was a separate topic in mathematics, like data analysis and geometry. For example, during a discussion of assessment in the field, an intern stated that her cooperating teacher works with topics such as "measurement and problem solving" (class observation, December 4, 1992) on certain days.
Messages about the importance of strategies and community discourse. Despite messages presented by Holly, Bob Cooper, and the Kamii video of the importance of community discourse of one another's developed strategies, the whole-class discussions about mathematics problems with the interns themselves did not include such strategy-sharing. This was particularly true with respect to activities in which the interns were engaged (with excellent arguments) in solving problems in small groups. After the problems were solved, the whole-class discussions saw the interns sharing only their answers with little time devoted to discussing strategies or the communication of the strategies that took place in the groups. These lost opportunities to capitalize on the messages (and examples) given in the lectures and videotapes occurred after the calculator conjecture activity, the pattern activities, and the geometry activities.

Often, the course discussion seemed to imply that there was only one "best" way to solve a given problem. For example, during the group activity eliciting guidelines for teaching computation of whole numbers, each group was given a multiple-digit subtraction exercise in which a student computed the wrong answer. The interns were asked to develop a pedagogical method to help the student "understand this subtraction correctly" (class observation, October 16, 1992). Each group of interns responded to this task by showing the child (some with manipulatives, some with no manipulatives) the traditional "borrow from the tens first" algorithm. This same algorithm was emphasized even if the exercise could have been more easily computed using "front-end" methods and the like. Occasionally, an intern would say "use different strategies," but this usually meant using different manipulatives or pictures to show the same algorithm. However,
at the end of the discussion, Holly brought up the example made in the Kamii video of children developing and sharing their own algorithms. Then, she had an intern illustrate an alternative subtraction algorithm.

*Messages about the role of patterns in mathematics.* The course messages presented that patterns underlie all of mathematics were often contradicted. Patterns, like problem solving, were usually treated as a separate mathematical topic. One way this was done was in the construction of the syllabus. Patterns were written as a separate topic to be dealt with on certain days. On those days, patterns were only treated as something young children experience and later as something to do in algebra. Also, during those days, only inductive numerical patterns were experienced by the interns in activities, giving a limited view of their use in all of mathematics.

To strengthen this implicit contradiction, patterns were not mentioned except on the days allotted to them. This separation of patterns from the rest of the course was much like the treatment of other topics (e.g., data analysis was not mentioned except for days devoted to it.). Therefore, not only were patterns treated as a different area of mathematics, the course’s messages of treating mathematics in a holistic manner were contradicted.

In conclusion, the course gave many Standards-like views of the nature of mathematics with respect to what mathematics consists of and how one does mathematics. However, there was also an implicit curriculum that contradicted those messages through the syllabus and unplanned and unchallenged comments made by the class. Thus, the
Interns were obstructed from or missed opportunities for connecting Holly's, Bob Cooper's, and the videos' explicit messages to new mathematical experiences.

**Implicit messages about the curriculum of elementary mathematics.** Holly and others asked the interns to consider a holistic curriculum of elementary school mathematics in which students do problems involving a variety of mathematical ideas, consider arithmetic through concepts of number sense, and engage in a significant amount of geometry and data analysis. Despite a variety of messages supporting these goals, the interns were subjected to other messages that seemed to assume a traditional curriculum.

**Messages about the structure of the elementary curriculum.** The course's planned messages about a holistic and relevant curriculum were contradicted a few times during the quarter. These contradictions included splitting the syllabus up mainly by mathematical subjects (with computation first) and never mentioning the subjects (such as data analysis, geometry, as well as the inclusion of patterns and the use of calculators) beyond the day(s) they were discussed. Also, the breaking down of topics into individual objectives was emphasized a few times when the class was not concentrating on holistic points. For example, although she went on to emphasize that rational numbers need to be taught conceptually, Holly also implied through the structure and words of her presentations (e.g., "when you come to operations"; "when you hit decimals") that they still need to be taught out of context in a sequential manner (concepts, then separate individual operations taught by cases).

Finally, despite the advocation that relevant problems be prominent in the curriculum, except for the data analysis, pattern, and calculator activities, the interns were rarely
given "real life" problems to solve. This was especially true in the topics that are traditionally in the curriculum: whole and rational number concepts and operations. For example, while presenting the guidelines for teaching rational numbers, Holly stated, "Stick with practical problems- a lot of them. You want to keep this into real life so they know what's going on" (class observation, November 13, 1992). However, the interns were only given a standard subtraction exercise involving a circular pizza and spent the rest of both of the rational number presentations concentrating on purely symbolic models.

*Messages about topics to be included in the elementary curriculum.* Except for when the importance of ideas involving number sense, data analysis, geometry, and patterns were explicitly discussed, the class treated the curriculum as if it only included arithmetic (with only the traditional algorithms). Several times during the quarter, interns would make passing statements like "if you've got some kids adding by one and others on multiplication" (class observation, October 30, 1992). This especially occurred during the group reports on important ideas for computation, where the interns were assuming that the traditional "borrowing" algorithm was the only one to be taught to students. Another example of an emphasis on only traditional topics was during the presentation by Nan Franklin about multicultural issues. During the talk, the only mathematical topics discussed were counting, addition, and subtraction.

Finally, the implication that traditional topics should dominate the curriculum was that their inclusion was never justified like patterns, data analysis, and geometry were.
In conclusion, Holly made a significant effort to convince the interns to emphasize patterns, data analysis, and geometry in a holistic curriculum, along with treating the traditional topics conceptually. However, other course messages implied that the non-traditional topics were separate "extras" to be added into the established curriculum.

**Implicit messages about learning mathematics.** With respect to learning mathematics, it was proposed that students learn mathematics through building connections in their minds and that, in order to maximize those connections, students should be provided with environments in which they are encouraged to develop and investigate problems with each other that they will solve through the formation of their own strategies. However, a traditional transmission view of learning in which students rely on an authority to learn how to solve problems was implicitly endorsed.

**Course's explicit theoretical message about learning mathematics.** As was described in the discussion of course messages about learning mathematics, there were few explicit discussions about philosophies of how children learn mathematics after the first class meeting's presentation distinguishing constructivism and behaviorism. However, as was also indicated, several messages about learning were recurrent throughout the course. In none of them, constructivist or behaviorist, was any reason why a message should be considered with respect to a theory of learning or results from research.

**Messages about mathematical learning environments.** Despite messages about how children should be allowed to explore and come up with their own solutions through reasoning and communication, such environments were not evident when the interns were involved with activities that would lend themselves to such exploration (i.e., real
problems for the interns). In particular, when introducing an activity, Holly would ask
the interns to try to convince each other of their solution, and then to convince the class.
However, when the interns presented their solution, they would only state their answer
with no argument as to why it is correct. Even after the activities during the second
pattern and second geometry classes in which excellent discourse occurred within small
groups, when the interns reconvened to present their solutions, I observed no attempts by
the interns to convince the class why a solution worked.

Another form of implicitly agreeing with a behavioristic philosophy of learning came
during discussions in which the interns gave their opinions or examples of activities from
the field. For example, one of these instances occurred when the interns gave examples
of assessment practices in the field during Holly's presentation of assessment guidelines.
In it, one intern shared some examples of her cooperating teacher's practices that
portrayed mathematics as a group of procedures ("multiplication and higher
multiplication" (class observation, December 4, 1992)) with assessment based on correct
answers. Also within this discussion, Bob Cooper's intern talked about his assessment
technique of having students explain their strategies. The class appeared to accept (with
little commentary) both examples as equally good.

Another implicit message that occurred frequently during the course was when Holly
would inadvertently say phrases during a presentation that were indicative of a
transmission form of a learning environment. For example, she often used the phrase
"get across to" when describing a teacher-student interaction involving learning. Other behavioristic language included "grasp the material," "reinforce," and "understood what you said."

Messages about students' ability to solve problems on their own. The course often presented the message that, given the opportunity to explore, children could come up with their own solutions to problems. However, this message was contradicted during two activities in which the interns were asked to look at a student's incorrect computational work involving whole and rational number operations and respond to it in some way. Time and again, the interns told the class that they would correct the student by showing him or her what to do (using a traditional algorithm) rather than have the student figure it out with the teacher or by him/herself. Like with the interns' field reports, no one questioned their reasoning as to why they would deal with their students as stated.

In conclusion, despite explicitly advocating a constructivist learning environment in which students are encouraged to investigate and solve problems among themselves, the course also sent implicit messages that students learn best by transmission. Therefore, the course allowed the interns to listen to new ideas about how students learn mathematics while holding on to their vision of how they learned mathematics in school.

Observed messages about teaching mathematics. The course presented Standards-like messages about the general role and specific actions teachers should take in a mathematics classroom. However, as with the other three variables, messages were also presented that implied traditional teaching roles should still dominate.
Messages about the general role of a teacher. Holly, Bob Cooper, and the videos presented messages that teachers should take a guiding role in fostering mathematical communities by providing opportunities for students to solve worthwhile problems through their own devised strategies. However, perhaps because of the interns' personal histories of being traditional students and Holly's personal history of being a traditional teacher, the methods class environment was not complementary to those messages during some mathematical discussions. The interns and instructor sometimes assumed traditional roles, with the interns relying on Holly to be the mathematical authority. For example, during a discussion about problems involving rational numbers, the class slipped into familiar roles, with the interns giving short responses to Holly's questions and Holly screening those responses for correctness.

Other implicit messages that teachers are in the role of transmitter and authority of mathematical information came through inadvertent and infrequent phrases spoken by Holly. For example, once she emphasized that it is important to be organized because "you're on show; you're performing" (class observation, October 21, 1992). Another example was when, prior to the class on assessment, she asked the interns to bring in "different ideas of how you found out what the kids have learned what you said" (class observation, November 25, 1992). Although these and other words were spoken in passing, they certainly could not help in getting the interns to change their imprint of what roles a teacher should take.

Finally, the interns were "teachers" in the class once: the peer teaching activity in which the interns made materials and lead a group of peers through a lesson. However,
during the lessons, each intern placed herself in a traditional role: standing in front
telling the students what to do, asking for one-word responses that were right or wrong
with little of the in-depth questioning or mathematical argument that was advocated in the
intended messages about teaching in the course. Whether it was Holly's intention for the
interns to be in such traditional roles is questionable; however, a lack of time prevented
her from redirecting the activity or discussing it after it was completed.

*Messages about specific actions teachers should take.* Although the course provided
models of *Standards*-like teacher actions such as planning worthwhile problems and
multiple assessment techniques through presentations and the vicarious experiences of the
videos and Bob Cooper, the course also made implicit messages about teacher actions that
offset the types of learning environments those models promoted.

For example, although Holly advised the interns to use a variety of questioning
techniques in assessing their students' thinking, in the methods class setting, Holly often
only asked the interns for short answers that did not reveal their thinking as to why they
were answering the pedagogical or mathematical question or comment in that manner.

With respect to the assessment of the course assignments, the interns were not
assessed in the same manner advocated in the class devoted to assessment. Instead, as
the guidelines for the course were for previous quarters, the interns were only assessed
on whether or not they completed readings in the book, their lesson plans from the field,
their resource files, and whatever else the interns did for their assignment options.

Some of the implicit messages were the result of actions that were *not* done. For
example, as was previously stated, despite the messages to allow students to explore and
explain their methods amongst themselves, the course did not afford the interns many opportunities to do so. Also, the role and actions of the teacher during class activities was not often exhibited or discussed, perhaps due to a lack of time, thus giving the interns little chance to observe what a teacher would be doing with real students during those times. This lack of discussion of the pedagogy that took place during activities also hurt potential ties that might have been made between the guidelines and the activities supporting them. Thus, the activities became strictly mathematical activities instead of potential pedagogical experiences for the interns.

*Messages about possible assumptions.* Finally, Holly appeared to inadvertently assume attributes about the interns that some may not have had. First, she occasionally appeared to imply in class that the interns had the same beliefs about teaching mathematics as she did. For example, while discussing multicultural considerations, she discussed her own views of teaching when she was a teacher:

> I remember one of the main gripes my students always had was me....Of course at the time I thought they were absolutely wrong and I was right. They said, "But it's always the same. We come in here and you correct our homework and then we do the next thing in the class. I explain it; and then you'll give the assignment and that's it." And I thought that obviously that's how every math class is supposed to go, don't they know? And, as you know and I now know [italics added], that was not the right way to be doing things. (class observation, November 6, 1992)

Also, twice during the course, Holly appeared to imply that the interns had their own criteria as to what made a good learning activity and what did not. In both instances, she warned them that they should be able to defend what the decisions they make in the classroom, although criteria to consider such matters was not discussed during the course.
In conclusion, there were several messages about teaching portrayed in the course. Messages that portrayed teaching in a Standards-like learning environment came during planned events such as presentations and videos, but often no portrayals were made during or after class activities. Messages that portrayed teachers in a behavioristic environment came from unplanned events such as the interns not serving as authorities during activities and discussions, inadvertent words and phrases, a lack of a variety of assessment practices, and Holly's possible assumptions about the interns.

To summarize, many of the explicit intended messages in the course were contradicted by implicit messages. Also, the course did not take advantage of opportunities to connect course events (e.g., presentations and activities within classes and the fractured course syllabus). With respect to the Strike and Posner model of belief change, the implicit messages and lack of connection of events could only have served to lessen the strength of messages anomalous to the interns' beliefs. The intelligibility and plausibility of the intended paradigm offered by the Standards and the course also may have been weakened by these factors of contradiction and disconnection. In addition, because the implicit messages often supported the interns' personal history-based beliefs, they might have lessened any motivation for the interns to engage in cognitive actions toward reconciling the course's perturbatory experiences with those beliefs. Finally, the fact that the implicit messages often occurred during portions of the course that the interns paid the most attention to (e.g., discussions that they participated in and
activities) while the intended messages occurred during portions less attended to (e.g., presentations) could only intensify this hidden curriculum's possible impact on the lack of change in the interns' beliefs.

The Lack of Connection Between the Course and Field Experiences

Another factor that may have contributed to the lack of change in the interns' beliefs was the contradictions between what was advocated or done in the class and what each intern experienced in the field. As with the contradictions within the course, these contradictions could have only served to weaken Standards-like messages about the four variables from either venue.

Each intern appeared to be greatly influenced by what she experienced in the field. Each felt that their overall field experience prepared her more to be a teacher than any university courses because the field provided her with interactions with real students in a real classroom instead of the artificial activities and theoretical discussions held in the courses.

Two of the interns noted that, in certain ways, their experiences in the field supported what the mathematics methods course was advocating. Amanda and Becky described how their field classrooms used activities involving manipulative materials in environments where students often did mathematics without a teacher and were not afraid to describe their solution methods using their own language. Each felt that these environments were like those that Holly and the videos portrayed. Amanda also thought that the activities
she did in the second pattern and the geometry classes promoted a learning environment among the interns similar to the one provided Alice’s students. She added that Bob Cooper’s seminar also reminded her of Alice’s theory and actions.

Carla also saw some similarities between the course and her field experience, but not many. She thought, through her beliefs, that the biggest similarity was that neither experience showed students learning mathematics and teachers really teaching (i.e., explaining) mathematics. She said this about Cheri’s class because Cheri was absent most of the days so Carla only saw the students working out of the book.

Despite some similarities between the course and the field experiences, the interns noted several differences between the two with respect to many elements. Amanda said that her field experience was more congruent to the philosophy of the strand than the course was, particularly when comparing Holly’s and Alice’s teaching strategies. For example, she thought that there were more presentations by the instructor in the course than in the field. She also thought that Alice maintained a holistic approach throughout an extended thematic unit that may have involved several activities, while the course often jumped from one topic or event to another within or among classes. Finally, Amanda perceived that mathematics was portrayed in two different ways in the sites:

With the methods course, I would think they would think that (math) was tedious and boring and monotonous and that they were drilled and practiced....But I would think that at (Alice’s class), they would think it was a time to explore and discover and problem-solve and cut-and-paste and be active and all sorts of stuff. (interview, December 10, 1992)

Becky also thought there were contradictions between the course and her field experience. She, too, thought that Holly made too many presentations for teaching in an
informal strand, especially when she saw little in Brenda's class. However, Becky thought that, as the quarter went on, that Brenda should have lectured more to her class. Overall, Becky considered the methods course to be more valuable than her field experience with respect to learning mathematical pedagogy because of what she considered to be the lack of emphasis on math in Brenda's class when compared to Holly's and Bob Cooper's strong messages on how important mathematics is in the curriculum. In particular, Becky noticed that many topics (e.g., fractions and geometry) were strongly encouraged in the course, but she saw none of those topics being experienced by Brenda's students.

Carla also noticed differences between what was emphasized in the methods course and what she observed in Cheri's class. Throughout the quarter, Carla noticed the differences in curriculum, with Cheri's class experiencing more traditional topics and Holly advocating topics (e.g., patterns, data analysis) that Carla was less familiar with. Carla was also aware of the differences between the course advocating the use of manipulatives and the nonutilization of them in the field. Finally, Carla noticed that there was much more emphasis given to mathematics by Holly than Cheri. Carla said that she talked to Cheri about mathematics only in the context of her assignments.

I, too, noticed differences between what was being advocated in the course and how mathematics was experienced in the field. Cheri's class demanded and exhibited little, if any, original thought as students marched their way through assignments about book- or teacher-taught traditional procedures. Brenda's class, despite the thematic units and the extra problem solving, did not experience much mathematics except for traditional topics learned from Brenda and practiced on worksheets. Finally, Alice's class was more
true to the Standard's and the course's intended messages in that students experienced a variety of mathematical ideas through interactions with the contexts of the thematic units and each other.

The potential impact of these contradictions between the course and field involve, with Becky and Carla, a weakening of the course's messages about mathematics and its pedagogy. Because of the greater impact of the field's reality over the course, the two interns' lack of reflection about the course's messages, and their traditional backgrounds and incoming beliefs that were more indicative of the field than the course, Becky and Carla would be more likely to see mathematics through their field than through their course experiences. And, because Holly and the cooperating teachers did not require critical analysis tying concepts dealt with in the course with the two interns' experiences in the field environments, the opportunity to strengthen similarities and resolve contradictions was lost.

Alice's class gave Amanda a rich example of what a Standards-like environment can be like and gave Amanda several connections between what was discussed in the class and a real classroom. The contradictions were caused, from Amanda's point of view, by the course's rather than by Alice's environment. Because Amanda reflected on the messages of the course with respect to her experiences with Alice's students, these contradictions might have enacted the changes in Amanda's beliefs about learning and teaching mathematics through resolution of these conflicts. However, if the course had been, to
Amanda, more like Alice's environment and explicit assignments had been made to reflect on the similarities between the two, it might have been possible that more change would have taken place in Amanda's beliefs about all four variables.

Why did the contradictions between the course and the field experiences take place? It appears that it was due to a lack of communication between Holly and the cooperating teachers.

The three cooperating teachers I interviewed noticed a lack of communication from their point of view. All of them indicated that no university instructor made an attempt to discuss the goals or events of the course with them. Also, with respect to mathematics, there was no mention of the course by the interns beyond showing the required course assignments.

Brenda and Cheri were particularly concerned with the lack of communication throughout the strand. They were only contacted by the university when asked if they would consider being a cooperating teacher. After that, they were given no instructions on what to expect to do with particular interns. The only communication they received from the strand was when an intern's supervisor came for observations. Brenda and Cheri also thought they were given too many responsibilities that could have been shared or done in tandem with the university courses, such as helping interns plan units and guiding them toward the holistic philosophy of the strand.

Holly, in turn, thought that many of the messages she intended for the interns were thwarted by cooperating teachers who were traditional in their approaches to mathematics. She noted many of the teachers she visited (in search of possible visitations by the class)
did not evidence much knowledge about mathematics education reform. Also, many of
these teachers did not want to teach math and thus welcomed any new ideas from their
interns who could handle math for them. Holly also held these teachers partially
accountable for the interns' lack of reflection and attention to only affective issues in their
field assignments. She noticed this from reading the interns' reports of activities
recommended by their teachers (e.g., one with 72 division computations).

Both field supervisors had Standards-like beliefs about mathematics and its pedagogy.
However, they never approached Holly to discuss the goals or events of the math
methods course, despite weekly meetings in which it was possible to do so. Therefore,
instead of having connections made between the theory of the course and the practice of
the field through their supervisors, the interns were only assessed on general teaching
principles.

Thus, despite the strand director's desire to communicate the philosophy of the strand
to the course instructors and for the instructors to share their course goals with the
cooperating teachers, there was a lack of communication between Holly, the three
cooperating teachers, and two supervisors involved in the study. This want of unity
perhaps precipitated the contradictions between the course and the field experience that
occurred and were noted by each of the three interns. Because the interns were not
required to reflect on similarities and contradictions between the messages implied by the
course and field experience, the interns were free to treat each venue separately and
choose which messages were more applicable to their perceived needs and beliefs. Also,
because the interns were inclined to filter messages that they disagreed with or felt were unimportant, *Standards*-like messages from one venue may have been weakened (or replaced) by contradictory messages from the other.

Thus, with respect to the Strike and Posner model of belief change in preservice teachers, the opportunity to challenge and change the interns' traditional beliefs through providing confrontational experiences was lessened by a lack of consistency in the course's and field's messages. The implicit messages of the course weakened the intelligibility of messages that were contrary to the interns' beliefs. The plausibility of the intended messages were weakened by the fractured syllabus, the traditional student and teacher roles taken on by the participants, as well as the lack of connections to Becky's and Carla's real life field experiences. Finally, the opportunities to experience the worthwhileness of the *Standards*-like messages in practice was weakened by the lack of connections between the course and field experiences, both in sometimes not providing opportunities for the interns to experience environments conducive to the *Standards* as well as in not compelling the interns to practice or reflect on messages from one venue while in the other.

**Summary of Potential Factors**

The interns' beliefs were mostly unchanged by the end of the course because of several possible factors. Some of these factors centered on the interns' lack of awareness of their beliefs and a lack of reflection of messages contrary to those beliefs. Other factors involved a lack of consistency in and a lack of connections between messages within and outside the course.
When put together, these factors could only discourage change in the interns' traditional beliefs. When the factors are put together with the additional factor that the quarter only lasted ten weeks, it is not surprising that the interns largely maintained their traditional beliefs about mathematics and its pedagogy.

To summarize, the following table (Table 4.10) outlines the Strike and Posner model of belief change in preservice teachers and how the interns' experiences during the quarter worked toward or against achieving the requirements of that model.
<table>
<thead>
<tr>
<th>Model requirement</th>
<th>Factors toward achievement of requirement</th>
<th>Factors against achievement of requirement</th>
</tr>
</thead>
</table>
| Awareness of Beliefs        | 1. Strand goal of interns' knowing what they need to know.  
2. Warnings to know where one stands to make and defend teaching decisions. | 1. Interns' complacency or lack of awareness of their subject matter knowledge, pedagogical content knowledge, and/or beliefs. Leading to perceived needs and expectations.  
2. Interns' lack of disposition to reflect (except Amanda with respect to learning and teaching).  
3. Course's lack of requirement to reflect on course events or messages. Allowing interns' filtering of course messages and events through expectations and beliefs. |

(Table 4.10 continues)

Table 4.10: Potential Course and Intern Factors Toward and Against Satisfying the Strike and Posner Model of Belief Change
Table 4.10 (continued)

<table>
<thead>
<tr>
<th>Model requirement</th>
<th>Factors toward achievement of requirement</th>
<th>Factors against achievement of requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valuing Importance of Beliefs</td>
<td>1. Strand goals of developing theory in interns and life-long learning. 2. Warnings to know where one stands to make and defend teaching decisions.</td>
<td>1. Interns' complacency or lack of awareness of their subject matter knowledge, pedagogical content knowledge, and/or beliefs. Leading to perceived needs and expectations. 2. Interns' lack of disposition to reflect (except Amanda with respect to learning and teaching). 3. Course's lack of requirement to reflect on course events or messages. Allowing interns' filtering of course messages and events through expectations and beliefs. 4. Lack of connection of course's explicit messages to other course events.</td>
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(Table 4.10 continues)
Table 4.10 (continued)

<table>
<thead>
<tr>
<th>Model requirement</th>
<th>Factors toward achievement of requirement</th>
<th>Factors against achievement of requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective Disposition</td>
<td>1. Holly and strand wanted interns to reflect.</td>
<td>1. Interns' complacency or lack of awareness of their subject matter knowledge,</td>
</tr>
<tr>
<td></td>
<td>2. Holly's recollections of her past thoughts and decisions.</td>
<td>pedagogical content knowledge, and/or beliefs. Leading to perceived needs and</td>
</tr>
<tr>
<td></td>
<td>3. Amanda appeared to reflect with respect to teaching/learning, particularly with respect to her field and cooperating teacher.</td>
<td>expectations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Interns' lack of disposition to reflect (except Amanda with respect to learning and teaching).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Course's lack of requirement to reflect on course events or messages.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allowing interns' filtering of course messages and events through expectations and beliefs.</td>
</tr>
<tr>
<td>Confrontational Experiences to Lead to Dissatisfaction with Existing Beliefs</td>
<td>1. Provided through presentations: particularly theory, teaching guidelines, standards, and Bob Cooper.</td>
<td>1. Course's implicit messages.</td>
</tr>
<tr>
<td></td>
<td>2. Also provided in videos of model teachers, problem activities, Amanda's field experience.</td>
<td>2. Lack of connection of Becky's and Carla's field experiences to course events or messages.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Lack of connection of course's explicit messages to other course events.</td>
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(Table 4.10 continues)
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<table>
<thead>
<tr>
<th>Model requirement</th>
<th>Factors toward achievement of requirement</th>
<th>Factors against achievement of requirement</th>
</tr>
</thead>
</table>
| Cognitive Actions Toward becoming Dissatisfied with Entering Beliefs (Recognizing anomalies, need/motivation to reconcile) | 1. Course engenders dissatisfaction with previous experiences (not beliefs) in first class.  
2. Holly reminds interns throughout course of this dissatisfaction. | 1. Interns' complacency or lack of awareness of their subject matter knowledge, pedagogical content knowledge, and/or beliefs. Leading to perceived needs and expectations.  
2. Interns' lack of disposition to reflect (except Amanda with respect to learning and teaching).  
3. Course's lack of requirement to reflect on course events or messages. Allowing interns' filtering of course messages and events through expectations and beliefs.  
4. Course's implicit messages. |

(Table 4.10 continues)
<table>
<thead>
<tr>
<th>Model requirement</th>
<th>Factors toward achievement of requirement</th>
<th>Factors against achievement of requirement</th>
</tr>
</thead>
</table>
| Consideration of Intelligibility of Confrontational Messages | 1. Problem activities, particularly area/perimeter activity to attempt to delineate problem from exercise.  
2. Model teachers, particularly Bob Cooper's showing connection of philosophy to his practice. Also Amanda's cooperating teacher. | 1. Course's lack of requirement to reflect on course events or messages. Allowing interns' filtering of course messages and events through expectations and beliefs.  
2. Course's implicit messages.  
3. Lack of connection of course's explicit messages to other course events. |
| Consideration of Plausibility of Confrontational Messages | 1. In Amanda's field, where learning environment matched messages.  
2. In model teachers, particularly Kamii's, Burns', and Bob Cooper's classroom environments. | 1. Course's implicit messages.  
2. Lack of connection of Becky's and Carla's field experiences to course events or messages.  
3. Lack of connection of course's explicit messages to other course events. |
| Consideration of Worthwhileness of Confrontational Messages | 1. In Amanda's field, where able to and did experience own examples of use of messages and was convinced that messages are better than traditional environment (especially through geometry activity). | 1. Lack of connection of Becky's and Carla's field experiences to course events or messages. |
CHAPTER 5

DISCUSSION AND CONCLUSION

Discussion

The purpose of this study was to uncover factors of the mathematics methods course and the preservice teachers toward any change or non-change in the teachers' beliefs. The major objective of this was to make recommendations for the planning and implementation of elementary mathematics methods courses that play the role of weaving together content knowledge and learning theories and hold the goal of altering preservice teachers' beliefs about mathematics and its pedagogy. It is this objective that will now be addressed.

These recommendations will address barriers that may have played a role in the preservice teachers' not changing their beliefs in this study while maintaining characteristics that may have worked toward encouraging changes. The recommendations (see Table 5.1) range from specific suggestions for improving methods courses to more general suggestions for improving entire preservice teacher education programs.

Factors Within the Preservice Teachers

There were two major factors within the preservice teachers that may have served to prevent changes in their beliefs about mathematics and its pedagogy. These were the
<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Program Needs for Implementing Recommendation</th>
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<tbody>
<tr>
<td>Change interns' beliefs about the nature and curriculum of mathematics through mathematics courses prior to methods courses.</td>
<td>Cooperation between school of education and mathematics department. Significant rewards for pedagogy in mathematics department. School of education may need to add requirements for graduation.</td>
</tr>
<tr>
<td>Develop interns' disposition to reflect and value theory through education coursework.</td>
<td>Consistent collaboration within the school of education guided by a mission statement of core beliefs.</td>
</tr>
<tr>
<td>Methods courses' roles are to weave knowledge and beliefs together toward developing a) theories of learning mathematics; b) knowledge of students' development of mathematical ideas; c) abilities to plan Standards-like instruction, and d) abilities to interact effectively with students.</td>
<td>Prior experiences outlined in the first two recommendations so that methods courses may concentrate on these intensive roles.</td>
</tr>
<tr>
<td>At least two methods courses needed to serve roles. Perhaps first course serving first two roles and second course serving last two roles.</td>
<td>Program needs to be willing to add requirements or an elementary specialist degree. Courses must be consistent with program mission.</td>
</tr>
<tr>
<td>Any field experiences connected to the courses must be consistent with respect to the courses' goals, messages, and activities. Perhaps first course with model teachers and small groups of students; second course concurrent with field experience planning and implementing activities.</td>
<td>Need to identify qualified cooperating teachers. Cooperating teachers and instructors must communicate regularly. Perhaps demanding on instructors.</td>
</tr>
<tr>
<td>Courses' pedagogy/assessment based on debates/reflection on models, activities, and own teaching experiences with respect to beliefs.</td>
<td>Instructor, cooperating teacher, and/or program must carefully develop or select events with alternative paradigms in mind.</td>
</tr>
<tr>
<td>Instructors must be able to provide experiences and tasks toward belief change.</td>
<td>Program might develop course(s) or other prior experiences for instructors.</td>
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</table>

Table 5.1: Recommendations for Programs' Changing Interns' Mathematical Beliefs
preservice teachers' entering perceptions of their mathematical knowledge (content and nature) and their perceived needs and expectations for learning to teach mathematics.

The Entering Personal History and Mathematical Knowledge of Preservice Teachers

The interns' perceptions and expectations evolved from their one-sided experiences with mathematics from elementary school through college. Because of their lack of alternative encounters, these personal mathematical histories limited the interns' ideas of what mathematics is or what mathematical pedagogy could be.

As a result, the interns felt assured that they did not need to have any other mathematical experiences to become elementary teachers. Instead, they believed that they only had to gather specific ideas to put with their assumed mathematical knowledge. Complacency also discouraged active reflection toward changing their assumed beliefs or even toward being aware of those beliefs.

The interns' assumptions, complacency, and expectations greatly inhibited the course's influence on their point of view. They not only acted as filters for what the interns perceived to be important in the course; they also limited the interns' comprehension of what they were experiencing.

It is not surprising that the interns in the current study had few prior experiences in alternative mathematical environments to develop subject matter knowledge (of and about mathematics) conducive to the Teaching Standards' recommendations, particularly from the point of view of their collegiate mathematical experiences. As in the mathematics content courses designed for elementary teachers, many courses emphasize only the development of interns' content knowledge in behaviorally-based learning environments.
(predominantly taught through lecture and assessed through examinations). Therefore, interns’ traditional beliefs about the nature of mathematics are often being reinforced instead of challenged (e.g., Ball & McDiarmid, 1990; Keen, 1995; Kistler, 1995).

**Recommendations.** It becomes apparent that preservice elementary teachers in this study would have benefitted from having prior extended alternative experiences in learning mathematics in mathematics courses before they entered the methods course. Such experiences would give the interns opportunities to encounter environments that would perturb their assumptions of what it means to know, learn, and teach mathematics from their familiar perspectives as students. Such experiences could also agitate what they believe they need to know in order to become teachers, both from the point of view of their own subject matter knowledge and the thoughts and behavior that a teacher of mathematics engages in.

Then, when the interns enter an elementary mathematics methods course as future teachers, they would have had experiences congruent to those of what is discussed and experienced in the course, so appropriate connections can be made toward altering their beliefs about children learning mathematics and their roles as teachers in the learning process.

This recommendation supports Simon’s (1994) model of the preservice teacher learning process, which states that preservice teachers’ mathematical experiences, development of key mathematical ideas, and application of their own mathematical learning should serve as the catalyst for their subsequent learning of theories and applications of mathematical teaching and learning with students.
However, the feasibility of providing such mathematical interventions for interns is in question (Anderson, 1989; McDiarmid, 1989, 1992). The lack of realistic rewards for excellent pedagogy in many mathematics departments within higher education institutions leaves little hope that these departments would endeavor to create such courses, let alone continue to staff them with persons holding the essential pedagogical content knowledge. Also, if such courses were developed and taught within schools of education, where qualified instructors may more likely be found, they may not be recognized by the institution as fulfilling the interns' mathematics requirements for graduation (Borko & Putnam, 1996).

Consequently, it is probable that cooperation is needed between departments of mathematics and education for meaningful, sustained, and consistent mathematical interventions for preservice elementary teachers to take place.

*The Perceived Needs and Expectations of Preservice Teachers for Learning to Teach Mathematics*

The perceived needs for learning to teach and the subsequent expectations the interns had for the methods course were limited to the collection of specific activities for use in their future classrooms, ideas for explaining mathematics, and, to some extent, the scope and sequence of the elementary curriculum. The interns did not value theoretical concepts or guidelines and did not have a general disposition to reflect on course events or messages. Thus, the interns subconsciously used their expectations as a guide when deciding whether a course event was important and subsequently ignored or misinterpreted several course events that contained potentially perturbatory messages.
From both theoretical and observed points of view, it is not surprising that the interns brought their perceived needs and expectations for the course to bear on which tasks they deemed to be important. Eccles (1983) argues that people consider the value of tasks through three integrated components: (a) the perception of importance of the task; (b) one's intrinsic interest in the task itself; and (c) the perceived utilitarian value of the task for the future. Because the interns' needs were mainly to develop activities for use in their future classrooms, course events that gave them such ideas were valued while events that addressed more theoretical concerns were not deemed to be important.

Recommendations. These results suggest that, if a teacher education program expects to alter interns' beliefs about mathematics and its pedagogy, two problems that should be addressed are (a) closing the gap between the goals of the program and the goals of the interns and (b) improving the interns' dispositions to reflect on the program's messages. In particular, if a mathematics methods course is to take on the role of weaving together subject matter knowledge, general and mathematical pedagogical theories, and field experiences, then interns entering the course should value all of those components, instead of just "real" experiences and specific activity ideas. That is, interns need to be motivated to value the roles of theoretical ideas and guidelines, as well as subject matter knowledge, in becoming a teacher of mathematics. Also, because the weaving of theory and practice must take place in the interns' minds, it is also imperative that they come to value the practice of reflecting upon their experiences with respect to those components so that they may come to their own well-thought-out conclusions about what they should believe.
If alterations in perceived needs, expectations, and reflective disposition take place early in the program, interns may come to understand and appreciate the meaning behind theories that are presented in most of their education courses. Thus, the interns' attention may no longer be so skewed toward concrete actions that they ignore any other kind of message. The interns can then actively reflect upon discrepancies that can lead them to rethinking their traditional beliefs.

How should teacher educators act to alter interns' perceived needs and expectations for learning to teach mathematics? One cannot simply tell interns what the purpose of a course is and assume they will thoughtfully go along with those new aims. Also, one cannot merely tell interns to begin reflecting about course messages discrepant to their own beliefs. Instead, because expectations involve one's beliefs of what is important in learning to teach, interns need to become aware of and be confronted with alternative messages of what teaching and learning to teach might entail so that they may see that their felt needs are necessary but not sufficient for becoming a teacher. That is, the interns' perceived needs and expectations are most likely to change if the teacher education program prompts those changes through guided reflection (e.g., through journals, simulated case studies or research with actual students).

In particular, some early opportunities in the program may involve the experiencing of good mathematics teaching as recommended in the *Teaching Standards*. The instructors of the content courses could share their pedagogical decision-making with interns so the preservice teachers, as learners, can see the importance of the reflective use
of pedagogical content knowledge when one teaches mathematics. This, perhaps with some reflection upon this open decision-making, may lead interns to reconsider what they need to learn in order to teach mathematics.

Just as the development of alternative mathematics content courses may require cooperation between the school of education and the mathematics department, developing early experiences to change interns' perceived needs and expectations for learning to teach mathematics requires collaboration within the schools of education. Such collaboration may include developing and consistently enacting a mission statement for the teacher education program. This statement should, among other things, address the interns' perceived needs and expectations for learning to teach. Enacting such a statement throughout the program will require cooperation and, perhaps, education of university instructors toward accomplishing its goals.

Factors Within the Role, Structure, and Pedagogy of the Methods Course

There were two major factors within the elementary mathematics methods course that may have impeded changes in the preservice teachers' beliefs about mathematics and its pedagogy, despite the intentions of the course instructor. The first barrier to change was not making the preservice teachers aware of what their beliefs were and subsequently not requiring them to reflect on course experiences that would force the teachers to question their traditional beliefs and, it is hoped, replace those beliefs with Standards-like perspectives.

The second barrier to change was not providing a consistent, intelligible, and plausible point of view about the nature, curriculum, learning, and teaching of
mathematics. Although many Standards-like views were provided to the interns through presentations, real problems, and model teachers, implicit messages often promoted a hidden curriculum that was not unlike the interns' entering traditional beliefs.

Finally, there was a third barrier to change related to the methods course: the lack of connections to the field experiences with respect to mathematics, largely due to the lack of communication between the instructor and the cooperating teachers beyond the assignments given to the interns. This disconnection prevented the interns from recognizing the value of the new viewpoints from the course based on their own experiences.

*The Role of Mathematics Methods Courses*

Despite structural differences, most teacher education programs have the same types of courses (Feiman-Nemser, 1990; Goodlad, 1990). It is likely that the only mathematical experiences that preservice elementary teachers encounter within a program are mathematics content courses and mathematics methods courses. Because the content courses are usually designed with the preservice teachers in the role of learner of mathematics, with mathematical pedagogy given little or no consideration (McDiarmid, 1989, 1992), the burden of instilling mathematical pedagogical content knowledge falls largely on the methods course(s). Therefore, mathematics methods courses must play the role of weaving together the interns' knowledge of and about mathematics, knowledge about children and how they learn, knowledge about the teacher's role in that learning process, knowledge about the role of classroom environments on students' learning, and knowledge of educational values and goals.
The magnitude of the task is further increased by the likelihood that one or maybe two methods courses is probably the most one can realistically hope for in the mathematics education of elementary teachers. With this limited time, how can mathematics methods courses be organized, taught, and assessed to maximize the interns' experiences with mathematical pedagogy toward altering traditional beliefs?

*Structure of Mathematics Methods Courses and Related Field Experiences*

*Methods courses.* A methods course needs to synthesize knowledge from a variety of fields to create a holistic picture of mathematical pedagogy. If the interns entering the course have had recent content courses that are true to the spirit of the *Standards* documents, then the burden placed on the methods course becomes lighter. If the interns have not learned mathematics from a *Standards*-like perspective, then the methods course faces the daunting task of redeveloping their mathematical knowledge as well as their pedagogical knowledge. This is a job that Holly and other methods instructors (Floden, McDiarmid, & Wiemers, 1990) do not assume as their own. It is for these reasons that one must assume the interns’ subject matter knowledge has been challenged before the methods course. That assumed, the course can concentrate on providing a holistic perspective of mathematical pedagogy.

*Recommendations.* To avoid the molecular approach of traditional classes, the syllabus for a course should not treat concepts such as learning mathematics, specific mathematical topics, and planning for instruction as separate. Instead, these (and other) topics should be interwoven during each class and class assignment. For example, one might structure the course to concentrate on each of the six standards for teaching
mathematics presented in the Teaching Standards: worthwhile mathematical tasks, the teacher's role in discourse, students' role in discourse, tools for enhancing discourse, learning environment, and analysis of teaching and learning. Each of these sections could concentrate on, among other particulars, the interns' personal history beliefs about the standard, others' perspectives on it (e.g., through the use of videotapes of children and teacher educators), what various learning theories assert about it, the use of examples involving a variety of mathematical topics and age levels, and planning with the standard in mind.

In this structured example, interns could consider what they already believe about the standard and compare it to other positions through the use of theory and real examples that use the theory. Also, the use of a variety of mathematical topics may challenge their beliefs about what should be included in the elementary curriculum. As the course progresses, the interns would perhaps develop a more coherent picture of what mathematical pedagogy and being a teacher of mathematics involves, thereby fulfilling the weaving role of the course.

Of course, this example is not the only way to present a holistic perspective of mathematical pedagogy. However, whatever structure a mathematics methods instructor chooses for the course, he or she must keep in mind the message that the structure of the course may present to the interns about pedagogical knowledge.
Related field experiences. If a mathematics methods course is to have a real-life component to it such as a field experience, then that experience should be tied directly to the goals of the course so that a coherent, consistent, plausible, and worthwhile message about mathematical pedagogy is made.

Calderhead (1988) argues that the theoretical knowledge that interns develop in teacher education courses is fundamentally different from the practical knowledge they gain in the field. To stress the importance of integrating these types of knowledge, he argues that theoretical knowledge can provide the analytic and conceptual apparatus for reflecting on one's practice, while practice can serve as a testing ground for one's theoretical knowledge. This interactive process requires substantial and meaningful metacognition within the preservice teacher when making decisions.

Unfortunately, even if interns are predisposed to value theoretical knowledge and reflection, they often take for granted that the knowledge gained from their teacher education courses will directly transfer to their observations, decisions, and actions in field experiences. However, they are not accustomed to integrating their knowledge in the immediate situations at hand and, as a result, rely solely on their practical knowledge to make observations, decisions, and actions (Munby & T. Russell, 1994).

Compounding this lack of integration of knowledge is the pressure on interns to conform to the norms of the field environments developed by the cooperating teachers as well as the field's perceived "unquestioned familiarity" to what the interns experienced in their own schooling. Interns tend to become comfortable in seeing and acting out their
own images of teaching within the "known" environment and thus disregard outside influences such as university coursework (Feiman-Nemser & Buchmann, 1986a).

Thus, field experiences can be a detriment to a mathematics methods course's objectives of developing and weaving together interns' mathematical pedagogical knowledge. If field experiences are allowed to operate essentially independent of the course(s) they are supposed to complement, the lack of a consistent message about mathematical pedagogy, the norms and familiarity of the field environment, and the interns' naivete' with respect to weaving together theoretical and practical knowledge may render a course's messages about Standards-based pedagogy moot.

**Recommendations.** If a program is to conduct a field experience simultaneously with a mathematics methods course, there must be criteria set so that the experience enhances rather than inhibits the course's mission of challenging and connecting interns' knowledge and beliefs about mathematical pedagogy. Such criteria should include the identification of cooperating teachers who sustain classroom mathematical environments that are conducive to the Standards-based messages of the course. These environments have the potential to confront interns' beliefs about the curriculum, teaching, and learning of elementary mathematics by connecting to the course's concepts instead of only to the interns' familiar background. Also, the norms for learning and teaching mathematics would be based on the same principles as the course so that the cooperating teacher's ideas do not conflict with and dominate the perspectives presented in the course.

Second, once such cooperating teachers are identified, the teachers and the university faculty must be willing to collaborate on each others' goals and syllabi. For example,
in the course structured around the *Teaching Standards*, when "worthwhile mathematical tasks" are the theme, the cooperating teachers could agree to model how they decide what tasks may be worthwhile for learning a concept or strategy as well as how they implement the tasks in ways that are true to their pedagogical philosophy. By such synchronized collaboration, interns could use the course as a sounding board to discuss and reflect on such models and begin to develop and/or revise their own theories of learning mathematics.

This collaboration would require a great deal of communication between the instructor of the course and the cooperating teachers with respect to reflecting on past, current, and future events in both venues and the impact these events are having on the interns. In particular, the cooperating teachers would be investing a significant amount of time and energy toward the education of people other than their own students. Means toward lessening the burden on the cooperating teachers could include the instructor (or others) acting as a supportive consultant, the instructor acting as the interns' supervisor in the field, videotaping the teacher's classes along with the teacher's comments with respect to the course's goals, or having the instructor take over a teacher's mathematics responsibilities with the interns observing and working with the teacher's students.

Finally, one needs to overcome interns' inabilities to use theoretical knowledge to make sense of their experiences in the field. Perhaps one solution to this dilemma would be to have two mathematics methods courses. Each course could still be structured by the six teaching standards. In the first course, the interns would learn to engage in observation by watching and discussing qualified cooperating teachers like the Bob
Cooper visit in the current study, videotapes of qualified teachers like the Kamii and Burns videos, simulations, or case studies. Through experiencing and reflecting on these activities with respect to their own developing theories, interns would begin to develop a "trained eye" for identifying important aspects of teaching and learning with respect to the current course theme (e.g., assessment). This course, in essence, would work within the third and fourth cycles of Simon's (1994) model for learning to teach mathematics by developing useful and personally meaningful theories of mathematics learning followed by knowledge of students' development of particular mathematical ideas.

In the second course, the interns would be placed in a concurrent field experience in which they use their developing theories of teaching and learning mathematics as well as their newly formed observation skills toward connecting those theories to practical knowledge. In the course, the six standards would still be emphasized, only now toward the reflective use of the interns' theoretical knowledge to, both individually and collaboratively, develop practical knowledge of planning for instruction and for interacting with students (Simon's fifth and sixth cycles) in the field.

Another suggestion that would allow a significant and meaningful mathematics education for interested preservice elementary teachers would be to begin developing mathematics specialist programs (e.g., McNerney, 1994). Such programs would include the types of specialized and consistent university and field experiences recommended above. They would not simply add more ordinary college mathematics courses to interns' transcripts, as many institutions in the Holmes consortium (1986) recommend. Preservice teachers would instead find themselves meaningfully developing the mathematical and
pedagogical knowledge and beliefs necessary to establish genuine *Standards*-based learning environments within schools. Disciplinary specialist positions provide schools with a resource to assist or, if necessary, take over for teachers deemed not proficient in providing children with appropriate learning environments for genuinely experiencing mathematics.

**Pedagogy of Mathematics Methods Courses**

The pedagogy of a university-based education course can have a major impact on whether or not the course will challenge interns' pedagogical or subject matter beliefs. Too often a mathematics methods course may convey inconsistent messages about mathematical pedagogy by espousing one philosophy and exemplifying another.

**Recommendations.** Doyle (1983) and Pintrich, Marx, and Boyle (1993) argue that the learning that occurs in classrooms is a direct result of the content and products of the tasks students engage in inside and outside the classroom. The *content* of a task refers to the nature of the knowledge involved in the task, including its difficulty and complexity. The content influences the cognitive strategies that students will necessarily use during the task. The *product* of a task is the response to the task that students create to demonstrate what they learned from the task. The product required of students and the criteria for its assessment also influence the type of cognitive and metacognitive strategies that the students will use and value in completing the task (Blumenfeld, Mergendoller, & Swartout, 1987; Doyle, 1983).

Ideally, preservice elementary teachers should be involved in tasks that will require them to use their mathematical knowledge in concert with their developing educational
theories and knowledge about mathematical learners and curriculum. In accordance with
the Strike and Posner model, these tasks should also involve perspectives that are
anomalous to the interns' perspectives about mathematical pedagogy so that they
reconsider their existing beliefs.

To be compatible with these goals, the products required from the interns should
include their thoughts as they proceed with the task and reflections after the task has been
completed. The assessment of these products should emphasize the cohesiveness of the
interns' reflections with respect to both their knowledge and their beliefs.

Such tasks could be the driving force behind the two mathematics methods courses
proposed in the preceding section. In the first course (Simon's third and fourth cycles),
the tasks would consist of gradually widening debates and reflections of and among the
interns and the instructor. These debates and reflections would focus on models of
activities or the thoughts or actions of actual teachers, with the instructor (and,
increasingly, the interns) introducing and/or fleshing out conflicting points of view with
respect to the various kinds of knowledge to be developed. The requirements of the
interns would consist of logs, personal responses to questions in journals, critiques of
activities or teachers, group projects in developing curricula, and the like. The
assessment of these assignments would be largely based on the depth to which the interns
publically debate and personally reflect upon their own beliefs.

For example, the course could begin by examining activities and debating about their
worthwhileness only with respect to what and how children should learn mathematics.
Later, the interns can widen the debates about activities to include what roles students and
teachers should play in the activities, the criteria and means of assessment of learning that should occur, and where the activities should fit in the overall scheme of the curriculum. Also, the interns may observe teachers in thought and action and begin to debate about the teachers' goals for learning and how they went about fulfilling those goals in planning, actions, and reflections.

Through the critical thinking encouraged by these debates and personal reflections, the interns may begin to develop a perspective of what it means to be a teacher of mathematics and the knowledge and reflection that is involved in learning to be a teacher. Through conflicting points of view, the interns might begin to perceive that pedagogical knowledge is problematic and that their personal, yet professional, resolutions of what they believe and set forth as guidelines is what will guide their future decision-making. An intern may also use conflicting points of view brought up by classmates and/or the instructor to begin to question his or her entering beliefs about mathematical pedagogy. The emphasis on assessing such reflections could further serve to induce the intern to look inward on such matters and begin to think like a professional teacher of mathematics.

In the second course (Simon's fifth and sixth cycles), the interns would be more involved in beginning to make their own knowledge-based observations, decisions, activities, curricula, and actions within qualified cooperating teachers' classrooms. The second course's tasks would still mostly consist of public debates and personal reflections, but they would be discussions of the interns' own fieldwork, rather than that of outsiders. The requirements on the interns would be similar to the first course, with personal justification for their decisions and actions playing a paramount role in assessment.
The structure and tasks of these proposed courses would give the interns increasing control over their learning, with the instructor serving to provide experiences and questions aimed at making the interns reflect on their existing beliefs with respect to those experiences and intelligent, plausible, and worthwhile alternative paradigms explaining them. Thus, the requirements of the Strike and Posner model for changing beliefs (awareness, confrontation, and empowerment) would be present.

Preparing instructors for teaching methods courses. Simon (1994) describes his theory of mathematics teacher education as developing out of knowledge already generated about mathematics education. He suggests that teacher educator education may follow along the same lines. In keeping with that spirit, perhaps the criterion for being a mathematics methods course instructor should mirror the guidelines the Teaching Standards sets forth for teachers. That is, course instructors should have an understanding of the goals of the Standards documents (1989, 1991, 1995), appropriate subject matter and pedagogical content knowledge for teaching elementary school, a well-developed theory of teacher education and belief change as it currently exists, knowledge of preservice teachers as learners of pedagogy, and curricular knowledge (e.g., techniques and programs designed to engender belief change such as assessment of teacher reflection).

It may be unrealistic to expect teacher education programs to extensively develop such knowledge in their prospective instructors, particularly if they are graduate students pursuing goals not directly related to teacher education. However, it may be reasonable to expect such programs to require their instructors to (a) participate in a course in which
the goals, syllabus, and the theory backing up the goals and syllabus is discussed or (b) (as was originally planned in the strand of the current study) participate in a "field experience" with a veteran instructor(s) as their mentor(s).

Sample syllabi for the two proposed elementary mathematics methods courses can be found in Figure 5.1.

Significance of the Study

This study is significant because it utilized the experiences of three preservice teachers in an elementary mathematics methods course and their concurrent field experiences in order to make specific recommendations for the role, structure, and pedagogy of mathematics methods courses in particular and the mathematical education of preservice teachers in general toward restructuring interns' beliefs about mathematics and its pedagogy in the direction of the NCTM Standards. In addition, the results and subsequent recommendations of the study lend support to the theoretical model of the mathematics education of preservice teachers posited by Simon (1994), particularly in the specific roles and structures that mathematics content and methods courses should hold within that education.

It is hoped that these recommendations will assist teacher educators in planning and implementing programs of study that will produce elementary teachers with the beliefs necessary for enacting Standards-like mathematical communities in their classrooms.
Math Methods Course I

Learning Elementary School Mathematics

Description

Course Catalog Description: The development of concepts of (a) what is important mathematics to learn in elementary school, (b) how children learn mathematics, and (c) how children learn specific mathematical ideas. Prerequisite: Mathematics I and II (usually taken within 2 quarters prior to this course).

Objectives of the Course: Prospective elementary teachers will develop their own guidelines about the elementary school mathematics curriculum, how children should generally learn mathematics, and how children learn specific mathematical ideas. They will accomplish this through responding to questions recursively posed to them throughout the quarter.

Instructor: Jane Doe

Meeting Times:
Weeks 1 - 2: MTWRF 10AM - 11AM in College Hall 253
Weeks 3 - 5: MWF 10AM - 11AM in College Hall 253
TR 9AM - 11AM in Jane's model classroom (observation) and teacher lounge (discussion/debate)
Weeks 6 - 10: TR 10AM - 11AM in College Hall 253
MWF 9AM - 11AM in Jane's model classroom (observation) and teacher lounge (discussion/debate)

Course Routine: Prospective teachers will consider questions posed to them according to the schedule on the next page. They will first consider their own prior experiences and beliefs as learners pertaining to the question. They then will consider new evidence from their experiences in Mathematics I and II (especially in weeks 1-2); their resolutions of similar questions from earlier in the course; observations of and discussions about model teachers and their students; readings about practice, theory, and results from research; and their own case studies of students. These considerations will be illuminated through class debates about the issues. Finally, the prospective teachers will formulate personal and revisable guidelines in response to the major and minor questions. These responses will then be used to guide them toward responding to similar questions later in the quarter.

(Figure 5.1 continues)

Figure 5.1: Sample Course Syllabi Integrating Key Features of Strike and Posner, Simon, NCTM Professional Teaching Standards, and Recommendations Emanating from the Present Study

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Math Methods Course I: Questions for Consideration

Weeks 1 - 2: What constitutes important mathematics for elementary school?
(a) What should be the role of problem solving?
(b) What should be the role of patterns?
(c) What should be the role of arithmetic?
(d) What should be the role of topics such as data analysis and geometry?
(e) What are general attributes of "worthwhile tasks" in learning important mathematics?

Weeks 3 - 4: How should students learn important mathematics?
(a) What does it mean to "learn mathematics?"
(b) What roles should students play in the learning process?
(c) What roles should teachers play in the learning process?
(d) Describe general attributes of good mathematical learning environments.
(e) What tools can assist the general learning of important mathematics?

Week 5: What is important to know about a student's mathematical learning?
(a) How should we gather such information?
(b) When should we gather such information?
(c) What can we and students learn from the information and its analysis?

Weeks 6 - 9: How do students develop specific important mathematical ideas?
(a) What are attributes of "worthwhile tasks" for learning important mathematical ideas?
(b) How do students learn to solve problems?
(c) How do students learn important mathematical ideas in computation, geometry, data analysis, and other mathematical areas?
(d) Describe attributes of good mathematical learning environments in learning particular mathematical ideas.
(e) What tools can assist in learning particular mathematical ideas?

Week 10: What is important to know about a student's learning of particular mathematical ideas?
(a) How and when can we gather such information?
(b) What can we and students learn from the information and its analysis?

(Figure 5.1 continues)
Throughquarter
Weekly Reflective Journal: Prospective teachers will make general comments and respond to specific questions about their experiences (including readings) and reflections on them (See example on next page).
Developing Guidelines: Prospective teachers will submit guidelines with respect to what they believe (a) is important mathematics to learn in elementary school (due during week 3); (b) how students should generally learn mathematics and be assessed on their learning (due during week 6); and (c) how children should solve problems, learn in a specific mathematical area, and be assessed on their learning (due during finals week). These guidelines should address the "questions for consideration."

Weeks 1 - 2
Resource File: Prospective teachers will analyze five activities with respect to their developing guidelines about what is important to learn in elementary mathematics. They will make recommendations whether or not the tasks present worthwhile mathematics for students to learn as well as represent the nature of the discipline in content and actions.

Weeks 3 - 5
Individual Case Study: Each intern will observe and work with one student in Jane's model classroom as he or she learns mathematics. Interns will pay particular attention to the "questions of consideration" with respect to how the student learns mathematics, including how Jane's decisions seem to influence the student's learning.

Weeks 6 - 10
Small Group Case Study: Prospective teachers will observe and work with three to four students learning specific mathematical ideas in Jane's model classroom as the students learn mathematics. They will report and analyze what and how the students learned, including how they obtained their data for analysis.
Resource File: Prospective teachers will select ten appropriate activities for students to learn in a particular mathematical area and justify the selections.

Evaluation
Interns' work will be evaluated mostly on the depth and consistency of the justification of their assertions and decisions with respect to their developing beliefs.
(Figure 5.1 continues)
1. Comment on the most important aspects of the course you experienced during the past week. Why do you consider these events or thoughts important?

2. From watching my classroom the past week, what do you think the teacher or students consider to be important mathematics? How does your response compare to our debates over the past few weeks?

3. What did you think of my response to Sally’s (the fourth grader) request for help in solving the problem? Why do you think I did that? How was that (and the general environment) different or the same to how you learned mathematics at that age? How was that different or the same to how you learned mathematics in Mathematics I and II? What was good or bad about it from the point of view of learning important mathematics?

4. Read Marilyn Burns philosophy of learning in About Teaching Mathematics (Burns, 1992) and Kamii’s learning philosophy in Young Children Reinvent Arithmetic (Kamii, 1985) (both on reserve in the library). Describe parts of each philosophy you agree with and disagree with. Which of the three philosophies (yours, Burns’, or Kamii’s) works closer to achieving the mathematical goals you established in the first few weeks of the quarter? Why do you say that?

5. Read about (in the books) and watch (on the videos in the library) the tasks students are engaged in in Burns’ and Kamii’s classrooms. Comment on how students in those classrooms go about learning mathematics. Discuss how their learning environment and tasks are (or are not) compatible with their teachers’ philosophies. How do you think adhering to a philosophy helps or hinders student learning? Describe the learning philosophy your favorite elementary school teacher probably used with respect to mathematics. How do you think he or she adhered to that philosophy?

6. Which philosoph(ies) from #3 do you see being enacted in my classroom with respect to the roles the teacher and students play and the general learning environment? How do you see the philosoph(ies) enacted in the role calculators play and how students learning is assessed?
Math Methods Course II

Teaching Elementary School Mathematics

Description

Course Catalog Description: The development of concepts and skills about (a) planning to teach elementary school mathematics and (b) interacting mathematically with students in elementary school classrooms. (Continuation of Math Methods Course I)

Objectives: Prospective elementary teachers will develop their own concepts about and proficiency in planning for mathematics instruction and enacting those plans through interaction with students. They will accomplish this through observation, enaction, and reflection of classroom events with respect to their developing theories in and outside a cooperating teacher's classroom.

Instructor: Jane Doe

Meeting Times:
- Weeks 1 - 2: TR 11AM - 12PM in College Hall 253
  MWF 9AM - 11AM in field classrooms (observation)
  MWF 11AM - 12PM in field library (discussion/debate)
- Weeks 3 - 4: MWF 11AM - 12PM in College Hall 253
  TR 9AM - 11AM in field classrooms (observation and participation)
  TR 11AM - 12PM in field library (discussion/debate)
- Weeks 5 - 10: MTWRF 9AM - 11AM in field classroom (participation)
  MWF 11AM - 12PM in field library (discussion/debate)

Course Routine: Each intern will become familiar with his or her cooperating teacher's mathematical philosophy, thoughts toward planning, and enactions of those plans within the field environment. Each will also become familiar with the students and their learning. Each intern will then select and develop tasks for use in that environment. Finally, those (and later) tasks will be enacted by the intern within the environment. Throughout the quarter, each intern will become increasingly independent in planning and enacting mathematical tasks. Also, the interns' developing philosophies about important mathematics, learning mathematics, and teaching mathematics will continue (from Course I) to serve as the basis for their actions. These underlying philosophies will continue to be illuminated through methods class debate and reflection on recursively posed questions (see next page), prior experiences, other model teachers and their students, and results from research.

(Figure 5.1 continues)
Math Methods Course II

Questions for Consideration

Weeks 1 - 2: Observation and immersion into field classroom’s learning environment.
(a) How is mathematics being portrayed in the classroom?
(b) What mathematics are the students involved with?
(c) What are attributes of tasks the students learn mathematics with?
(d) What role(s) does your cooperating teacher play in the environment?
(e) What role(s) do the students play in learning mathematics?
(f) What tools are used for learning mathematics? How are they used?
(g) How is mathematical learning assessed?
(h) How do your responses compare or contrast with your guidelines for doing and learning mathematics?

Weeks 3 - 4: Selection, development, and analysis of tasks for field experience with respect to guidelines developed in Course I.
(a) How do your tasks compare to the guidelines you have set forth generally and for the specific area(s) you are planning in?
(b) What are the tasks' role(s) for teachers and students? How do they compare to your guidelines and to the field classroom’s environment?
(c) What tools are being used in your tasks and how will they help students learn the mathematical ideas?
(d) What do you want to learn about students' learning from the task and how will you gather and analyze that information?

Weeks 5 - 10: Implementation of tasks with students and reflection on planning and implementation.
(a) What are your general reactions to your teaching and the students' learning?
(b) How were the tasks' goals for learning satisfied? Not satisfied?
(c) How did your and the students' roles and actions contribute to or deter learning?
(d) How did the tools employed contribute to or deter learning?
(e) How did the assessment of the students contribute to or deter learning or understanding what the students learned?
(f) How did decisions you made with respect to task, discourse, tools, and assessment contribute to or deter learning?

(Figure 5.1 continues)
Math Methods Course II

Assignments

Throughout Quarter
Field Reflection Report: The intern will report on experiences with respect to mathematics that occurred in his or her field classroom during the past week. The intern will also reflect on those experiences generally and with respect to specific questions posed by the instructor and the "questions for consideration" for the specific week.
Developing Guidelines: The intern will develop personal and revisable guidelines for planning mathematical curricula and activities (due at the end of the fifth week) as well as for interacting with students (due during finals week).

Weeks 1 - 2
Case Study of Cooperating Teacher: The intern will interview the cooperating teacher with respect to his or her philosophies and how curricula and specific tasks are planned, implemented, and reflected upon (see sample interview guidelines on next page).

Weeks 3 - 4
Resource File: The intern will select three activities and develop two activities for use in the field classroom. The intern will plan implementation of each activity by answering the general "questions for consideration" as well as considering details such as objectives for the specific task and how it contributes to the field classroom's curriculum, questions that the intern and students might ask, rules of discourse, organization of materials, physical organization of the classroom and students, and specific assessment tools and rubrics. Rationale for each detail must be included. The planning for later tasks may be ongoing as the intern implements and reflects on the initial tasks.

Weeks 5 - 10
Report on Implementation and Reflection of Each Unit: For each unit planned during the third and fourth week, the intern will report on the implementation of the task. This will include the students and interns' actions as well as the interns' thoughts and decisions during the task, particularly pertaining to interactions that took place. The intern will also reflect on the task's outcomes by addressing the "questions for consideration" with respect to the intern's curricular and learning philosophy.

Evaluation
Each intern will be evaluated mostly on the depth and consistency of thoughts and actions with respect to his or her developing beliefs in both the field classroom assignments as well as class discussions.

(Figure 5.1 continues)
Figure 5.1 (continued)

Math Methods Course II

Sample Assignment: Case Study of Cooperating Teacher

Due in the Middle of the Third Week

After observing your cooperating teacher and his or her students for a week with respect to the "questions for consideration," interview your cooperating teacher. You should address the "questions for consideration" for Weeks 1 - 2 (i.e., what the teacher sees as happening in the classroom) as well as the following (i.e., how the teacher goes about planning for events in the classroom):

1. Describe the teacher's philosophy of what is important mathematics, how one learns mathematics, and how one teaches mathematics.

2. How does the teacher use the following when planning mathematical curricula and specific events for her classroom (You might concentrate on what you observed for specific examples):
   (a) The teacher's philosophies (found in #1)
   (b) Research results on how students learn mathematics (generally and specific areas)
   (c) Recommendations by organizations (e.g., State Model, NCTM Standards)
   (d) Colleagues (inside and outside the school)
   (e) Print or electronic sources (and what sources are used)
   (f) Own ideas
   (g) Other

3. When selecting or developing specific tasks for students, how does the teacher decide:
   (a) If the task is worthwhile with respect to curricular and learning goals?
   (b) How to adapt the tasks to the classroom with respect to participant roles, participant discourse (e.g., teacher questioning, rules of justification), learning tools used, physical organization of the classroom, and assessing learning outcomes?

4. When implementing tasks, how does the teacher decide:
   (a) How the task is evolving with respect to expectations?
   (b) What to (or not to) pursue in depth?
   (c) When to provide information, clarify an issue, when to model or lead, and when to let students struggle?

5. When reflecting back on the curricula or specific tasks, how does the teacher decide:
   (a) If the curricula or tasks were successful?
   (b) What to change for future implementations?
Suggestions for Future Research

The nature of a case study is one of generating hypotheses to be tested by further research. The results and subsequent recommendations of this study suggest that the following be investigated:

1. How typical was the role, structure, and pedagogy of the elementary mathematics methods course in the current study, particularly with respect to restructuring interns' mathematical and pedagogical beliefs?

2. What are the effects of altering interns' beliefs about the nature of mathematics before methods courses on the interns' subsequent approach to the methods courses and the methods courses' influences on their mathematical and pedagogical beliefs?

3. What are the effects of the emphasis on and requirement of reflection throughout the teacher education program on interns' approach to their education courses and on their mathematical and pedagogical beliefs?

4. What are the effects of the recommended structure and pedagogy of elementary mathematics methods courses on interns' mathematical and pedagogical beliefs?

5. What are the effects of coordination of elementary mathematics methods courses with field experiences on interns' approach to the courses and on their mathematical and pedagogical beliefs?

6. What are the effects of coordination within schools of education and between schools of education and mathematics departments on interns' mathematical and pedagogical beliefs?
Conclusion

This study investigated an elementary mathematics methods course's potential impact on three preservice elementary teachers' beliefs about the nature, curriculum, learning, and teaching of elementary school mathematics. From interviews with the interns, it was ascertained that the interns' beliefs changed little. From observations of the course and interviews with key participants, several factors were identified as being potential influences on the lack of change. These identifications were partially based on a theoretical model of belief change that centered on personal awareness, perturbatory experiences, and empowerment as the catalysts for change.

Initial recommendations were made for eliminating or minimizing the influence of these factors in future mathematics methods courses. These recommendations were implemented in sample syllabi for the proposed mathematics methods courses.
APPENDIX A

Instrumentation
A.1: Initial Mail Survey

The purpose of this survey is to find out YOUR opinions about your preparation to teach and learn mathematics as well as how it should be taught and learned in elementary school. There are no right or wrong answers! Please do not spend much time on any one item - simply respond to each by circling the one response that best reflects YOUR opinion.

USE:

SD D A SA

Strongly Disagree Agree Strongly Agree

1. I have a lot of self-confidence when it comes to math. SD D A SA

2. I enjoy being challenged by mathematics. SD D A SA

3. I will find it difficult to explain to students why solutions to mathematics problems work. SD D A SA

4. The inadequacy of a student's mathematics background can be overcome by good teaching. SD D A SA

5. Most subjects I can handle O.K., but I have a knack for flubbing up math. SD D A SA

6. If students are having difficulty in math, a good approach is to give them more practice in the skills they lack. SD D A SA

7. Given a choice, I would invite the principal to evaluate my mathematics teaching. SD D A SA

8. I will typically be able to answer students' mathematics questions. SD D A SA

9. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching. SD D A SA

10. I am sure I could do more advanced work in mathematics. SD D A SA

11. When a student has difficulty understanding a mathematics concept, I will usually be able to help the student understand it better. SD D A SA
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<tr>
<td>SD</td>
<td>Strongly Disagree</td>
<td>D</td>
<td>Disagree</td>
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<td>12. When teachers give math homework, the problems should often differ from those done that day in class.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<tr>
<td>13. If elementary school students use calculators, they won't learn the math they need to know.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>14. For some reason even though I study, math seems unusually hard for me.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>15. The range of ability in most classes makes whole group instruction in math virtually impossible.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>16. The most important thing is not whether the answer to any math problem is correct, but whether students can explain their answers.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>17. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>18. Elementary school mathematics should primarily be a collection of computational skills involving addition, subtraction, multiplication, and division.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>19. It is a good idea to have students work together on math assignments in class.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>20. I wonder if I will have the necessary skills to teach mathematics.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>21. When students can't solve problems, it's usually because they can't remember the right rule or formula.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
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<td>22. Students should occasionally leave math class feeling confused or stuck.</td>
<td>SD</td>
<td>D</td>
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<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Agree</td>
<td>Strongly Agree</td>
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23. People who are good at mathematics are those who are able to think logically, in a step-by-step manner.  

24. Basic computational skill and a lot of patience are sufficient for teaching elementary school math.  

25. If a student is confused in math, the teacher should go over the material again more slowly.  

26. For elementary school students, it is more important to generate and answer their own math problems than to answer math problems from a textbook or a test.  

27. A teacher should avoid presenting topics in more than one way since the students may become confused.  

28. Elementary school students usually don't need to be told how to solve mathematics problems.  

29. I'm no good at math.  

30. To be a well-educated person, it is just as important to study major areas of mathematics as it is to read classic literary works.  

31. In learning math, it is important to master topics and skills at one level before going on.  

32. There are quite a lot of things in mathematics that must simply be accepted as true and remembered; there aren't really explanations for them.  

33. It is not important for students to master the basic computational skills before studying topics like probability and statistics.
34. I would expect students to develop and use unconventional approaches to solving mathematics problems. SD D A SA

35. Even when I try very hard, I will not teach mathematics as well as I will most subjects. SD D A SA

36. The role of the student is to receive mathematical knowledge and demonstrate that it's been received. SD D A SA

37. If a student asks a question in math, the teacher doesn't have to know the answer. SD D A SA

38. There are basically two kinds of minds, and some people are good at logic and mathematics while others are better at English and more creative things. SD D A SA

39. High school algebra is unlike anything presented to students in the lower grades. SD D A SA

40. Students learn math best by listening carefully to the teacher's explanations. SD D A SA

(SEE NEXT PAGE)
Four teachers - Aletha, Bob, Cass, and Debbie - describe their role as teachers in helping their students learn mathematics:

Aletha: "I mainly see my role as a facilitator. I try to provide opportunities and resources for my students to discover or construct mathematical concepts for themselves."

Bob: "I think I need to provide more guidance than that. I try to lead my students to figure things out by asking pointed questions that I hope will get them to the answer without my telling them."

Cass: "I emphasize group discussion of math in my classroom. We talk about concepts and problems together, exploring the meaning and evaluating the reasoning that underlies different strategies. My role is to initiate and guide these discussions."

Debbie: "That's all nice, but students really won't learn math unless you go over the material in a detailed and structured way. I think it's my job to explain, to show students how to do the work, and to give them practice doing it."

Order the teachers according to how close each is to your philosophy of teaching mathematics. List the one closest to yours first and the one furthest from your philosophy last.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

(SEE NEXT PAGE)
PLEASE ANSWER THE FOLLOWING QUESTIONS

NAME______________________________________________________

CAMPUS ADDRESS_____________________________________________________________________

____________________________________________________________________________________

CAMPUS PHONE NUMBER______________________________________________________________

HOME PHONE NUMBER_______________________________________________________________

WHAT IS YOUR PREFERRED OR SELECTED AREA OF CONCENTRATION?
   (Circle one)
   Multi-cultural Language English and Literature
   Unified Arts Mathematics Natural Sciences
   Social Sciences Child and Family
   Other (Specify)______________________

AT WHAT GRADE LEVEL WOULD YOU PREFER TO TEACH? (Circle one)
   K-4  5-8  Undecided

CODE NUMBER ___________________________
Mathematics Background

1. Please list the approximate titles and grades for the mathematics courses you took in high school:

<table>
<thead>
<tr>
<th>Title</th>
<th>Grade</th>
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2. Please list the math courses that you have taken at OSU along with the quarter you took each course, (if able to recall) the name(s) of the instructor(s), and the grade you received:

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<tr>
<th>Course Number</th>
<th>Quarter</th>
<th>Instructor(s)</th>
<th>Grade</th>
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(SEE NEXT PAGE)
3. Please list any math courses you took at other institutions. Name (as best you can) the title of the course, the quarter or semester you took it, the grade you received, and the institution:

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Quarter/Semester</th>
<th>Institution</th>
<th>Grade</th>
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The final question:

Would you be willing to participate in a paid ($100) study of your experiences in your mathematics methods course that will involve less than 15 hours of your time over the quarter? (Circle one)

Yes  No

Thank you very much for taking the time to complete this survey. Your responses are confidential and will not influence your grade in any course or other experience. I hope you will be able to participate in the study - I look forward to working with you.
A.2: Telephone Solicitation Interview Guide

1. Introduction

2. Describe my connection to mail survey

3. Would like to ask a few questions about some of the responses s/he made on the survey (asking why s/he answered the way s/he did as well as to ask if further evidence was given to him/her, would s/he maintain or change the belief- ask what kind of evidence would be needed). Assure that there are no "right or wrong" answers here.

4. If suitable responses are given, describe that I will be conducting a study of the mathematics methods course and field experience and would like to study a few teachers from the class in-depth (to better ascertain factors of the course that interacts with their prior experiences and beliefs). This would include describing the data collection methods (3-4 hour interview at beginning, 2 hour interview at end, and weekly one hour interviews as well as looking at graded written work done in the course/experience, confidentiality, and financial reimbursement). Ask if they still would be interested in participating in such a study (Note that they can withdraw from the study at any time but must complete all interviews and written materials before receiving the $100). If not, go to #5. If so, ask when would be a good time to set up the first interview (also that a contract must be signed at that time indicating confidentiality, etc.)

5. "Thank you for your time"
A.3: Pre/Post Quarter Intern Interview Guide

First Day
(Possible Probes in boldface)

0. Describe need for audiotaping, assure confidentiality, etc.
1. What brings you into teaching? When did you first start thinking you might want to teach? Why are you interested in teaching?
   (Probe own intellectual interests and the perspective they hold as a student. Try to see what she especially enjoys about school or learning.)

2. Let's talk about you and mathematics. What adjectives do you think about when you think of the word "mathematics"?
   Why do you think of mathematics as...? What experience(s) lead you to describe it this way?
   Now let's look back in detail to your experiences in mathematics.

3. What stands out to you about your experiences in elementary school and middle school? (K-8)? (e.g., teachers, activities, school work).
   (What do you mean? Can you give me an example of that? Is there anything else you remember?)
   (You haven't mentioned much about (what you learned, your teachers, how you felt about different subjects- also below))
   What were your favorite subjects in school then? Why?
   What do you remember about mathematics in those grades? (e.g., outstanding teacher, bad teacher, content, way it was taught, general liking/disliking, activities, assignments, tests, etc.).
   Possible probes for math experiences:
   What do you think your teachers' goals were for you to learn about mathematics? Did these correspond to your own goals? Which of these goals were accomplished for you? Which goals were not accomplished? Why or why not?
   How did you go about learning mathematics during this time? What sorts of strategies would you use when working on a math problem, assignment, studying for a test, or taking a test, etc.?
   What were your attitudes toward mathematics during these years? Why do you think your attitudes were this way? Did you consider yourself "good" at mathematics? What makes you say that? Were your (general) attitudes toward other school subjects the same or different? Why? (How were these other subjects different than math?: content, method of learning, teacher's treatment, etc.). How hard did you work on mathematics?
Overall, what did you learn about mathematics during these years (i.e., what have you learned about mathematics as a discipline?)

If I were to give you a "magic button" that you could push to change anything about your experiences provided for you during this time (content, methods of teaching, assessment, goals of teachers, etc.), what would you change? Why? What would you keep the same?

If I were to give you a "magic button" to push to change any aspect of YOUR learning mathematics (on your part), what would you change? Why? What would you keep the same?

4. Now do #3 for 9-College and 105-106.

5. Overall, describe your parents' (or other family members') influence on your mathematics experiences.

   (Beginning of Post-Quarter interview)

   (Pre-quarter interview continues)

6. How do you stand with mathematics now? What aspects of mathematics (content or doing math) do you like? Dislike? Why?

   On your information sheet, you indicated that you chose ____ as your area of concentration. Why? What is different about math from ____? What is the same?

   What does "mathematics" mean? What does "doing mathematics", "learning mathematics", or "understanding mathematics" mean?

   What are different types of math problems (including word problems - what is a word problem?) Which types are better math problems than others? Why? What about at your chosen grade level?

   What makes a math problem difficult or easy?

   Some people think that math is a human creation; while others think that it was always "there" waiting for someone to discover it. What do you think? Who creates/discovers mathematics?

7. How would you describe a person who is good at mathematics? What does/did a person do that makes him/her good at mathematics? What does that person do when solving mathematics problems? Studying for a mathematics test? What reasons can you give for a person being good at math? Is there just one reason for everybody or does it go person to person? Are these reasons for all levels? What about at your preferred grade level?
How about a person who is not very good at math? Why is he/she not good at math? Are there some people that, no matter how hard they try, won't be good at math? If so, what is it about mathematics (or the people) that makes it so difficult?

8. Who was your best teacher of mathematics? What did s/he do to make you feel this way? What do you think made him/her that way? What are other attributes of good math teachers that you haven't mentioned? What are the essential roles that good math teachers must assume?

What are the most important acts that teachers do that help the most in learning mathematics? Does this depend upon the grade level we're talking about?
Does one need a teacher to learn math? Why or why not? What does one need a teacher for in learning mathematics?

9. What are your expectations/goals for the math methods course? What do you hope to learn from the course? What do you hope to do in the course? Do you need to take it? Why or why not?

(Do the same for the field experience.)

10. Today we've talked a lot about your experiences with mathematics as a student. For tomorrow, I'd like you to think about yourself as a future teacher of mathematics.

(End of First Day of Pre-Quarter Interview)
(End of First Day of Post-Quarter Interview Continues)

Yesterday, we talked about your past experiences with mathematics as a student. Today, let's talk about your future experiences with mathematics as a teacher.

11. What courses and field experiences in education have you had?

What stands out to you from those experiences (teaching, children, learning, subject matter)?

12. You indicated on the demographic instrument that you want to teach at ___ grade level. What attracts you to this grade level?

Do you have a preferred grade? What attracts you to it?

In what aspects do you feel qualified from a mathematics point of view, to go into teaching at ___ grade level? In what aspects do you feel unqualified?
Are there some things you would like to know more about or be able to do better before you have your own classroom (e.g., students, management/discipline, "experience"? What would you hope to learn from more "experience"?)?

Possible probes: Some people mention {subject matter, children, classroom management, experience}. Is there anything else you would like to know about them/it? How or where do you think you can learn that?

What, in your opinion, are the most important reasons for including math in elementary school? What are the most important things for students to "get out of" elementary school mathematics? What other reasons might you suggest? What about high school mathematics? What are the most valuable things to learn about each topic you've mentioned?

13. Suppose you were to teach at your chosen grade level in the coming fall. If the principal requested you to tell him/her the goals you would like to accomplish with your students in mathematics this year, what would you say? Why? What about the topics that students will encounter this year?

(Probe on terms like "problem solving," etc.). (If not familiar with the curriculum, "Are there any important ideas that come to mind around that grade?" "Are there any things you'd say regardless of the grade you were teaching?")

What background would you expect your students to have when entering the year? How would you hope that they got this background? What sort of questions would you ask a student's previous teacher in terms of that student's mathematical background?

14. Now let's assume that we are in your classroom in the middle of the school year. Envision yourself in that classroom. What image would you like to present as a teacher?

How would your students learn mathematics? What sorts of things would I see you/students doing? (Probe hard if given "nice" terms)

What would be attributes of an "ideal" math student in your class? What would s/he do to learn math? What would s/he be able to do? When preparing for a test? What kind of work would s/he exhibit? What would his/her goals be?
15. Now let's get into teaching a specific topic: Multiplication concept and algorithm.

What would be some of these major things you would want your students to know about multiplication when they leave your class? Why are these important? Would there be a sequence in which you would want your students to learn multiplication? If so, what would that sequence be and what are your rationales for that sequence? If not, why?

What are some typical misconceptions/mistakes people make when dealing with multiplication/algorithm? Why do you think these misconceptions occur? What could be done to correct them?

How would you go about preparing to teach multiplication? What things would you consider? What sources would you use?

How would you go about introducing multiplication to someone who has never experienced it in school before? What are some of the first things you would do as a teacher? What would be the students' actions at this time? If you were to give an initial activity to the students what would it be like? If you were to give your students an initial assignment (for in or out of class), what would the problems be like? Give some examples.

Probes: For example? What would I hear or see you doing?
Why would you do it this way?
How did you come up with this idea/approach?
Is there another way you can imagine doing this?

What actions would you want your students to engage in to learn multiplication (e.g., listening, group discussions, group work)? What percentage of the time would you be lecturing, group work, etc.? If group work is allowed, how would you group the students? What would go on in those groups? Give some problems you would want your students to be able to solve in multiplication. How would you expect your students to go about solving the problems (i.e., is it important for them to be shown first?)? How many of the same type of problem should they solve?

What types of questions might you expect from your students? How would you respond? By what criteria would you judge a student to be successful/unsuccessful in learning subtraction?

(Probe "know/understand." What would you look at or pay attention to? If want students to explain- What kind of explanation would satisfy you?)
What would an 'A' student do to learn multiplication (and evidence of work) versus a 'D' student? How would you handle students who are having difficulty?

What role would calculators have in the learning process? If there is a role, how might you use them? What role would a textbook have in the learning process? What about other materials? What role would memorization have in the learning process? If there is a role, at what point would memorization come into play (beginning, middle, or end)? How would you judge the effectiveness of your teaching? What would you hope evaluators of your teaching would look for?

16. Now I would now like you to respond to some specific situations that may come up in your classroom. Remember, there is no "right" response to any of these situations. I want to know how you think you would handle the situation if you were the teacher: (Respond to his/her responses with further conversation, if necessary and/or to test the strength of convictions).

A student walks up to you and states, "I can't remember how to borrow when there is a zero there (or, I can't remember how to add fractions with unlike denominators)." Probe: Why would that be your response? What if he wanted to know why that worked?

A student says that she has been playing around with different rectangles and has come to the conclusion that if rectangle A has a larger area than rectangle B, then A's perimeter is also larger than B's. She shows you the following picture as proof of her claim.

Probe: What if every example done yields the same result? (If focuses on praising the student, ask if there is anything else she would like to say.)

A student, when multiplying decimals, finds that 13 x .25 = 3.25. She thinks that is wrong because "multiplication is supposed to make the numbers bigger."

A student working the exponent key on her calculator notices that when she raises a number to zero, the calculator always gives "1." If doesn't explain why, ask how she would find out (herself, with student, etc.).

A parent of a child who does not know an addition algorithm argues that he should be allowed to use a calculator to solve word problems involving larger numbers so he can "keep up" with the rest of the class. If defends, ask her to justify response. What if another teacher is allowing calculators?
Fred claims that he is a better pitcher than Sally (from the standpoint of striking out batters) because he has struck out more batters than Sally has. How does she allow conflict to be resolved?

A first grade student calls a square a "rectangle." What are the important geometrical ideas children should encounter in the early grades?

A second-grade student was playing with his calculator and reports that he subtracted 5 - 7 and got "-2." If "you can't do it," the student asks why not- if the calculator can? What about future teacher who says he can?

You have been assigned a textbook that includes a chapter on probability and statistics. How much would you include it, and how? What are important principles, skills needed at this or other grade levels? How important is it relative to arithmetic?

A parent argues that students should deal with solving real-world problems instead of spending so much time memorizing basic facts (or vice versa - with a child having difficulty with problem solving- "My child really can't understand it. There is too much other math to do to spend so much time on problem solving.")

Why is that what you would say?

A student multiplying 245 x 32 gets 1225 by the following work:

```
  245
x32
________
  490
 735
1225
```

1. If says "I'd show her where to put the zeroes in" - Say "A student says that it changes the numbers."
2. If says "I'd show them to move the numbers over" , Say "A student asks "why do we have to move the numbers over? I thought we were supposed to line numbers up in math.")

The same student indicates that she prefers the "lattice" algorithm she invented. Should she emphasize this? Should she share with the rest of the class? What if the rest of the class agrees with her?
A student walks up to you and asks what is 7 divided by zero?

1. If "undefined" - What do you mean by 'undefined'?
2. If "you can't divide by zero" - What if a student asks 'why can't you divide by zero'?
3. If divide by smaller and smaller numbers - "What would I see or hear you doing"?
4. What if this didn't make sense to the student?
5. If student says " It seems that if you divide by nothing, you don't divide and so you would still have 7" - How would you respond?

Your class asks, "What good is learning mathematics?"

17. Probe for contradictory responses or more information from the Likert scale (some of this will come throughout the interview)

(End of Pre-Quarter Interview)
(Post-Quarter Interview Continues)

18. What have you learned from your math methods course with respect to mathematics as a subject (content and nature)? Elementary school mathematics? How children learn mathematics? Teaching mathematics? How did the math methods course satisfy your expectations? How did it not? What things would you like to know more about (and how will you get this knowledge?)

How do your feel you've changed as a result of the methods course with respect to each? (e.g., How do kids learn math?) What factors of the methods course contributed to each change (or non-change)?

What were some useful things you got out of this course? Useless things?

What were some ideas in the math methods course that you did not buy into? Why?

How do you see Holly as an instructor? How was she a good role model? A not so good role model? (discourse leader, comments to intern's responses). How do you see videos (Kamii, Burns, Fennell) as role models?

If you had a "magic button" to change the experiences provided for you in the methods course (overall or particular incidents), what would you change? (e.g., activities, how activities were handled in class, discussions, textbook or other materials' role, topics that were discussed too much/too little, assessment scheme, grade levels that were emphasized)

If you had a magic button to change the way you handled the course (overall or particular actions), what would you change? (e.g., during class, out of class work activities, the assignments you chose).
Combined Experience

19. What relationships do you see between your math methods class and your field experience? What contradictions do you perceive? Which experience is more valuable for you now? Why? Which do you think will be more valuable in the future? How would you improve the experiences (on campus or in the field) to better serve your needs as a future teacher of mathematics?

In your comparing your math methods course's vision of math education and your own field experience, in what ways do you feel the following were the same or different: the elementary school math curriculum, how children learn mathematics, how mathematics is taught, the "picture" kids get about mathematics.

Compare the relationship you had with Holly and the relationship you had with your cooperating teacher with respect to learning about teaching mathematics. What about your field supervisor? Also, what did you learn from each that was the same/different?

How do you agree or disagree with comments that the three have made to you about your experience/performance, etc.?

What subject did you learn the most about this quarter in your classes/in your field experience (as a student and as a future teacher)? The one you changed your opinion about? Why these subjects- what was done differently here than in math/other subjects?

As you have just "graduated" from your last formal experience in learning to teach elementary school mathematics, how would you suggest that the math education of future elementary teachers be changed or kept the same overall (e.g., in structure, content, instruction, field experiences, other courses, etc.?)?
A.4: Weekly Intern Interview Guide

Methods Class

0. (Before interview): Generate a list of main principles or activities to discuss.

1. Describe for me what you feel were the most important issues of this week's methods class. Why did you select these as the most important? What did you learn from them? What is your opinion about what was done, both as a student in the class and as a future teacher? What did you disagree with in the discussion/activity/lecture? What did you agree with? How did what happened remind you of your own experiences as a student of mathematics?

   What about this activity (not discussed yet or brought up above and/or outside class activities)? What was important about it? What did you do during this activity? What were you thinking? What sort of conversations were taking place (between classmates or instructor- including out of class, including feedback from instructor on an assignment or test)? Why do you think this activity was included?

   What ideas did you find useful/useless about this week? Why?

   Is the course fulfilling your expectations?

   What are your biggest concerns regarding the methods course?

   What assignment options are you considering doing? Why?

Field Experience

2. (Bring in specific observed occurrences as deemed necessary) What are the most important things that happened with respect to mathematics? What did the teacher do? The students? You? What important interactions occurred? What mathematics is being done in the class? What sort of activities are the students involved in? What mathematics problems are they solving? How do you think students are thinking about mathematics from all this?

   What did you do to help students with mathematics? What types of questions are being asked by the teacher, students, or supervisor to you? To others? What responses are being given?

   What do you agree with in how your teacher is handling mathematics? Disagree? How would you handle a similar class in the future (tasks, content, etc.)?

   How do you agree or disagree with comments made by others about your experiences? Why?

   What are your major concerns about the field experiences?
Combined Experience

3. What relationships do you see between your math methods class and your field experience? What contradictions do you perceive? What aspects of either one are having an impact on how you perceive elementary school mathematics, teaching mathematics, or how children learn mathematics? How are they influencing you? What are the virtues/pitfalls of each experience? Which experience is more valuable for you now? Why? Which do you think will be more valuable in the future? How would you improve the experiences (on campus or in the field) to better serve your needs as a future teacher of mathematics?
A.5: Pre-Course Instructor Interview Guide

0. (Before interview): Obtain any course information from the instructor as soon as possible.

1. How long/many times have you taught 502? Tell me about your background in mathematics and teaching.

2. What other courses will you teach this quarter? What courses will you be taking this quarter?

3. What are the purposes for including mathematics in elementary school?

4. Describe an excellent elementary school math teacher. (Are they born or made?) Which attributes/actions would you hope your students will recognize this quarter? Which attributes would you expect them to?

5. What are attributes/actions of a good mathematics student (elementary school)?

6. I'd like to know some information about the course, as YOU teach it, from the points of view of content, rationale for the content, assignments/tasks given to students (and rationale for those assignments), and its interaction with the field experience and the rest of the block. First, describe what was discussed in planning with the others in the strand (e.g., strand coordinator, other instructors, cooperating teachers).

7. Imagine you are to provide a colleague with information so that he/she could take over your course for a year. What would you tell him in terms of:
   a. The goals of the course?
   b. The topics covered in the course (outline)?
   c. The rationale for those topics and what you would hope the interns would get from it?
   d. What a typical presentation of the topic would consist of, if there is a "typical." What would your role be, the students' role, the text's role, other materials' roles?
   e. What sorts of tasks will the intern's be engaged in, both in class and out of class (campus only)?
   f. Why do you choose those activities?
   g. How would you assess the students? How will you judge their success in the course?
   h. Overall, what do you feel your responsibility in the course is? What are the intern's responsibilities?
i. If an intern were to be discussing the course after taking it, how would you hope he/she would describe it? Say about it?

j. If you walked into a typical students' class during student teaching and/or during his/her career, what would you hope to find? What would you expect to find?

8. Now let's talk about the field experience for the block.
   a. What is the role of the field experience with respect to 502/block?
   b. What ideally should be done with respect to mathematics?
   c. Do you have students discuss what happens during the field experiences? If so, in what kind of format (written, seminar, etc.?)?

9. What improvements would you like to see for the course or field experience (content, activities, assessment, interactions of course and field, etc.)?

10. How well do feel the students you teach are prepared to teach mathematics from the point of view of their mathematical knowledge (both concepts/skills and what mathematics is and how it is done)? What is your opinion of the 105/106 sequence? Do you feel the students need more math? Different math? How do you feel about any content presentation in 502? What recommendations might you make? (Also will ask about particular syllabus items/activities if provided)
A.6: Post-Course Instructor Interview Guide

1. What are your overall feelings regarding this quarter's class?
   (surprises/disappointments?)

2. What stood out for you as highlights of the course (what worked best/worst, critical incidents, particular students, surprises, disappointments, etc.)

3. How well do you feel your goals for the course were accomplished?
   What were the most important messages the interns received from the course? (e.g., with respect to mathematics, how children learn mathematics, elementary school math curriculum, teaching mathematics, etc.) How well do you feel these were received?
   In what ways do you feel the interns (or some of them) changed their beliefs about those things? Why? What factors in the course contributed/didn't to these changes? (reprise at end?)
   What do you think the interns liked about the course? Disliked? (evaluations)

4. If you had a "magic button" to change anything about the course, what would you change? Students' actions, your actions, content, assignments, etc. What would you keep the same? Which of these might you do the next time you teach 502?
   Evaluate from your perspective the following aspects of the course: a. videos (Burns/Kamii/Fennell, data analysis, multicultural); b. activities (e.g., elementary, problems for interns); c. class discussions; d. text; e. other materials.
   What do you think the interns got out of each? How well were they received? What might be done differently or the same?
   What was your favorite class? Why? Least favorite? Why? Other classes that are memorable to you? a. Do you have stronger/weaker subjects - how were they dealt with differently?; b. Switch to multicultural issues for 2 days; c. Interns' lack of response to probes.
   Characterize your role in the class. Characterize the interns' role? Should they change? Which interns stood out (good/bad) - at least with respect to the characteristics of those who you worries or doesn't worry about.
How did you go about assessing each intern's work? How
long spent? The confusion among interns? For particular
options: Resource file, Math and Literature, Learning center,
2 lesson plans. Which were chosen the most? The least?

How well did the course interact with the rest of the
strand (especially field experience)? What interactions have
you had since the beginning/middle of the quarter?

5. What did you get out of the course?
A.7: Field Supervisor Interview Guide

1. Tell me about your background in teaching and in mathematics.

2. What do you believe are the most important reasons for including mathematics at the elementary school level?

3. What are the most important things to learn/learn about in mathematics at this level?

4. If you were to teach a third/sixth grade class (the level of the student teacher's experience), what would a typical math time be like? (OR: How would you handle mathematics?)

5. What are the most important attributes of a good mathematics teacher at this level? Which of these attributes would you hope that the preservice teachers would begin to gain? Which would you expect them to gain? What are attributes of a good math student?

6. How long have you been a supervisor? With the strand? What were the major goals that you have set out for the student teachers Autumn quarter? What would an ideal (overall) experience be like? What specific experiences did you want them to have or to look for? What subject-specific experiences did you want your students to have? If a preservice teacher were to be discussing the field experience during it, what would you hope she would say? After it?

7. What specific things did you ask of the cooperating teachers? What coordination existed among the strand people—you, the cooperating teachers, other supervisors, and methods instructors?

8. Describe what typically happened when you went to observe a preservice teacher. When you went to observe a student teacher in a school, what did you look for and want to discuss with the student teacher? What discussions about the experience happened outside the field? What did you discuss with the preservice teachers with respect to on-campus experiences? Math in particular?

9. What overall impressions did you have about the field experiences this quarter? Surprises? Disappointments? What goals were accomplished? Were not? (Including specific cooperating and preservice teachers).
10. When you would observe (intern), what were your overall impressions? What did you discuss with (intern)? What specific things related to mathematics did you observe/discuss? What overall impressions did you have about (intern's) cooperating teacher? Specific to mathematics?

11. What do you think (intern) got out of the field experience? What changes do you think occurred?

12. What concerns do you have about (intern)? What specific incidents lead you to say this?
A.8: Cooperating Teacher Interview Guide

1. Tell me about your background in teaching and in mathematics. How long have you been involved in the strand?

2. What are the most important reasons for including mathematics in the elementary school curriculum?

3. What is a "good" mathematics student like? (e.g., how does he or she learn mathematics?). How do you judge him/her to be successful?

4. What were the most important things you want your students to learn about mathematics this year—especially this past fall? How much emphasis was placed on math vs. other areas?

5. How do you assess students' mathematical understanding? Do you feel this assessment method is successful for you/students?

6. What other materials do you use (text, manipulative, technology)? How are they used? What sources do you use for activities?

7. In what ways do you consider yourself good at teaching mathematics? Not so good?

8. What restrictions are placed on you (with respect to mathematics) by the district, etc.?

9. What did you plan to do with (intern) last quarter? What did you see as your role with her? What goals did you have for her? What activities was she involved in? (With respect to mathematics?) Describe the pre-quarter meetings regarding this field experience. What did you/others agree/disagree/plan to do with respect to the things set forth? What interactions occurred between you and the math methods instructor?

10. What overall impressions do you have regarding this field experience? What goals do you feel were accomplished/not accomplished? How do you think (intern) changed/stayed the same? What might you/(intern) do differently, if given the opportunity? What particular incidents lead you to say these things? What concerns do you have for (intern)?
A.9: Strand Director Interview Guide

1. Describe the strand's philosophy of teacher education. What are the overall goals for the preservice teachers involved in this strand? What would an ideal intern do and how would he/she change? What about the typical student? What mathematical goals are held for the interns?

2. Describe the organization of the strand: courses, field experiences, practicum. What demands will be placed on the interns in each?

3. Describe the preparation for this/other quarters involving yourself, the instructors, the cooperating teachers, and field supervisors. What have been the reactions of these people?

4. What directions have been given to the interns prior to this quarter?
APPENDIX B

Course Syllabus and Course Events
B.1: Course Syllabus

Ed T&P 502 - Math Methods
Autumn Quarter 1992

Instructor: Holly Phone: xxx-xxxx
Office: xxx xxxxx
Mailbox: xxx xxxx
Office Hours: Monday 1:00-2:00 and Friday 10:30-11:30

Class Schedule: W 1:00-2:30 PM and F 9:00-10:30 AM


Overview: Mathematics instruction at the elementary and middle school levels should actively involve the student in the development of concepts and the use of problem solving processes. Since students construct meaningful mathematics from the experiences provided for them, teachers must be familiar with classroom activities and environments that can result in effective teaching and learning. The course is therefore designed to help students develop a conceptual framework of mathematics with problem solving as the integral strand. Specific goals include the following:

1) Students will extend their understanding of developmental theory and its implications for teaching/learning mathematics.
2) Students will become familiar with learning experiences that aid children in constructing mathematical concepts.
3) Students will learn to identify and develop problems related to the child's environment and appropriate to the child's developmental level.
4) Students will become familiar with professional resources and with current issues in mathematics learning.
5) Students will design and use a variety of teaching methods and evaluation techniques.
6) Students will become familiar with resource materials (professional journals, manipulatives, books, and computer software) that can be used to develop concepts and to generate positive attitudes toward mathematics.

Values

1) Students will develop an appreciation of the role of mathematics in the total elementary school program, and of the historical and cultural significance of mathematics in contemporary society.
2) Students will develop the ability to evaluate and improve their own professional competencies.
3) Students will develop an awareness of the breadth of the field of school mathematics and an appreciation of its interdisciplinary connections.
Attendance and Participation: You are expected to prepare for and participate actively in class discussions and activities. Tardiness and absence effect your performance and that of the whole group. Please let me know if you cannot attend a class. [30 points]

Lesson Plans and Teaching (required of all students): Planning and implementation of four mathematics lessons during your field experience this quarter. These lessons will consist of two two-day units. At least one of the units must involve the use of manipulatives. The lessons may be taught to small groups or to the whole class. Your lesson plans together with an evaluation sheet (to be provided) for each unit will be turned in. Be sure to complete and include any handouts or assignment sheets used. [40 points]

Portfolio: The above assignment plus a minimum of three more chosen assignments will comprise your math methods portfolio. The purpose of structuring the assignments in this way is to give you the opportunity to choose work that is meaningful to you. Choose assignments that will help you become a competent mathematics teacher. All work should reflect your growing understanding of how children learn mathematics.

There are three portfolio dates: October 28, November 18, and December 4. At least one assignment must be turned in on each of the first two dates, and the entire portfolio is due on the last date. More than one assignment may be turned in on any portfolio date. Although your best work is expected on all assignments, corrections and suggestions will probably be made; you may re-do any assignment handed in on the first two dates and turn it in with the completed portfolio to be re­graded.

The points to be awarded for each assignment is the maximum number given. The actual number awarded will depend on the quality and completeness of your work. The minimum number of points for an A is 165 and for a B is 140, so plan accordingly.
1) Review of articles: Summarize and give evaluative comments on three articles on teaching elementary or middle school mathematics. I will provide two of the articles, and the third will be any 3-5 page article of your choice (please hand in a photocopy). Journals of interest include Learning, School Science and Mathematics, Arithmetic Teacher, Mathematics Teacher, and Elementary School Journal. The reviews should include the summary (approximately 250-300 words), your critical review of the article and your personal reflections.

2) Learning Log: In your own handwriting in a notebook keep a log of your understanding of mathematics learning and teaching as the course goes along. Note your doubts, your difficulties with new concepts, etc. Give your reactions to issues raised in the field as well as in class. At least one entry per week is expected. [30 points] Turn in the log on each of the three portfolio dates!

3) Math resource file This should include a minimum of 50 items. These activities, games, and ideas should come from a variety of sources (at least 5 sources). I've put books on reserve in the library, journals are available, etc. Type of organization is your choice but should be self-explanatory and allow for continued use beyond this course. The file must include ideas on geometry (area, spatial sense), statistics (organizing data), and probability as well as arithmetic. [40 points]

4) Mathematics and literature project. Design a lesson/activity that uses literature to approach mathematics, report the intended grade level, materials needed, bibliographic information, the mathematical concept or skill involved, and a brief explanation of the lesson. [30 points]

5) Student case study. Do a profile of a student's understanding of mathematics (counting or addition or area, for example), his/her struggles with it and eventual growth. This may be done over a period of a few weeks or during one unit. Begin by observing the child and his/her work, then interview the child, probing her/his real knowledge of the topic. In your write-up discuss what preparing this in depth profile did for you as a future teacher. [40 points]
6) **Small group project.** Two or three students work cooperatively to prepare an activity exploring the use of a manipulative to develop a skill or concept. The team will have 15-20 minutes to engage their colleagues in a simulated classroom activity using the manipulative. Submit a paper which:

--- states the grade level(s) for which the activity is planned;
--- gives the specific objective of the activity;
--- describes the activity and how the manipulative is to be used;
--- states your rationale for teaching the concept or skill in this way;
--- and reflects briefly on the benefits/frustrations of working as a team.

Each member of the team should hand in a short paragraph detailing her contribution to the project. Projects should be presented on **November 18th**. Let me know if you have chosen this option so I can schedule your group. **[30 points for each team member]**

7) **Learning center.** During your field experience, prepare and have students use a learning center. Five or more activities should be provided. Submit a report which includes:

--- grade level for which the center was prepared;
--- objective(s) of the center as a whole;
--- a description of each activity and its contribution to the main objective of the center;
--- some highlights of your center;
--- some problems encountered;
--- and students' comments (positive and negative) on the activities **[40 points]**

8) **Classroom observation.** Observe mathematics activities in your field placement. Record your observations for at least 4 classes (I'd suggest during 2 classes in each of 2 consecutive weeks--but this isn't a requirement). Interview the teacher, to determine his/her rationale for the activities. Include personal reflections on the activities (what made them work; how you would restructure them, etc.) and on the classroom climate (relaxed? competitive? interested? lively?). Hand in your observations (handwritten is OK if legible) as well as the teacher's rationale and your reflections (typed). **[30 points]**
9) Reflective self-assessment. Have the mentor teacher or a friend videotape you teaching one of the required lessons. Watch the tape and note
---your strong points (at least three!);
---what you would improve next time in your teaching technique;
---any changes you would make in your lesson plan.
Furthermore, give the students five minutes at the end of the lesson to write down what they learned (not how you taught). Give your reflections on their comments. [30 points]

Please type all work, except where expressly stated above, or where drawings and math symbols make it very difficult.


Question for discussion in our first class: Are those children (in the Baratta-Lorton class) really learning any math?
<table>
<thead>
<tr>
<th>Week of:</th>
<th>Topic</th>
<th>Reading Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/30 &amp; 10/2</td>
<td>Understanding How Children Learn Math</td>
<td>Ch. 4</td>
</tr>
<tr>
<td>10/7 &amp; 10/9</td>
<td>Numeration and Place Value</td>
<td>Chs 6 &amp; 7</td>
</tr>
<tr>
<td>10/14 &amp; 10/16</td>
<td>Arithmetic Operations</td>
<td>Chs 8 &amp; 9</td>
</tr>
<tr>
<td>10/21 &amp; 10/23</td>
<td>Planning for Math Instruction</td>
<td>Ch 5</td>
</tr>
<tr>
<td></td>
<td>Technology in the Classroom</td>
<td>Ch 2</td>
</tr>
<tr>
<td>10/28 &amp; 10/30</td>
<td>Data Analysis</td>
<td>Ch 14</td>
</tr>
<tr>
<td>11/4 &amp; 11/6</td>
<td>Fractions and Decimals</td>
<td>Chs 11 &amp; 12</td>
</tr>
<tr>
<td>11/13</td>
<td>Patterns</td>
<td>Ch 16</td>
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<tr>
<td>11/18 &amp; 11/20</td>
<td>Geometry</td>
<td>Chs 10 &amp; 15</td>
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<tr>
<td>11/25</td>
<td>Estimation</td>
<td>Ch 13</td>
</tr>
<tr>
<td>12/2 &amp; 12/4</td>
<td>Assessment</td>
<td>Ch 17</td>
</tr>
</tbody>
</table>

A note on Assignment 1: The articles for review are:

Stigler, J., & Perry, M. Cross cultural studies of mathematics teaching and learning: recent findings and new directions. [This one is on reserve in the Education Library]

The third article is, of course, your choice. Enclose a copy of the article with your review.
B.2: Field Experience Reflection Sheet

NAME__________________________________________

DATES OF THE TWO LESSONS IN YOUR UNIT

COOPERATING TEACHER __________________________

SCHOOL ________________________________

BRIEF DESCRIPTION OF UNIT

_________________________________________________________________

_________________________________________________________________

Please complete the following open-ended phrases in a reflective manner:

Today I discovered...

I believe that the teacher's role in this lesson was...

I learned this about children...

I believe the following went well...

I believe that I could do the following to improve my teaching...

I learned this about myself...

_________________________________________________________________

COOPERATING TEACHER'S OBSERVATIONS AND COMMENTS:

Signed ____________________________________________

Date ______________________________________________
B.3: Day-to-Day Course Events

CLASS 1- Sept. 30

1. Introduction to course- Presentation on reading book, multicultural article, how to "listen to one another."
2. "Biography" activity- common words describing math experiences, key words.
4. Behaviorist/constructivist Presentation (contains "lunch" real-life activity example)
5. Tile activity- gives attributes and interns guess combinations.

CLASS 2- Oct. 1

1. Introduction- "Won't know exactly how to teach math from 502," don't expect full credit for turning in, and source for "girls and mathematics"
2. Presentation/Discussion on how children come to understand math: observe/imitate; categorizing.
3. Teddy Bear categorizing activity in middle of presentation, "What's in the bag" activity, "need to defend yourself" warning
4. Presentation on "2nd theme"= Patterns. Hellen Keller, clapping (Math Their Way), odd/even, intern question on algebra, Presentation/Discussion on Activity (MTW): counting and what a child needs to count. Lots of "little ideas" thrown in by Holly.
5. Intro to Fennell video- Presentation on Standards- key points.
6. Fennell Video.
7. Short discussion of "what impressed you."
8. Quick activity of "riddles" to each other.
CLASS 3- Oct. 7

1. Explains purpose of "5 minute" text assignment.
2. Wrapup of "what's in bag" activity
5. Brief introduction of Ohio Curriculum- Patterns.
6. 100s chart on overhead/with interns- sieve. Gives 4-point square problem to interns with math discussion.
7. Asks for other patterns in 100s chart.
9. Presentation on "even has partner" and have children explore "even + even."
10. Presentation/discussion on adding first n odds- triangle #s.
13. Holly gives own pattern to figure out (in class)

CLASS 4- Oct. 9

1. Presentation on Burns "collection" books- Burns' thoughts, etc.
2. Presentation on Burns' tile activity- birthday squares. What Burns' student wrote.
3. Does same activity with interns in groups. Followed by discussion on math.
4. Short presentation on Burns' student's report.
6. Warning on physical use of materials.
7. Activity- painted cubes. Discussion on the math. "Kinds of assignments you can give." Then on assessment of activity; discussion on "what can you as a teacher learn from the assignment?"
8. Discuss what interns wrote in 5 minutes on place value. ("ignore patterns for now"). Presentation on "development of place value knowledge," "37"-assessment of place value knowledge.
9. Presentation/discussion on dice roll activity; Interns' and Holly's ideas for extension.
10. Group activity on evaluating place value activities- if worthwhile and teaching place value. Reported by groups.
CLASS 5- Oct. 14

1. Multiplication rap song, reminder of portfolio due, questions about course assignments.
2. Discussion of "ideas got from reading chapter" on important things for computation. Includes discussion on manipulatives (includes presentation of activity of dice/numerals).
3. Introduction of Kamii Video.
5. Discussion of Kamii video on discourse of classroom in video. Including pleasing teacher; our way of defining "master teacher" must change.
6. Discussion of field ideas for basic facts computation.
7. Presentation of planning math/lit assignment. Gives examples of books- reads and describes activities with them. Includes Burns-farmer example.
8. "Unifix cubes in pocket" place value activity with presentation of another class of kids who came up with traditional algorithm.

CLASS 6- Oct. 16

1. Presentation on time-extension plea for assignments. Goal of class= change imprint. Talk about upcoming Bob Cooper visit.
2. Group activity on writing most important guidelines for computation. Interpreting text guidelines and reporting in traditional ways.
3. An intern's algorithm of foreign country lecture.
4. Presentation of "Zurkle" place value activity.
5. Quick asking of use of calculator and quick activity.
CLASS 7- Oct. 21

1. Response to intern's question of lesson plan format- including importance of questions.
2. Presentation on Standards. Background, children can add/subtract well but can't problem solve. Gives "math community" assignment. Lists guidelines on overhead (role of teacher, "not memorize" discussion, problem-solving (as fun), connections); role of teacher in Standards-like environment.
3. Dog area activity to illustrate meaningful problems versus exercises.
4. Presentation on planning. Warning of being sure of where you stand and knowing problems are good.
5. "Goals of year" discussion.
6. Back to presentation on planning- gives list on overhead from textbook. Deciding on organization of classroom (whole group, etc.)
7. Skips rest of list to go to "goals of questions" presentation. Lists goals with examples. Connects to interns' goals of year.
8. First Burns video.

CLASS 8- Oct. 23

1. 5 minutes of writing on calculator textbook chapter.
2. Discussion of Burns video- ways of questioning, respect for students, ways to get students to talk, language important.
3. "Dirty Dozen" questions.
4. Asks interns when they would use calculators.
5. Calculator activities- Aunt Bebe, "shortest route," estimation of squares, "99," parentheses, ("purpose of these activities is to throw ideas at you"), hot dog, hidden number game.
CLASS 9- Oct. 28

1. Presentation on book (Anno).
2. Introduce data analysis video (want them to be convinced of importance...)
3. Data analysis video
4. Discussion on data analysis video. Mostly on likes/dislikes of video for kids.
5. Activities ("ideas for you to use" from Used Numbers) for data analysis: raisins (terms); "typical" families definition (and interns' multicultural concerns); "typical family" activity; median- lining people up by height; back to raisins; why do data have shape on the graph?; NBA activity; presentation example of 6th grade investigation; pets and median; compare heights of 1st/4th graders; sleep investigation (students coming up with questions); graphs for tiny kids: crackers, shoes.

CLASS 10- Oct. 30

1. Asks interns for their "math community" guidelines- mostly copies from seminar. Holly discusses ability grouping with intern. Asks for more ideas.
2. Introduction to peer teaching activity: "teach to colleagues," will be telling colleagues how to do activity.
3. Rest of time on peer teaching- preparing and giving activities.

CLASS 11- Nov. 4

1. 2 interns led statistics activity. Model problem for interns and interns do it in groups. Discussion on the math.
2. Presentation/discussion of "goals of teaching data analysis:" "basic guidelines of whatever you decide to do." Lots of silence to questions.
3. Skips syllabus to go to introduction of multicultural video (including discussion of reasons for achievement in Japan).
5. Discussion of multicultural video (reasons for achievement- cultural/non-cultural).
CLASS 12- Nov. 6

2. Holly's presentation on multicultural issues. Includes books, multicultural-families, what "we used to think was good teaching." Asks interns for ideas.
3. Discussion of fraction problems. Class falls into traditional roles.

CLASS 13- Nov. 12- Bob Cooper's classroom

1. Gives circumference/height problem and talks about background and frustration with textbooks, etc. Major point= math through problem solving.
2. Talks about his class- pencil and paper not first priority- "do nothing but problem solving." Easel, dice roll for forming numbers, patterns, beans/cups (place value), adding with bases, magic cards.
3. Critiquing resources. On one, he critiques that it's too predictable. Talks about Burns. Then activities from Family Math, etc.
5. 3-bean salads. Logic lineups, nim, geoboard.
6. Lecture on "Don't underestimate kids."
1. Short discussion on Bob Cooper: main point for interns = sources.
2. Presentation on books of number art, probability (Math=fun), number families, eating fractions.
3. Presentation on curriculum of fractions = one of 2 main obstacles. Holly (in planning class) went through readings and put together guidelines and ideas for overhead.
4. Develop concept, more time needed.
5. Building kits: shows examples of use ("hold up 2/4," etc.).
6. Start with area model. Hold off number lines and set models.
7. Textbooks not helpful.
10. Do a lot of counting (out loud with interns) and showing (with models).
11. Equivalence. Then quickly to "=1 and close to 1."
12. Symbols then come in.
13. Be critical of texts/worksheets.
15. Then on to presentation on operations. Division - idea of "fitting into." Asks 2 divided by 1/4 - silence. Interns fall into traditional role of relying on instructor. Intern asks if that's how to show rule. Holly responds with that to show that rule makes sense: "building up to a rule."
16. Group activity of "correcting" kids' mistakes. Interns report: lots of "showing."
CLASS 15- Nov. 18

1. Holly announces that she will give talk and use groups to break up boredom today.
2. Recap of guidelines- number sense. Talks about Burns' "a way of thinking" with respect to activities.
3. Spend time on concepts (if kids can do it, still might not understand it), expand use of materials, mental math, then introduce words.
4. K-4- alot of oral language, counting, showing, comparing, estimating- don't hit symbols too quickly.
5. Asks for ideas from field (folding strips; Bob Cooper's 60/150, weather).
6. Games to assess knowledge- "uncover," "cover up."
7. Presentation on equivalence/partitioning.- with strips, generate poster, unifix cubes- interns in role of "students." Hoping students will generate a rule for equivalence.
8. Operations- addition (like/unlike denominators. Subtraction just like it).
9. Then on to remaining group reports- more "showing" the student.
10. Multiplication- idea of "of." Models it: "go thru alot of those."
11. Division- "fit into." Want students to come up with rule. Shows example slowly with strips. "Work through several, noting that same as multiplying by reciprocal from before."
13. Final message of students knowing own mistakes.

CLASS 16- Nov. 20

1. Presentation/discussion of purpose of patterns. Interns' ideas of purpose and Baratta-Lorton quote.
2. Introduction to pattern problems activity. Exhibits developing inductive pattern, graph, formula. Tells interns to do same in groups.
3. Pattern problem activity: good discourse, etc.
4. Discussion of activity - only on math. No proof, no discussion of teaching/learning/nature, etc.
5. Problem activity-tiles- factors.
CLASS 17- Nov. 25

1. Presentation/discussion of locker problem
2. Presentation/discussion of function machine- only math.
3. Tells interns to prepare ideas of assessment from field for last class.
4. Presentation/discussion of geometry ("main ideas to get across"). Interns give suggestions; Holly talks on reading trade book and activity examples (projector shadows, standard units story, dazzle draw, short logo, etc.).
5. Tangram problem activity- like in Bob Cooper's. To show going across parts of math. Short discussion- Holly gives talk on what to do with results.
6. Problem activity on tangrams. Cheer when groups find solution, etc.
7. Lecture on base 10 area of region.
8. Percent of area of tangrams- quick activity.
9. Introduce second Burns video- to see how math can be connected.
10. Stopped tape to go.
1. Introduces pentominoes.
2. Pentominoe problem activity: "try to convince your partner" and interns don't.
3. Short discussion on math of pentominoes- finding symmetry, etc.
4. Presentation on checkerboard activity. Has 2 interns do it.
5. Presentation on activity of folding pentominoes to make a box.
6. Notes that purpose of activities has to do with visualization.
7. Presentation on activity of cutting milk cartons into pentominoes.
8. Notes: "a little bit of what you'll be able to do with classroom."
10. Short message on if uneasy with apparatus.
13. Another geoboard problem activity on similar figures- make copies on paper.
14. Presentation/discussion on collecting junk, cutting cardboard cylinder.
15. Presentation/discussion on pi.
16. Short mention of bike-trail activity.
17. Last minute activity on area of pentominoes. Asks interns for ideas- no time.
CLASS 19- Dec. 4

1. Advises to read text on assessment.
2. Presentation on assessment guidelines. Find what they know already. Interns present ideas instead of addressing the original question of WHEN is it appropriate.
3. Rest of guidelines. Interns come up with field ideas of developing problem situations (more than 1 step, Appalachia), multiple assessment techniques (cooperating teacher's grouping according to improvement, Bob Cooper's assessment), calculators on tests (one intern's upside down calculator).
4. Problem activity on geometry-mirrors. Only do with respect to math - Interns' math is not assessed nor is there discussion on the assessment of the activity.
5. Then has interns make own figures.
6. Finally talks about assessment of mirror activity.
7. Right back to discussion of math of mirror activity.
8. Intern describes cooperating teacher's poor use of journals.
10. Course evaluations.
APPENDIX C

Letters and Permission Forms
C.1: Written Solicitation for Mail Survey

OSU Letterhead
Student's Address
Date

Dear Ms. Teacher:

I would like to welcome you to what I hope will be a rich
learning and teaching experience for you in (strand). My name
is Vic Ferdinand and I am currently working on my dissertation
at Ohio State with Professor Sigrid Wagner in mathematics
education. My major interest is in improving the mathematics
education of elementary teachers so that it is meaningful and
useful for them in their future teaching careers.

As a future educator, you are probably aware of the great
concern and criticism throughout the United States about the
mathematics education that children experience in school.
Part of the criticism is centered on how teachers are educated
before they enter the teaching profession. In response to
these criticisms, several recommendations have been made to
improve teacher education. However, these recommendations
have been made with little or no guidance from the teacher's
point of view. Very little is known about how teachers
experience their teacher education coursework or how that
coursework impacts on their knowledge about teaching specific
subjects.

This fall, you will have an opportunity to be part of an
effort to improve teacher education for yourself, your
classmates, and future teachers. This effort will involve a
study of your mathematics methods course and field experience.
In it, some members of the class will be asked for their
opinions on what these experiences mean to them, especially in
light of their past experiences as mathematics students and
outlooks toward the future as teachers of mathematics.

Of course, any responses given by anyone in the class will be
held in strict confidence by the principal investigator of the
study and will NOT influence grades or any other evaluation
involved in your teacher education program or career. In
particular, no responses will be revealed to your instructors,
supervisors, or cooperating teachers. Keep in mind that the
intent of this study is not to investigate you or your
classmates but rather to investigate your experiences from
your perspectives in order to improve those experiences.
In order to understand what your opinions are about elementary school mathematics, I am asking you to please fill out the enclosed 20-minute questionnaire. In it, you will be asked for your opinions about how you feel mathematics should be taught and learned in elementary school as well as how well prepared you think you are to teach and learn mathematics. All that is required of you is to read each statement and circle the response that most accurately reflects YOUR opinion. There are no "right" or "wrong" responses, only HONEST ones.

After filling out the questionnaire, simply place it in the stamped envelope and drop it in the mail. The deadline for returning the questionnaires is Wednesday, September 16. For those who return completed questionnaires by that date, a drawing will be held at the beginning of the quarter in which five winners will each receive $20.

Once again, your responses will be held in confidence by the investigator and will not influence any grades or other evaluations made of you in your program or your career. They are only to be used for the purposes of the study. Therefore, it is critical that you respond with YOUR opinions. In order to insure this confidentiality, your name is requested only on the separate cover sheet of the survey. The code number written on the survey will be known by myself and will not be shared with anyone.

If you have any questions about the questionnaire or the study, feel free to call me (Vic Ferdinand) at xxx-xxx-xxxx (call collect if necessary) or Professor Sigrid Wagner at xxx-xxx-xxxx.

Thanks so much for your help!!

Sincerely,
C.2: Intern Human Subjects Consent Form

THE OHIO STATE UNIVERSITY Protocol No. _____

CONSENT FOR PARTICIPATION IN SOCIAL AND BEHAVIORAL RESEARCH

I consent to participating in research entitled:

The Influences of an Elementary Mathematics Methods Course on Preservice Teachers' Beliefs about Teaching and Learning Mathematics

Dr. Sigrid Wagner or her authorized representative has explained the purpose of the study, the procedures to be followed, and the expected duration of my participation. Possible benefits of the study have been described as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Further, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me. Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ______________________ Signed: ______________________

Signed: ______________________ Signed: ______________________

(Principal Investigator or his/her Authorized Representative) (Person Authorized to Consent for Participant- If required)

Witness: ______________________

HS-027 (Rev. 3/87) -- To be used only in connection with social and behavioral research.)
C.3: Contract for Intern

The undersigned agrees to the following actions and guidelines with respect to the study by Victor Ferdinand:

1. To submit to interviews at the beginning, during and end of the course. The first interview will last a total of approximately three to four hours. The interviews during the quarter will take place weekly and last approximately one hour each. The final interview will last approximately two to three hours.

2. To allow the investigator to periodically observe her field experience.

3. To allow the investigator to photocopy and examine any graded work done in conjunction with Education Theory and Practice 502 or her field experience.

4. That participation in the study will in no way influence any grade or other evaluation in the teacher education program she is currently enrolled in or any future position. In order to maximize confidentiality, no utterances made to the investigator, written or oral, will be revealed to any other person involved in the teacher education program throughout the duration of the quarter. Also, any references to her in any written or oral report of the study after the quarter will use a pseudonym to protect her identity.

5. That the undersigned may freely withdraw from the study at any time.

6. That, should the undersigned fulfill obligations #1, #2, and #3, she will receive $100 in compensation for her time and effort. If #1, #2, and #3 are not completely satisfied, then the $100 shall not be awarded.

SIGNED: ______________________________

SIGNED: ______________________________
C.4: Letter of Support from Strand Coordinator

To Whom it may Concern:

As coordinator of the (strand) for preservice elementary teachers, I hereby give my permission to Victor Ferdinand to do the following during Autumn Quarter 1992:

1. Observe and audiotape each meeting of the course Ed T&P 502 (mathematics methods).

2. Select three of the enrolled preservice teachers, interview them throughout the quarter, examine their written work, and observe their field experiences (with permission of the three teachers).

3. Interview the instructor of the mathematics methods course, the cooperating teachers in the field, field supervisors, and myself.

Signed:__________________________________________

Date:____________________________________________
To Whom it may concern:

As instructor of the course Ed T&P 502 (elementary mathematics methods) in the EPIC strand for preservice elementary teachers, I hereby give my permission to Victor Ferdinand to do the following during Autumn Quarter 1992:

1. Observe and audiotape each meeting of my class.

2. Interview me at the beginning and end of the course, as well as during the course (at my convenience).

3. Select three students from the course and confidentially interview them throughout the quarter about their experiences in the course as well as examine their written work (with the students' permission).

SIGNED: ______________________________

DATE: _______________________________
APPENDIX D

Personal History and Motivations of the Researcher
D.1 Personal History and Motivations of the Researcher

I first became interested in the mathematical education of preservice elementary teachers when I was asked to teach mathematics content courses in 1986. During the courses, I noted that many of the interns did not have sufficient subject matter knowledge to teach elementary school mathematics and had never before considered mathematics as a reasoning process. This disturbed me as I began to realize that many of those interns would soon be providing children with some of their first school experiences with the discipline of mathematics. Also, because of the mathematics coursework required of interns in their program, it became evident to me that the experiences provided to these interns in those courses may be the last and, considering many interns' personal histories, only chance for them to experience mathematics and its pedagogy as a problem-solving process before they begin teaching. However, I also became increasingly aware that the pedagogy of these courses, despite the inclusion of a "lab" component in which manipulatives were used, was mostly in a traditional presentation-recitation format, leaving few opportunities for the interns to treat mathematics as inquiry.

These concerns were crystallized and amplified during my years in the doctoral program, particularly as my perspectives of mathematics and its pedagogy became increasingly compatible with those of the Standards. These occurrences became possible because of reflections on questioning within my coursework (especially through Dr. Richard Shumway) and on readings about (a) constructivism (especially those by Leslie Steffe and Ernst von Glasersfeld), (b) research on elementary school mathematics
(especially those by Paul Cobb and his colleagues), (c) and research on teacher knowledge and learning (especially those by the National Center for Research on Teacher Learning).

From this education, I began to focus on elementary teachers' beliefs about mathematics and its pedagogy as being a major force behind their teaching and I wanted to investigate how we as teacher educators can use the opportunities provided for interns' mathematics education (i.e., content and methods courses) to impact on those beliefs toward establishing elementary classrooms that treat mathematics as inquiry. To begin this endeavor, I decided to investigate what was there and how we can improve on it.

With the resources at hand, I needed to choose between investigating mathematics content or methods courses. I chose a methods course for three reasons: (a) Methods courses were taught in the College of Education, where I believed there was more likely to be an explicit Standards-like point of view (and consequently a better chance for events anomalous to traditional beliefs) than in the content courses, which were taught in the Mathematics Department; (b) I believed methods courses would be more likely to consider mathematical learning environments and interns' personal histories involving them than the content courses; and (c) I had never taught or experienced a methods course and thus I conjectured that I would be less biased in the collection and analysis of the data than had I studied a content course that I had taught before.
LIST OF REFERENCES


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Fisher, P. O. (1993). Beliefs about and attitudes toward mathematics and mathematics teaching held by prospective elementary teachers at the University of Nebraska-Lincoln. Dissertation Abstracts International, 54, 450A.


