PRESERVICE TEACHERS' BELIEFS AND CONCEPTIONS OF MATHEMATICS LEARNING AND TEACHING

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by

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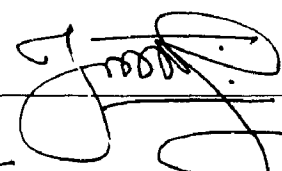
SIGNATURE: 

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CERTIFICATION OF THESIS WORK

We, the undersigned, certify that Henry Kang, candidate for the Degree of Master of Education has presented a thesis on *Preservice Teachers' Beliefs and Conceptions of Mathematics Learning and Teaching*, that the thesis is acceptable in form and content, and that the student demonstrated a satisfactory knowledge of the field covered by the thesis in an oral examination held on July 22, 1996.

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ABSTRACT

The purpose of this study was to explore the beliefs about mathematics teaching and learning held by two preservice teachers during their teacher education program. Filed data and interviews were used to explore these preservice teachers' individual experiences with mathematics, first as students learning mathematics and then as students learning to teach mathematics, and the beliefs which they held apparently as a result of those experiences.

These teachers held negative beliefs about mathematics, and about mathematics teaching and learning. If beliefs influence action, and it seems reasonable that they do, then negative beliefs about mathematics, and about teaching and learning mathematics will result in problems in teaching.

The study suggests that teacher education, besides providing opportunity for preservice teachers to deconstruct such negative beliefs, should also provide an environment where preservice teachers can practice positive views of, and alternative methods of, teaching mathematics. This would help preservice teachers to teach in such a way that their students could learn positive views of mathematics, even in the face of a socialization process in schools which does not promote positive views of teaching and learning.

This study also emphasizes the need for preservice mathematics educators to enable preservice teacher candidates articulate and deconstruct their beliefs and conceptions about mathematics, and about mathematics learning and teaching, which they bring with them to the teacher education classroom.

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CHAPTER 1

INTRODUCTION

Preservice teachers (students in a teacher education program learning to teach in schools) entering colleges of education have, for the most part, come through a school system where mathematics was taught in a traditional way. It is not surprising therefore to find that their initial teaching experiences reflect their history of living in the middle of a traditional view of mathematical knowledge. This mathematical history presents itself in colleges of education as a major impediment to acceptance of new ideas and confidence in working through these ideas in practice.

For the past decade, professional educators have been presented with several reports on how to improve teaching both as an activity and as a profession. One of the recurring themes of these reports (The Holmes Group, 1986; Carnegie Task Force, 1986) has been the professionalization of teaching - the elevation of teaching to a more respected, more responsible, more rewarding and better rewarded occupation. This theme is based on a more fundamental premise: that the standards by which the education and performance of teachers must be judged can be raised and more clearly articulated (Shulman, 1987). As a result, many teacher educators are in search of new approaches to teacher preparation and new ways of describing and evaluating teachers. They hope to graduate teachers who will be able to meet the challenges presented by the needs of the society, the needs of the

students, and the needs of the disciplines.

In mathematics education, as in other areas of education, the difficulties of looking at alternative views of teaching may, in part, be attributed to the curriculum of *the* teacher training program. A large part, however, is likely to be associated with the beliefs and conceptions about mathematics teaching and learning that novitiates live with during their teacher education. Mathematics educators need to know their preservice teachers' conceptions of mathematics and understandings of themselves as teachers of mathematics. They need to know how these conceptions change during the teacher education program and to what such changes can be attributed. They also need to be aware of some of the impediments to transformation of preservice teachers' beliefs, and consequently practice, and their resistance to change, to better enable them to navigate the preservice teachers through the teacher preparation landscape (Shulman, 1987) of new ideas and new instructional strategies.

This study is thus designed to explore the beliefs and conceptions of mathematics teaching and learning held by some preservice teachers during their teacher education program. Shulman (1987) contends that understanding of some of the impediments to the development of preservice teachers as they move from a state of expertise as learners through a novitiate as teachers may be of great benefit. The students' beliefs about mathematics and mathematics teaching seem likely to be one source of such impediments (Hamm & Langbort, 1991).

Though students continue to enroll in teacher training courses in various education institutions, the number of persons entering the teaching profession with specialization in mathematics continues to decline (Howe & Gerlovitch, 1981; Brown & Borko, 1994; Violato, 1987; Violato & Travis, 1990; Hamm & Langbort, 1991 and Morine-Dershimer, 1993). There is, however, a renewed interest in mathematics teacher education. Mathematics teacher educators have begun to reflect on their philosophies of mathematics education, on the goals and objectives of mathematics teacher education, and to reexamine their practice (Davis, 1994).

Preparing teachers to teach mathematics in elementary schools is not an easy task. Tobias (1987) believes that many of those who choose to become elementary teachers are uncomfortable with learning and using mathematics. Their anxiety as learners of mathematics and consequently their anxiety as teachers of mathematics sometimes are a hindrance to their efforts to become mathematics teachers in the elementary grades. Many have little or no content knowledge background in mathematics. Most of what they are able to recall of their experiences with mathematics centers around arithmetic and its basic operations. Even for those who have a more advanced knowledge in mathematics, Tobias continues, the subject is near the bottom of the list of what they feel comfortable teaching. That is perhaps because their 'knowledge' is of a rote or "instrumental" nature and not understood in a "relational" or connected way (Skemp, 1989). There is as a result a tendency for them to teach mathematics in much the same way that

they learned arithmetic (Hamm & Langbort, 1991).

Recent studies of preservice teachers show that many hold dated behavioural models, misconceptions, and misunderstandings of the nature of mathematics (Graeber, Tirosh and Glover, 1989). By dated behavioural models, I mean long ago acquired beliefs and conceptions that are strongly held even though they have little congruity with contemporary learning experiences. These prospective teachers' beliefs about mathematics are often similar to those held by severely mathematics-anxious people (Frank, 1990).

Recent theory in mathematics education emphasizes the need to think of mathematics teaching as not simply explaining content, but as engaging students in the processes of doing mathematics (Thompson, 1994). Through these processes students are able to construct knowledge by interacting meaningfully with the environment, an environment which includes a world of shared meaning with others - a social world. In the process of *doing* mathematics students bring forth, or enact, their personal lived world of mathematical meaning in interaction with the meaning brought forth by others. This sense of knowing and doing mathematics is considered an enactive approach to cognition, or enaction (Maeers, 1995; Kieren, 1994; Davis, 1994; Varela, Thompson, & Rosch, 1991).

According to Dewey (1916) and the Curriculum and Evaluation Standards (NCTM, 1989), there is a distinction made between knowledge and the record of knowledge. To 'know' mathematics is to 'do' mathematics. The Curriculum and

Evaluation Standards maintain that "a person gathers, discovers or creates knowledge in the course of some activity having a purpose" and that the value of informational knowledge "lies in the extent to which it is useful in the course of some purposeful activity" (p.7). Reform in mathematics education promotes the active 'doing' nature of mathematics and the paralleled instructional strategies to enable 'doing' mathematics to occur.

Teachers are thus expected to play a key role in this effort to reform mathematics education but their limited views of learning and teaching mathematics are a major impediment to that effort. Prawat (1990) says that access to knowledge relevant to one's teaching is an important aspect of empowerment, particularly if that knowledge challenges questionable beliefs. Shulman (1986) posits therefore that we must learn about teachers' knowledge and its development from careful observation of those who are just learning to teach so that we can better equip teacher candidates to participate in the reform of mathematics education.

Purpose and Significance of the Study

Constructivist thought on teachers' cognitions suggests that teachers are knowing beings and that their knowledge influences their actions. Knowledge, then, forms a system of beliefs which directs perceptions and behaviours. In this formulation, theories, or theoretical orientations consist of sets or systems of individual beliefs. Preservice teachers entering a teacher education program bring

with them such systems of individual beliefs, and conceptions (Brown & Borko, 1994). These prior beliefs, and knowledge, which are not only about the nature of mathematics and mathematics teaching and learning, but about teaching and learning in general, which have been developed during the preservice teachers' years as students in schools. Munby (1982), maintained that advances in understandings about appropriate ways of addressing the improvement of teaching depend upon our securing considerable knowledge about the nature of the beliefs that preservice teachers hold. Our knowledge of preservice teachers' beliefs and knowledge is difficult to formulate due to the great variability of teachers' beliefs and conceptions as described by researchers in this area. This variability in the description is probably due to the diversity of purposes, methods, designs, and analytical frameworks used by researchers (Brown, 1985; Cooney, 1985). Teachers' beliefs about mathematics learning and teaching seem even more problematic. This study was thus designed to describe the beliefs about mathematics of two preservice elementary mathematics teachers in the course of their teacher education program in order to understand what they feel, think and believe about mathematics. To describe these beliefs three broad questions guided the interviewer to enable the preservice teachers to talk about their experiences with mathematics. These questions are:

(1) What are the beliefs and conceptions that preservice elementary teachers have about mathematics and mathematics learning and teaching prior to teacher

education?

(2) How are these beliefs and conceptions transformed (if at all they are) during their teacher education?

(3) What major "events" or "situations" occasioned this transformation?

Interviews explored these preservice teachers' individual experiences with mathematics, first as students learning mathematics and then as students learning to teach mathematics. Filed data on the preservice teachers' mathematical histories, including questionnaires administered by one of their professors, and interviews, provided the sources of information from which an analysis and description of beliefs could be made. This approach is similar to studies carried out by Munby(1982), Thompson(1984), and Shulman (1986 and 1987), who all maintained that knowledge about preservice teachers' beliefs and conceptions can be best articulated through interviews and histories from their years as students. The above-mentioned questionnaire focused on the preservice teachers' experiences with mathematics, addressing such issues as 'What is mathematics?', 'What immediately comes to mind when you hear the word *math*?'. The Interview sessions focused on questions such as those outlined above, as well as on the preservice teachers' experiences in the learning of mathematics as prospective elementary teachers.

Assumptions

Getting people to verbalize their beliefs, especially intuitively reasonable ones, is a difficult proposition. Johnston (1994) maintains that, if we are to report on preservice teachers' beliefs and conceptions about mathematics teaching and learning, then we have to get the preservice teachers to talk about the whole issue of their preservice training and become aware of what they are living with. Accepting this position, this study of preservice teachers' beliefs of mathematics teaching and learning was guided by some assumptions. It was assumed that:

(1) beliefs and conceptions acquired by preservice teachers during their student years prior to their teacher education are retained into their preservice teacher education program. This assumption follows from a study of teachers conducted by Lortie (1975) which confirmed that those planning to teach usually form definite conceptions about the nature of teaching long before they actually enter the role themselves, or even before they formally begin preparation for it.

(2) preservice teachers' knowledge of mathematics has little influence on the way they verbalize their beliefs and conceptions about mathematics and mathematics teaching and learning. Borko and Brown (1994) maintain that the preservice teachers' schemata for pedagogical content knowledge are less elaborate, interconnected, and accessible. As such, it is logical to

assume that their professed beliefs and conceptions will be more intuitive and more construed.

(3) the advantages that each of these two preservice teachers might have enjoyed in their different schools as students over each other, such as rural school versus urban school, had no influence on their teachers' interaction with them as individuals.

Boundaries of the Study

In order to restrict the scope of the study the problem was delimited as follows:

1. The study was conducted with two preservice elementary mathematics teachers.
2. Analysis was made based on the espoused beliefs of the preservice teachers as collected through the filed questionnaires from the earlier methods classes and the interview sessions.
3. No attempt was made to study the relation between espoused beliefs and instructional practice during field experience.

Summary

This chapter suggests that much can be learned from studying preservice teachers as they learn to become teachers. It has outlined the importance of securing understanding about preservice teachers' beliefs about learning and teaching mathematics in an effort to help teacher educators and others better assist student teachers in their professional development.

Outline of the Study

This first chapter has outlined the nature, purpose and significance of the study, the assumptions and delimitations of the study.

Chapter two presents literature related to preservice teachers' beliefs and conceptions about mathematics teaching and learning. This literature review will examine constructs that preservice teachers live with during their teacher education.

Chapter three describes the methodology employed in the collection of the data, together with background information about the participants.

Presentation and interpretation of the findings is outlined in chapter four.

The fifth and concluding chapter derives from the findings some conclusions and makes implications for future research on teacher education.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

This chapter describes some literature concerning beliefs in general and beliefs about the teaching and learning of mathematics in particular. It also describes some views of the nature of mathematics. There are two reasons for doing this: the first is to outline the major theoretical influences in the field of preservice teachers' beliefs and conceptions about mathematics teaching and learning, and the second is to lay the foundation on which to examine constructs that preservice teachers live with during their teacher education.

Background on the Nature of Beliefs

The topic of belief is widely encountered in psychology and philosophy and, more recently, in educational research. According to Munby (1982), understanding this topic is not only central to the task of improving teaching, but is also central to how one addresses the total concept of professional education. Because there appear to be many perspectives about what constitutes beliefs, I have decided to examine the concept of belief in general before looking at the impact of beliefs about mathematics teaching and learning. The reason for this is to clarify the impact that beliefs can have on instructional behaviour.

Beliefs, according to Abelson (1979), are disputable bodies of knowledge that

can be held with varying degrees of conviction. They are also said to exist in alternative worlds. In such fixations, the holder could possess two different sets of beliefs about the same idea or about the same concept (e.g., belief about the concept of infinity as a very large quantity and as a very small quantity). They can suffer from lack of consensuality, are often held or justified for reasons that do not meet generally accepted criteria, and, thus are held independent of any demonstrated validity. These generally accepted criteria sometimes depend on the cultural context and may vary from one group to the other. Some beliefs may become knowledge when supported by later theories.

Researchers have noted that teachers often treat their beliefs as knowledge (Grossman, Wilson, & Shulman, 1989). Looking at beliefs from this perspective has led to an examination of the whole concept of beliefs in relation to knowledge. The two concepts seem to have more in common than one might suppose. Indeed, Needham (1972) and Wolgast (1977) argued that to search for a definitive characterization of either concept may prove to be futile. In contrast, Abelson (1979) suggests that useful distinctions are possible between the structure of beliefs and belief systems on the one hand and knowledge and knowledge systems on the other.

To Abelson (1979), belief and knowledge is analogous respectively to affect and cognition. Belief systems depend heavily on affective and evaluative components (feelings, moods, subjective evaluation). Knowledge deals more with

experiential learning through events. It is sometimes considered indisputable and is habitually associated with truth and certainty. This truth and certainty is often established based on canons of evidence obtained from current theories (Feyerabend, 1975; Kuhn, 1962; Lakatos, 1976). What is accepted as knowledge varies, depending on the particular historical-cultural context (Benson, 1989). Thompson (1994) states that what may be considered as knowledge at the present time may be called a belief later if subject to disagreement with later theories.

Plato, according to Schmitt (1992), argued that knowledge was more valuable than true belief, despite the fact that it is no better as a guide to action (Meno 97a - 98c). Knowledge, he claimed, was simply justified true belief whose justification is the result of a clear reason for holding such a belief. This claim led to a widely held view in epistemology that knowledge is "indefensibly justified true belief" (p.159). Such a point of view was opposed by Russell (1912), who observed that what is considered as justified true belief is not sufficient to be called knowledge. If this were so, then most of what is considered as teachers' beliefs would be knowledge since teachers can invariably produce a reason for their thinking and actions.

Hintikka (1979) in his arguments about beliefs said that

> If something is compatible with everything you believe, then it must be possible for this something to turn out to be the case together with everything you believe without making it necessary for you to give up any of

> your beliefs. If your beliefs are to be consistent, it must also be possible for all your beliefs to turn out to be true without forcing you to give up any of them. (p.49)

The above statement can be interpreted to mean that when one acquires a new set of beliefs which are assimilated without modifying a belief system, then the new set of beliefs is said to be compatible with what one strongly believes. And if one is able to accommodate these two sets of beliefs about the same idea, knowing *when* to retrieve *what*, then one can easily be tempted to consider this accommodated set of beliefs as knowledge. However, from the above quotation, it would appear that one often does not know what one *believes* and what one *knows*. If this were so then there would be nothing in the name of belief or if there were anything, then this could only be accessed by inference and introspection. Such a stance forced many to be tempted to assume that knowledge and belief are self-intimating. But Hintikka (1979) did not agree with these assumptions that knowledge and belief are states of mind recognizable by introspection. He argued that it was not true that whenever one knows or believes something one knows that one does, and that whenever one does not know or believe something, one knows that one does not.

A later way of thinking about beliefs and belief systems was developed by Harvey (1986). Harvey argues that a belief system is a "set of conceptual representations which signify to its holder a reality or given state of affairs of

sufficient validity, truth and/or trustworthiness to warrant reliance upon it as a guide to personal thought and action" (p.660). Hintikka's discussion of beliefs emphasizes more of the cognitive aspects, while Harvey, on the other hand, examines the whole concept but emphasizes the affective and psychomotor aspects.

In this study, the above definition of beliefs and belief systems by Harvey (1986) has been adopted. The adoption of this definition is because Harvey more than Hintikka has dealt with the affective component of beliefs and their consequent influence on instructional behaviour. As Ernest (1988) maintains, research literature on mathematics teachers' beliefs indicates that teachers' approaches to mathematics teaching depend fundamentally on their systems of beliefs. Therefore, the beliefs and conceptions that preservice teachers hold to be true about mathematics will influence their instructional behaviour. This influence on instructional behaviour will further affect (positively or negatively) how the preservice teachers learn mathematics, how they learn to teach mathematics and it will also influence the attitudes they pass on to children.

Studies on preservice teachers (Brown & Borko, 1994; Brown, 1985; and Cooney, 1985) have revealed that these "conceptual representations" or beliefs are apparent. These beliefs are about, in the case of this study, the nature of mathematics, the nature of learning mathematics and the nature of teaching mathematics.

The next section examines the literature about preservice teachers' beliefs

on the nature of mathematics, learning mathematics and teaching mathematics. For purposes of this study, therefore, the concept of a "teacher's beliefs" will be used to refer to those propositions (values, attitudes, preferences) about mathematics, mathematics learning and teaching that preservice teachers hold to be true in relation to mathematics.

Background on the Nature of Mathematics

Traditionally, throughout history, the nature of mathematics has been viewed either as an objective reality independent of the knower or as a subjective reality independent of the known. This difference in viewpoint has been termed a dualistic or an ontological-epistemological debate (Varela, Thompson, & Rosch 1991; Bateson, 1987) and is characterized by absolutist assumptions and separation on the one hand and idealist assumptions on the other. In terms of classroom learning the objective assumptions emerge as isolated, unconnected learning, a reliance on correctness or the right answer, or needing to be told what to do, whereas the idealist or subjective assumptions surface as being right with little or no interaction with the external world - the knower creates meaning with no interaction, no reliance on outside sources.

Thompson's (1994) perspective on classroom learning seems to fall some where between the absolutist and idealist assumptions, valuing both the knower and the known in an interactive act of learning. This view of learning is similar to an

enactivist view (Maeers, 1995; Davis, 1994; Kieren, 1994; Varela, Thompson, & Rosch, 1991). From this orientation, in terms of classroom learning, students engage in purposeful activities that grow out of problem situations, requiring reasoning and creative thinking, gathering and applying information, discovering, inventing and communicating ideas, and testing those ideas through critical reflection and argumentation (Thompson, 1994). Knowing mathematics occurs in the doing, making and personal understanding of mathematical concepts within an environment of shared understanding with others (Maeers, 1995). The succeeding section develops the literature pertinent to understanding the problem of learning and teaching mathematics.

Background on Beliefs about Mathematics Teaching and Learning

Many researchers have documented characteristic features of teachers' beliefs. Some of these studies focused on the beliefs professed by novice teachers while others studied their expert counterparts.

Brown and Borko (1994) examined the research on the process of becoming a teacher, focusing on the individual and the changes he or she undergoes in assuming the role of a professional teacher. Working under the assumptions: (1) that good mathematics teaching can be identified and described; (2) that becoming a mathematics teacher includes both generic and subject matter specific components; and, (3) that becoming a teacher is a life-long process, Brown and

Borko underscored the importance of strong preparation in one's content area prior to student teaching. For example, preservice teachers should, according to Brown and Borko, be required to obtain a B.Sc. or B.A. in mathematics before enrolling in a teacher training program. They further noted that without adequate content knowledge, student teachers are likely to spend most of their limited planning time learning, rather than planning how to present the content to facilitate the student's understanding. Their study further suggested that preservice teachers without adequate content knowledge are likely to lack confidence in their ability to teach well. This lack of confidence is attributable to the kind of experiences that the preservice teachers had prior to teacher education.

Experiences prior to or during teacher education occur within events that lead to different kinds of learning. The nature of some of these events may be personally meaningful and may lead to meaningful learning. But the significance of an event according to Owens (1988), is not measured solely in terms of its nature or frequency. Rather, the meaningfulness must be considered in relation to the individual's perception of the nature and importance of the event. As far as this study is concerned, the recalled experiences of preservice teachers will be used to infer the preservice teachers' beliefs about mathematics teaching and learning.

Some studies on teaching and teacher education have focused on teacher behaviour as opposed to teacher cognition (Thompson, 1984). Some researchers (Fennema & Franke, 1994; MacKay & Marland, 1978; Clark & Peterson, 1976)

working on teachers' thoughts and actions during instruction, have discussed teachers' behaviour in terms of instincts and intuition. Thompson (1984), on the other hand, argues that insofar as teachers' behaviour is rational, it is reasonable to assume that their conceptions of the subject matter and its teaching will have some bearing on their actions. And these actions are what determine the direction in which learning occurs in the classroom. She also claims that it is worthwhile for teachers to examine their conceptions because of the potential influence that these might have in the formation of behaviour patterns which may become habituated. Research on teaching and teacher education in mathematics has also reiterated the importance of examining these conceptions.

In empirical studies conducted with high school students about their mathematical beliefs and how this affected their mathematical performance, Schoenfeld (1985) noted that the students did not only consider mathematics to be an objective discipline that can be mastered but they also believed that mathematics is a discipline mostly to be memorized. Such experiences, according to Schoenfeld, are apparent in teachers' ways of presenting mathematics which stress the importance of understanding and the utility of mathematics but unfortunately provide students with little experience of either.

These empirical studies also indicate that teachers' rhetoric of this kind is usually ignored when the students engage in mathematical tasks that call for the exploitation of the results of formal mathematics. The manner of presentation of

mathematics to children, especially children with average or low ability, gives them a view of mathematics as a 'knowing that' and 'knowing how' discipline where coming up with the right answer to a problem is all that is required (Miller, Malone, and Kandl, 1992).

Nespor (1987), revealed that teachers often have well formed opinions of the value of different components of course content and that these attitudes influence how they teach the content. As a result, students develop strong beliefs about mathematics and how best it can be studied. Such early experiences remain with students and help to shape their mathematical beliefs and conceptions and consequently their mathematical behaviour when they enter teacher education programs.

Research on mathematics learning from Kindergarten through to Grade 12 (Schoenfeld, 1985) shows that students' understanding and beliefs about the nature of mathematics play a major role in shaping their experiences with mathematics. This could be explained in terms of how the teachers interact with individual students and how the various teachers presented mathematics to the students.

In a study of preservice elementary teachers' beliefs about mathematics and mathematics teaching, Collier (1972) used Likert scales to measure the beliefs of prospective teachers at different stages of their preparation program. Collier found that prospective teachers nearing the end of the program had more informal and less ambivalent views about mathematics and mathematics teaching than teachers

beginning the program. Also, prospective teachers who had been identified as high-achievers viewed mathematics as less rigorous and had less ambivalent views of mathematics instruction than the low-achievers. Though the results of this study indicated a slight positive progression in the beliefs of the teachers toward an informal view of mathematics and mathematics instruction as they went through the program, the following recent studies show that this is an exception.

A study conducted by Miller, Malone and Kandl (1992), on secondary mathematics teachers' perceptions of the meaning of understanding in mathematics explored the perceptions of understanding held by three secondary mathematics teachers' in Perth, Western Australia. They investigated how these three teachers assisted their students in achieving mathematical understanding. The researchers observed that the approach the teachers took towards helping their students understand the mathematics being studied varied with the teachers' perceived needs to exercise control of the students' behaviours. This study also suggested that there exists a mismatch between the perception of understanding held by some secondary mathematics teachers and the meaning of understanding promoted by some professional groups in the United States, the United Kingdom and Australia. This study also claims that most students learning mathematics believe that examinations are the main reasons for studying mathematics. The students therefore learned by rote memory.

Hamm and Langbort (1991), in their study entitled "Basic Math Knowledge

and Prospective Elementary Teachers", examined how well preservice teachers understand mathematics concepts included in the elementary school curriculum. After administering a mathematics test to 180 preservice teachers in a mathematics methods course which included concepts drawn from grades five and six textbooks, they found that the preservice teachers were lacking in conceptual knowledge in most of the areas which they were to teach after graduating from the teacher training program. This study, as well as studies conducted by Smith and Shepard (1988) and Fennema and Franke (1994), show that the preservice teachers' ambivalent feelings about mathematics are often communicated to the children they teach, thus allowing for various categories of beliefs about the subject and how it can best be learned.

Elementary school teachers are often considered generalists because of the variety of school subjects or disciplines they will be required to teach. Hamm and Langbort (1991), found that preservice elementary teachers spend most of their time studying new approaches, pedagogical knowledge and principles of the various disciplines they will be teaching, leaving little or no time to acquire more knowledge of the content of each subject. This led Hamm and Langbort to claim that some elementary teachers are lacking in conceptual knowledge in most subject areas, including mathematics.

To some teachers and teacher educators, the amount of subject content knowledge may not be a critical concern, but there are others who believe that a

sound knowledge of the content and of the associated pedagogical principles are essential qualities of teaching which teachers should be entitled to possess. Research in this direction has not been encouraging. Peterson, Fennema, and Carpenter (1989) carried out a study of an "expert" first grade teacher who professed to have a rich knowledge in addition and subtraction, but not fractions. They observed that not only were the "expert's" methods of instruction for addition and subtraction different from those for fractions, the classroom discourse was different when fractions were the context of problem solving. There was less discussion and less mathematics occurring during lessons involving fractions than during problem solving involving addition and subtraction. Teachers' beliefs and knowledge undoubtedly influence classroom practice by acting as a gatekeeper through which teachers interpret and ascribe meanings to their experiences as they interact with children and the subject matter. This study, and others (Shavelson & Stern, 1981; Thompson, 1985) reinforce the proposition that teachers' views and preferences about the subject matter and its teaching play an important role in their effectiveness as primary mediators between subject content and the learners.

In another study on teachers' conceptions of mathematics, Thompson (1984) investigated the relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. This study revealed that many factors appear to interact with the teachers' beliefs and conceptions of mathematics and its teaching in affecting their decisions and behaviour, including beliefs about

teaching that are general and not specific to the teaching of mathematics. As a result. some inconsistencies between teachers' professed beliefs and practices may also be viewed as manifestations of espoused teaching ideals that cannot be realized because the teachers do not possess the skills and knowledge necessary to implement them. This study also showed that not only do teachers hold beliefs about the subject they teach, they also have conceptions about their students and the social and emotional make-up of their class. And for some teachers, the study revealed, these conceptions are likely to take precedence over other views and beliefs specific to the teaching of mathematics.

While there is some evidence that the mathematical content knowledge of teachers, particularly elementary and middle school teachers, is not very good, (Brown, Cooney, & Jones, 1990; Post, Harel, Behr, & Lesh, 1991) there is little evidence to support assumptions of a clear relationship between teachers' knowledge of mathematics and student learning (School Mathematics Study Group, 1972; Eisenberg, 1977; Begle, 1979; Erickson, 1986).

Thompson (1993) maintains that looking at research on mathematics teachers' beliefs and conceptions in isolation from research on mathematics teachers' knowledge will necessarily result in an incomplete picture. This is because the mathematical content and teaching methods experienced by many (preservice) teachers during the student years influence their perceptions and practices as teachers of mathematics. This is even more so with elementary

mathematics teachers who teach other subjects besides mathematics and so distribute their preparation time among the other disciplines. This renewed way of looking at research on mathematics teaching falls in line with the following quotation by Hersh (1986):

> One's conception of what mathematics is affects one's conception of how it should be presented. One's manner of presenting it is an indication of what one believes to be most essential in it.... The issue, then, is not, What is the best way to teach? but, What is mathematics really all about? (p.13).

In a theoretical paper based partly on empirical findings of studies of mathematics teachers' beliefs, Ernest (1988) noted that among the many key elements that influence the practice of mathematics teaching, three are most notable:

1. The teacher's mental contents or schemata, particularly the system of beliefs concerning mathematics and its teaching and learning;
2. The social context of the teaching situation, particularly the constraints and opportunities it provides; and,
3. The teacher's level of thought processes and reflection (p.1).

The above key elements noted by Ernest seem to corroborate the claims made by Thompson (1994) that teachers beliefs are not connected in any simple way to instructional behaviours.

Summary

Though all the above studies differ in both the design of the studies and their interpretation of the array of preservice teachers' beliefs and conceptions, yet all agree that preservice teachers' attitudes influence their instructional practice. The preservice teachers' "conceptual representations" are formed through learning experiences in which they interpret events of the present through those of the past. Therefore, prior school experiences form part of a larger set of events that are important factors in the preservice teacher's development.

The literature review suggests that changing entrance requirements to teacher education is one of many steps towards understanding problems in making positive changes in mathematics teaching and learning. We have seen that a "good" teacher education programme does not necessarily result in the graduation of teachers who are equipped with the knowledge and skills to change mathematics teaching and learning. Before we try to reform teacher education (by adding more content, or changing the methods used by preservice teachers), it seems logical to try to understand better the beliefs which student teachers hold. It would be better to look at preservice teachers who are undergoing a teacher education process in order to become aware of their experiences with mathematics and the beliefs which have emerged from those experiences.

The next chapter outlines the data collection procedures employed in this study to explore these beliefs. Some background information about the preservice teachers will also be presented to help us understand how their beliefs may have been constructed and how these beliefs may be transformed.

CHAPTER 3

METHODOLOGY

Introduction

This chapter presents an overview of the research methodology including a description of the design of the study, the participants, the data collection procedures, and the instruments used to obtain these data.

The purpose of this study was to describe and interpret some preservice elementary teachers' espoused beliefs about mathematics learning and teaching. The methodology used in this research project made use of qualitative research data collection procedures. This methodology, similar to that used by Thompson (1984), combined filed data from questionnaires on the preservice teachers' mathematical histories with in-depth interviews about their experiences with mathematics and mathematics learning and teaching as student teachers and as prospective elementary mathematics teachers.

According to Munby (1982), to study a preservice teacher's beliefs and conceptions requires judicious choice of the context in which these beliefs are explored. Munby recommends the interview method for learning about a preservice teacher's beliefs and conceptions rather than the traditional classroom observation because it provides a sort of distance from immediate and particular classroom incidents and appears conducive to broadening the domain of inquiry. These interviews need to be extensive in their coverage so that there are opportunities for

all relevant contextual pieces to emerge. This use of the interview method is further supported by Thompson (1984) who argues that if teachers' characteristic patterns of behaviour are a function of their views, beliefs, and preferences about the subject matter and its teaching, then any attempt to improve the quality of mathematics teaching must begin with an understanding of the conceptions held by the preservice teachers. Even if the preservice teachers' behaviour is mostly reflexive and spontaneous, Thompson continues, it remains worthwhile to examine their conceptions because of the potential influence that these might have in the preservice teachers' professional formation.

Another study (Stonewater & Oprea, 1988) suggests that the use of interviews and mathematical histories to report on preservice teachers' beliefs and conceptions during their teacher education program will provide information that reflects their experiences as students and as prospective teachers at a time when their experiences as teachers in a classroom environment are limited.

Prior to collection of data for this study, an application for approval of the research was submitted to the Human Research Ethics Review Committee of the University of Regina in September, 1995. A description of the study, the methods and the procedures to be used to gather the information from the participants was provided, and the purposes for which the information would be used were outlined. A copy of the letter of permission from the preservice teachers to use archived data of their mathematical histories collected before the study was begun was appended

to the application. The approval of the research by the Human Ethics Review Committee was granted in October, 1995 (see Appendix A). Following the approval of the study by the Research Ethics Review Committee of the University of Regina, the preservice teachers were contacted by telephone, and a meeting was established at a time and milieu convenient to the preservice teachers. This meeting was intended to brief the preservice teachers about the purpose of the study and about how the data would be collected. It was clearly stated in the letter of permission that the preservice teachers' voluntary participation in the study included the release of filed data of their mathematical histories collected by their mathematics methods instructor some time during their mathematics methods course.

In a manner similar to that used by a number of researchers on teaching (Munby, 1982; Olson, 1981; Smith & Shepard, 1988), the teachers' beliefs were elicited inductively. The belief interviews used an adaptation of the heuristic elicitation technique, developed by anthropologists to determine belief systems in groups of people. Within this framework, beliefs consist of a set of assertions held by informants and realized in natural language as declarative sentences. This methodology uses both open-ended questions to construct the informants' propositions about the world and closed-ended questions to establish the interviewer's understanding of the response.

Participants

One male and two female prospective elementary mathematics teachers enrolled in a variety of teacher preparation classes at the Faculty of Education of the University of Regina, Saskatchewan, Canada volunteered to participate at the outset of this study. There were no specific criteria used in the selection of the preservice teachers other than the fact that they were prospective elementary teachers and were willing to participate in the study. All three prospective participants were beginning their sixteen-week internship experience (see Appendix C for an outline of the four year elementary B.Ed. Program at the University of Regina). The male teacher, however, quickly became very involved during his internship in teaching mathematics and this experience was determined to influence the validity of the study. Thus, the study proceeded with the two female preservice teachers who were interning but had not yet taught mathematics.

The two preservice teachers, Jeanne and Tracy (pseudonyms), both entered the Faculty of Education in the same year. They took courses in education, arts and science. The arts and science courses were offered outside the Faculty of Education. During their fourth semester in the Faculty of Education, they took their first mathematics methods course (See Appendix C for an outline of the four year elementary B.Ed. program at the University of Regina). In this course they had the opportunity to express their personal experiences with mathematics as students by

responding to a questionnaire prepared by their mathematics methods instructor. Their professor, with their permission, archived information provided on the questionnaire. Jeanne and Tracy were aware that the data might be used for other research studies by their professor or her graduate students. Although the initial intention of this data, according to the professor, was to understand the different mathematics backgrounds that all these preservice teachers had, it was also intended to make the course more valuable to the preservice teachers by helping them develop professional skills that they will need in the future. This data, with permission from the mathematics education professor and the preservice teachers, became available to the researcher.

That same semester, Tracy and Jeanne became involved in a number of professional activities such as the Saskatchewan Science and Mathematics Student Teachers Society (SSMSTS) at the Faculty of Education of the University of Regina. The SSMSTS is a society made up of science and mathematics preservice teachers. Jeanne and Tracy also participated in the Western Canadian Association of Student Teaching (WESTCAST) meeting in which they made presentations.

As a result of their active participation in the SSMSTS, Jeanne and Tracy were voted to the executive of the SSMSTS for the next academic year. During this academic year, in their fifth semester of university, they did not take any mathematics methods courses. They continued with their active participation in the SSMSTS, making presentations at workshops within and outside the faculty. In this

semester they had the opportunity to put some of their skills to use when they went into schools to work in classrooms with teachers and children (see appendix C for the elementary program). They taught lessons not only in mathematics but in other disciplines. They either taught in pairs, or alone. Tracy and Jeanne did their pre-internship in different elementary schools.

During the sixth semester (after pre-internship), Tracy and Jeanne both took another mathematics methods course. This course, like the previous one, was geared towards providing opportunities for these preservice teachers to develop the knowledge, skills and confidence they needed. In this course they focused on middle grades (grades 5 - 8) mathematics teaching and their continuous professional development. These two preservice teachers published compendiums, presented at SSMSTS workshops, and presented at a Regional meeting of the National Council for Teachers of Mathematics (NCTM).

In their seventh semester, Tracy and Jeanne, while in internship, a sixteen week period in schools, attended and presented in a "sciematics" workshop. This workshop involved both science and mathematics preservice and inservice teachers within the province of Saskatchewan. It was at the beginning of this semester that Jeanne and Tracy were contacted for this study and were informed of the study and its purpose. In their filed data, Jeanne and Tracy, at the beginning of their teacher training, presented feelings and attitudes (which were to prove of interest), of being anxious about and lacking confidence in, learning and teaching mathematics.

Data Collection Procedures

The data collection that was used in this research project was similar to that used by Thompson (1984). This study combined filed data from questionnaires on the preservice teachers' mathematical histories with in-depth interviews on their experiences with mathematics as students and as prospective mathematics teachers. The data collection, analysis and interpretation was done through qualitative methods.

The general plan for conducting the study was to hold two interview sessions, each lasting one hour with each preservice teacher. The data collection process was divided into two phases. Phase one data was the filed data containing the mathematical histories of the preservice teachers. This data had been collected by their mathematics methods instructor with the use of two questionnaires: one administered at the beginning of their mathematics methods course and one at the end of that course. Tracy and Jeanne agreed that the information they provided on the questionnaire could be used in the future for any research-related activity so long as they could not be identified. Although this questionnaire was administered with the aim of helping these preservice teachers reflect on their experiences and make more meaning out their learning activities in the course, the questions also elicited information about their beliefs and their conceptions of mathematics. The questions focused on the preservice teachers' experiences with mathematics, what mathematics is all about and how mathematics is learned (see Appendix B for a

complete questionnaire). In order that the two questionnaires could be compared at the end of the mathematics method course, the preservice teachers were advised to include their names on the questionnaire. This data was then filed by the instructor and was released to the researcher following the preservice teachers' permission and willingness to participate in the study.

Phase two data collection consisted of interviews to follow-up the information given in the personal mathematical histories of these preservice teachers. The interviews were of two types: focused interviews for eliciting the preservice teachers' reaction to scenarios of mathematics classrooms during their years as students learning mathematics, some of which had been expressed in the questionnaires they had responded to; and open-ended discussions aimed at developing an understanding of the preservice teachers' beliefs and conceptions of mathematics and its teaching. At this stage, the preservice teachers were in their early stages of their internship and it was decided that interviews would take place out of their classrooms. This was because the focus was to explore the professed beliefs and conceptions about mathematics learning and teaching that these preservice teachers lived with during their teacher education program not on their experience in practice teaching.

The methodology employed in the interviews of this study involved questions structured to the specific characteristics of the preservice teachers' experiences, as outlined in their mathematical histories. While initial questions were general and

open-ended, further probing was tailored to the individuals according to their feedback to the general questions.

The first interview session focused on the two questionnaires during which the preservice teachers were specifically directed to reflect on their first methods course in elementary mathematics. Each of the two preservice teachers, in turn, addressed each question, while the interviewer maintained the conversation through probing, paraphrasing, and appropriate interjection. This procedure was followed until all the questions were addressed. This session lasted approximately one and a half hours.

At the end of the first interview session, the data was transcribed by the researcher and tentative hypotheses and inferences were made from them. These were further explored in the second interview which was also audio-taped and transcribed by the researcher. The second interview session took place five days later. This five day time gap was to allow for some analysis and reflection on the first interview by the researcher and to plan for the next.

Questions for the second interview session focused on the second mathematics methods course, and Jeanne and Tracy's involvement in professional development activities during their teacher education. Here, three open-ended questions were asked and probing was used to elicit further information. These questions were: (1) What made you want to become a teacher? (2) Why did you choose elementary grades to teach? (3) What does it mean to you to be a teacher?

These questions were posed following the same procedure as in the first interview session.

The interviews were conducted with both preservice teachers present, rather than individually. The joint interview created a conversational setting in which recall of a classroom incident in turn helped each of the preservice teachers in recalling further individual experiences and events and thus enabled each to more fully explore their beliefs. By adopting this approach it was possible to weave some of the issues raised in the filed data into the interviews so that the issues lend appropriate context to the collection, analysis and interpretation of the data. Also, when analyzing the data, it was then possible to say "they" where the two preservice teachers seemed to share a similar experience.

Summary

This study is based on interviews and filed data analyzed to provide a description of two preservice elementary teachers' beliefs about mathematics, and its teaching and learning. The methodology was derived from suggestions and recommendations of similar studies previously conducted.

The next chapter provides an interpretation of the findings from the filed data and interview sessions of each of the preservice teacher's beliefs and conceptions of mathematics and its teaching and learning. The results are presented as responses to the three research questions which framed the study.

CHAPTER 4

PRESENTATION OF FINDINGS: TRACY AND JEANNE'S BELIEFS

Introduction

The purpose of this study is to explore three questions: (1) What are the beliefs and conceptions that preservice elementary teachers have about mathematics and mathematics learning and teaching prior to teacher education? (2) How are these beliefs and conceptions transformed during teacher education? (3) What major "events" or "situations" occasioned this transformation? As is often the case with qualitative research designs, it is virtually impossible to present all the raw data collected from the questionnaires and interview sessions (Miller, Malone, & Kandl, 1992). Responses to each question are reported using both particular and general descriptions within the framework of interpretive commentary (Erickson, 1986). Probing questions seeking for further information relevant to the three broad questions were used in the interviews and the responses to these are grouped according to how they seemed to answer the three major questions.

To keep the analysis of the data within context, responses to the above three questions are reported under two main sections: school (Kindergarten through Grade 12) experiences with mathematics, and experiences with mathematics during teacher education at the University of Regina. The first section discusses the first of the three major questions "What are the beliefs and conceptions about mathematics that these preservice elementary teachers bring to teacher education

programs?" The second section discusses "How are these beliefs and conceptions transformed during teacher education?" and "What major "events" or "situations" occasioned this transformation?"

School Experiences with Mathematics

This section describes Tracy and Jeanne's responses to open-ended, specific, and probing questions that addressed the general question: What are the beliefs and conceptions that preservice elementary teachers have about mathematics and mathematics teaching and learning prior to a teacher education program?

Responses were grouped into the following four categories:

- the effect of their teachers' interactions with Tracy and Jeanne;
- the effect of their teachers' presentation of mathematics on Tracy and Jeanne;
- Tracy and Jeanne's confidence as learners (of mathematics);
- Tracy and Jeanne's intuitive and constructed beliefs about mathematics.

Each of these above categories will now be discussed in depth.

The Effect of their Teachers' Interactions on Tracy and Jeanne

Tracy's years as a student (of mathematics) in Kindergarten to Grade 12 were characterized by a number of positive and negative experiences some of which are summarized below. When asked to talk about the interaction of her

mathematics teachers with the students of her class, she had this to say:

> I had excellent teachers in grades 5, 6, 7, & 8 and they, I think, when I look back, they made the difference for me now. They created a lot of opportunities that I don't think I would have had otherwise. They really pushed me and you know, sometimes very bright pupils, or very energetic pupils, if they are not pushed, they won't, ... and they just don't put in the effort. These two teachers were very excellent. They made us work very hard and they gave us (or me) very good work.

Teachers' views and preferences about a particular subject matter and how it should be taught play an important role in the teachers' effectiveness as primary mediators between subject matter and the learners. The teacher's interaction with the students is dependent on the preferences and views about teaching and learning held by that teacher. Tracy's teachers in the middle grades (grades 5 - 8) obviously believed that students could learn more when placed in environments that were not only demanding but challenging. This was a favourable environment to Tracy's learning styles.

In their response to a question asking them to describe an outstanding teacher they each had, the preservice teachers volunteered information about how their current work as preservice teachers was affected by the teaching they received. To Tracy, it was more the *persona* of her teacher that influenced her learning than how the actual teaching process was conducted. As Tracy comments;

> There is one teacher whom I admire up till today. Though he was not very strict but he was very firm and very fair. He set the rules with the class and you knew in one way or the other when you had stepped over it. And I respect that in people, you know, to do what you believe in.

When Jeanne was asked the same question, her response was very similar to that of Tracy. Here is her response:

> I had certain teachers that I admired not because they were teachers. Like my grade 8 teacher and she was pretty good. She did a lot of motivation and encouraged the students to try out things in order to be successful. I also had an excellent grade 12 teacher who always seemed to recognize and respond to the needs of individual students.

Jeanne's admiration of her grades 8 and 12 teachers because they encouraged and responded to individual needs of students may lead one to infer that Jeanne did not receive all the attention she wanted during her school years. Growing up in a home where her parents were teachers might have led her to assume that teachers were supposed to behave in a similar way as did her parents to her. As the following remarks show, she simply regarded her teachers as "teachers who knew their job".

> Though she was good, I simply considered her as just another teacher who knew her job. I did not admire her as a teacher because my parents are also teachers and I had always considered what they did and how they did it as part of their job.

From these accounts, there is little doubt that Jeanne's interactions with her (mathematics) teachers were very different from Tracy's. Whether or not these differences contributed to their learning (of mathematics) can only be hypothesized. Nevertheless, some of these differences will be discussed in the next chapter with a view to suggesting them as ideas worth considering in the context of teacher interaction with individual students. Teachers interact not only with students in terms of students' academic and social diversity, but they also interact with the subject matter, often acting as learning facilitators (Fennema & Franke, 1994). The next section presents some of these interactions as the (mathematics) teachers presented mathematics to the students.

The Effect of their Teachers' Presentation of Mathematics on Tracy and Jeanne

The role played by subject-matter knowledge in teaching is more complicated than one would imagine. A teacher's knowledge of the concept of addition in elementary grades mathematics does not alone dictate what he or she chooses to teach. This knowledge must be organized in a particular way (Fennema & Franke, 1994). Teaching mathematics to elementary grades students melds subject-matter

knowledge with a host of other understandings - knowledge of students, of learning and teaching, of schools, of curriculum and of educational aims. What teachers know about elementary grades mathematics influences not only what they choose to teach but also how they choose to teach it (Shavelson & Stern, 1981; Thompson, 1985; Hersh, 1986; Thompson, 1994). Following are accounts by Jeanne and Tracy of how their mathematics teachers presented mathematics to them during their years as students:

Jeanne

> I don't really remember much until grades seven and eight. Mathematics to me was just like ... all you did was just do questions in a textbook, ... you just memorized them when studying for a test. It was no big deal, ... everyday it was the same thing. You learned the new stuff, you did the new exercises, you corrected it, and the next day you did the same thing all over again.

Some teachers look at mathematics only from one perspective and are unable to see and demonstrate patterns, connections and interrelations within the subject's content. Consequently, as Hamm and Langbort (1991), Smith and Shepard (1988), Fennema and Franke (1994) maintain, teachers' ambivalent views are often communicated to students through teaching and exercising control of the

subject matter. This may affect the way the students grasp mathematics concepts as Tracy experienced.

Tracy

> You know some teachers one year they show you how to do it (the approach to solve a problem) and the next teacher shows you a different way to do it, and even though they don't make the connection for you, ... they just insist that their way is *the* way and makes you feel like you don't know how to do it. Whereas you do know how to.

When a teacher is assigned to teach a subject he or she is not trained for, in most cases, the presentation of the subject is text-driven. As Hechinger (1985), claims, "unqualified teachers, i.e., misassigned teachers, lean heavily on textbooks that often provide a watered-down version of the subject" (p.2). The testimony of Tracy is an instance of this phenomenon of teacher "misassignment". Also, for teachers with a conceptually weak understanding of a subject, the presentation of that subject becomes text-driven, and taught in a rule-based right-answer approach (Ringstaff, 1987). As Tracy claims,

> I think it was because of the (mathematics) structure. Our mathematics teacher was a physical education teacher who didn't really have time. This was just like his subject that he had to teach and he didn't really teach it. He just sort of led it.

Tracy and Jeanne's Confidence as Learners (of Mathematics)

No matter how much subject content knowledge a teacher tries to impart to students, no matter how much the students seem to understand, if the students' confidence in themselves as learners is absent or not encouraged, the teaching and learning process will be ineffective. Within the discipline of mathematics, as is also the case with other disciplines, if students are not taught to build confidence in their learning process, a problem in mathematics which they could easily solve could become a nightmare to them. As Schoenfeld (1985) noted in his study of high school students beliefs about mathematics and the effect these beliefs had on their mathematical performance, the students learned mathematics mostly by rote. In this study, Jeanne and Tracy were asked to recount their experiences as students of mathematics.

Jeanne

> I think at some point I didn't like mathematics, I know I didn't like mathematics and then at a later point when I got enticed with it I began to be afraid of it (mathematics). Like I didn't feel confident, I didn't think I was good at it. So not only did I not like it but I thought I was not good at it. So then I thought I hated it and like I did, I hated it in the high school. ... I think partly because of the teacher that we had.

Jeanne's confidence as a learner of mathematics was not encouraged and as a result, she developed fear and hatred in the subject, an experience that haunts her still as we will see in the next section. Jeanne's mathematics teachers were either not aware of Jeanne's situation or didn't have an understanding of Jeanne's learning style in mathematics. Tracy, on the other hand, had a different experience when it came to learning mathematics. Not only was Tracy's morale in mathematics high, her confidence had been reinforced by her mathematics teachers. This led to her subsequent success in the subject.

Tracy

> In the high school I took all the algebras, geo-trig 10,11,12 and calculus which I took in grade 12. And so for me, it wasn't as much hating it, ..., it was expected of you, so you didn't really have a choice. You just had to take it and I did well and could understand the concepts because I am one of these sort of, I see an example and I do the rest as that same example. It's not necessarily that I know how to do it, it's just that I know the pattern and that was easy for me to pick up and you could just recite through it.

While Tracy was able to observe some patterns among the mathematical procedures used by her mathematics teachers in elementary and secondary school, from which she developed confidence in mathematics, Jeanne, on the other hand,

was never able to see any patterns or connections in the procedures. As she continues to claim, each mathematics question was always a new challenge to her.

Jeanne

> To me, I don't have that concept of ... when you are looking at a mathematics question you do it the same as the other ones, like I can't figure that out. I am not good at it. Like for me, each question is like a new challenge, it's like Oh my God, what will I do with this one!

The above account indicate that Jeanne did not learn mathematics in a "relational" way (Skemp, 1989). It would seem that mathematics was presented to her in a way that she found difficult to relate the various mathematical concepts.

Tracy and Jeanne's Intuitive and Constructed Beliefs about Mathematics

It appears as though the teachers that Tracy and Jeanne had for mathematics shaped their beliefs and preconceptions, and therefore their understanding of mathematics, through the manner in which mathematics was presented to each of them. While Tracy often found success in mathematics, her beliefs about the nature of mathematics and its teaching continued to be strongly negative. This means that even success in mathematics did not change her

negative feelings about the nature of mathematics. This is interesting as one is often tempted to believe that success in learning, especially mathematics, results in interest and liking of the subject. Tracy's remarks in the interviews indicated that she regarded "mathematics" as a very technical word referring to a patterned and methodical subject (NCTM, 1989). She admitted that she rarely thought about mathematics concepts and rarely understood why things were done the way they were.

Tracy:

> I am that sort of, I see an example and I do the rest as that same example. It is not necessarily that I know how to do it, it's just that I know the pattern and that was easy enough for me to pick up and you could just recite through it.

Tracy clearly held certain seemingly incompatible views of mathematics, evidently as a result of her experiences in the study of the subject. One was a positive view that seemed to have been influenced by favourable experience with her school mathematics. Her teachers presented mathematics to her in a very "technical" manner through which she learned simply by following and matching the pattern used in solving a problem. The other view was related to her experience with mathematics in the middle years. When she was in grade 7, she was placed in an accelerated program and thus covered grades 8 and 9 mathematics while in

grade 7. This experience, instead of helping her develop a great interest and confidence in the study of mathematics, appeared to have caused Tracy to look at mathematics differently. From then on, mathematics to Tracy became a "hoop" that she had to go through, "a necessary evil or gatekeeper that had to be passed to reach the better things in life".

During Jeanne's years as a mathematics student, she regarded mathematics as a mechanical discipline that was different from the other school disciplines. To her, in the following quote, mathematics was different from algebra since according to her beliefs, algebra was like a different subject with a different level of thought:

Jeanne:

> Mathematics, unlike other subjects such as the social sciences, there is no 'what do you think', 'give your answer', 'what can you relate to the story?', etc. Mathematics often carries the connotation of problem solving with very unrelated symbols. As such, learning algebra in the high school was very scary and lamenting, unlike learning geo-trig which seemed very straight forward. Even teaching algebra now is still a little frightening.

To Jeanne, each mathematics example was a new challenge. She rarely saw any interrelatedness. To her, proofs in geometry and trigonometry were not difficult. The pattern could easily be found because it was verbalized rather than

figurative and formulaic. She also confessed to not having admired any of her teachers. To Jeanne, not only was the subject of mathematics different from the other disciplines, the mathematics teachers were not the same as the other teachers. In Jeanne's own words, they were really "hard liners". Jeanne is probably looking at mathematics as a complex and abstract subject which is only understood by a selected few (the gifted) like the teachers.

Jeanne's struggle with school mathematics shaped her intuitive notions about mathematics and culminated in her identification of two worlds of mathematics: mathematics in the real world and mathematics as a subject. Real world mathematics involved everyday use of mathematics concepts such as addition, subtraction, multiplication and division in the context of everyday activities.

Jeanne:

> It is called money, you know, making money to buy your Curriculum Vitae, all those kinds of things. Not getting any trouble with mum and dad, or even whatever it is, it's just living. It is not ... find the dimensions of... .

In the classroom, mathematics was a subject. Though Jeanne had used mathematics skills in her high school years while working as a cashier in a retail store, she didn't see that as an application of what she was learning in school. Nonetheless, she could do that without any problems. To her, it was just a skill that

everyone growing into the adult world had to know without being taught. She could do all these basic manipulations and calculations without any difficulties. She never stopped to think that this was learned mathematics knowledge that she was applying. This is similar to the candy sellers in Brazil who, according to Saxe (1991), saw no connection between the advanced mathematical calculations necessary for buying and selling candy on the streets and similar calculations taught within the framework of formal school mathematics. Also in a similar vein, Ginsburg and Allardice (1984) report that the lived experience of mathematical learning or ethno-mathematical knowledge (d'Ambrosio, 1985) is often not related to the formal mathematics taught in schools. Many students like Jeanne see the two as unconnected.

Jeanne:

> For me, looking at mathematics in the real world was different because I had worked in a retail store all through high school and to me, making change wasn't a problem. I could make change in my head, I don't need a calculator, I don't need a tool. I could count back, up and down from a dollar, five dollars, ten dollars, fifty dollars, etc, and there is no problem. But that's a skill. I just learn it and I practice it and I am good at it. But this wasn't math. No. You know, when we go shopping for groceries and we've got to spend one hundred dollars, and I am adding in my head seven

> percent tax, eighteen percent interest, I have this much money coming in and I can pay over this period of time, all that kind of stuff. Because it wasn't math, it was like a skill. Like you had to learn how to do that kind of stuff to be a grown-up, to be an adult, because that's what adults do. You balance your cheque book, you know, all those kinds of things.

Tracy's primary concern appeared to be restricted to the realm of the school. She was most concerned with grades, and it is this that appeared to motivate her as evident in the following remarks:

Tracy:

> There is concern about marks in every subject, but this one(mathematics) in particular because it was harder. You know, in other subjects like English, social studies, or whatever, you could just write anything and marks were not an initial concern, that came afterwards. Also, when you have an average that is over ninety percent, you don't want to take a class that will bring that mark or average down. So that was the main concern.

Despite all these experiences with mathematical knowledge, Jeanne, more than Tracy, developed a dislike of mathematics much of which centred around her perception that mathematics taught in the schools had no real life application. Tracy's reasons for her fear and dislike of mathematics centred more on her

performance in the subject in relation to other subjects. She excelled in the other subjects and was afraid her performance in mathematics was going to be a major impediment to an excellent overall performance. Tracy and Jeanne's learning of mathematics did not end at the school level. In the university, a mathematics course was one of the requirements in teacher education. The next section presents Tracy's and Jeanne's experiences with mathematics at the university level.

Experiences with Mathematics during Teacher Education

Introduction

From the preservice teachers' experiences with mathematics during Kindergarten to grade 12 student years it is obvious that the way their teachers treated them as individuals, the manner in which mathematics was presented to them, and the way their teachers treated mathematics, had in one way or another affected their confidence as learners (especially of mathematics). As a result, by the time these students graduated from high school they had acquired various sets of beliefs about the nature of mathematics and about themselves as learners of mathematics. These beliefs were brought with them into their teacher education. The succeeding sections describe their experiences with mathematics as prospective elementary teachers.

University Mathematics Experiences

The teacher education program at the University of Regina is organized into components spread over eight semesters. These components include subject content courses and courses addressing pedagogical principles (See Appendix C). Jeanne and Tracy took a university mathematics course in their first semester as one of the requirements of the degree. When asked about their initial feelings and impressions about this university mathematics course Jeanne and Tracy had the following comments to make:

Tracy:

> Because it was the only mathematics class, sort of *arts mathematics* class that we had to take towards our degree, we didn't have to take calculus or advanced mathematics. We already knew by that time that it was not a very serious mathematics class, that it was an educational mathematics class and there were connotations there that it wasn't as difficult and which is true, I think. We basically did a lot of problem solving in the class.

Jeanne:

> I knew I was going into the middle years program and that I was going to teach mathematics. So I knew I had to take at least one mathematics class but not a lot. So to me, it was like taking another "hoop" you know, like just do it and move on. I didn't have much choice.

While Tracy saw this as a course not to be too worried about, as something she had to take anyway, on the other hand Jeanne saw it still as a gatekeeper for her to complete her education program.

This mathematics class to Jeanne was like revisiting her grade 12 experiences with mathematics. Mathematics continued to be a "hoop" that she had to go through to complete the program. She experienced difficulties in this class similar to those of her high school mathematics.

Jeanne:

> I had the same problems that I had in grade 12. I forgot lots of the stuff that I forgot in grade 12. It was very identical, ... but I was thankful to that though, because it was in calculus. You know, calculus was for smart students in mathematics I definitely was not smart enough. So it had to help if I had to take calculus. So in a way it was good but it was the same as grade 12.

Jeanne and Tracy interpreted their individual experiences with the university mathematics course in different ways. To Tracy, this mathematics course was just one of her requirements and she didn't really care for the course. She did it because she had to, and so spent little time on it. Jeanne, on the other hand, saw it as one 'last chance' to gain proficiency in the areas that she had had trouble understanding in her high school mathematics.

Methods Courses in Mathematics and other Areas of Study

Methods courses in mathematics were among the requirements that Tracy and Jeanne had to complete. The first methods course enabled students to experience learning mathematics concepts and learning mathematics teaching strategies. The mathematics methods classroom became an environment where students could take risks in both their learning and teaching of mathematics, share their ideas with others and develop individual and group projects to extend their ability to teach mathematics. As Tracy revealed, this class was one of the most interesting that she had taken in her program.

Tracy:

> I was sort of interested because I was hoping that it wouldn't be learning a whole bunch of content; it would be learning more how to approach it. And so because it was middle years, like ah!, we took middle years, we've done that mathematics.

The mathematics method course seemed to have a focus different from that of the university mathematics course. Tracy was quite relieved and excited, first because it was not going to be content-based, and secondly because she didn't want to be like her school mathematics teacher who was lacking in both content and pedagogical knowledge.

Tracy:

> I was actually excited about that. I wanted to know more because I didn't want to be like my mathematics teacher who just used the book. You don't need to be taught how to do that (use the textbook). You need to be taught how to do other things.

To Jeanne, this class was a completely new and exciting experience, especially as she realized that she would be using a familiar text, one which she had used when she was in the elementary grades. She overcame her fear and wanted to learn how to teach mathematics differently.

Jeanne:

> ... There was that sort of initial fear, but not too much. ... I was anticipating learning how to do it and I took that opportunity very seriously because I knew that I had this *attitude* about mathematics. And as a mathematics teacher, I knew that I could not have that attitude about mathematics in front of the class. And even if I did have that 'deep doubt about my own abilities', like that 'insecurity about my own personal abilities', I couldn't show that to the students because I needed to foster them, their abilities, and confidence in mathematics. This is also because I think that probably my confidence in mathematics was never fostered and that's why it decreased so much. So at least my main goal was to

> figure out ways to teach mathematics so it would *keep kids involved*, *keep kids finding success*, you know, *keep kids liking mathematics*, something different that I didn't have. But yet in a way, I also knew I had to take it seriously because I needed to cover the content, like I needed to be refreshed with the content, I didn't necessarily need to know all the content when we were at that level. Also, I had heard that it was a really good class, and that the instructor was really great and you made a lot of stuff, you know, that kind of thing. So I wasn't too worried about the work load and marks, like I wasn't worried about that kind of stuff, I was just worried about trying to get something out of it.

In the mathematics methods course, Jeanne was slowly developing a different feeling towards mathematics. Because it had been her greatest struggle in high school, she was determined not to let her students develop the kind of anxiety about mathematics that she had in the high school. So not only was the mathematics methods course a good one for Jeanne and Tracy, it opened up for them, a new way of thinking about mathematics. They both give credit to their mathematics methods instructor. To Tracy, this instructor demonstrated a strong conviction that what they were learning could actually work in a classroom setting. This was just the kind of convincing belief that Tracy needed to hear.

Tracy:

> When I heard from other people who had previously taken the class that this was a good class to take especially with this instructor attached to the class, I knew it would be a good class.

Also, Tracy strongly believed that one could not know everything, especially about mathematics, and she agreed that though mathematics was artificially presented in schools, mathematical knowledge is useful when applied to solve everyday problems in life.

Tracy:

> You cannot know everything before you start teaching, especially about mathematics. So worrying about the content should not be a major setback to training to be a teacher. Also, though mathematics is often artificial, mathematics knowledge is useful when applied to solve everyday situations.

Professional Experience and Social Interaction

The methods courses in mathematics acted as a re-awakening for Tracy and Jeanne as far as mathematics learning and teaching was concerned. To Tracy, mathematics had lost its value and the fun which should be involved in its learning. To her, the mathematics methods courses were just what she needed to re-

establish the long lacking interest. To Jeanne, it was much more than a "re-awakening", as she gradually found herself gaining satisfaction in learning mathematics. Not only were the methods courses in mathematics a great motivation for her, they had really helped in breaking the barrier that had long existed when it came to doing mathematics. She was gradually gaining confidence with mathematics and this led her to start thinking about new ways of presenting mathematics to her students in a manner that would encourage students to develop a liking for the subject.

It is worth thinking through some of the "events" that might have led to this sudden change of thinking about mathematics. In this connection, Tracy revealed that first and foremost, it was only in her mathematics methods class that students were advised to stop thinking about marks and to think of themselves as developing professionals, and to try and get the best out of the class in terms of pedagogical knowledge and pedagogical content knowledge. This was very helpful to Jeanne as she began to embrace a new way of thinking about, and a renewed interest in mathematics.

These preservice teachers had many other experiences during their teacher education. The most remarkable of all their professional experiences and social interactions was their involvement in student societies like the SSMSTS (Saskatchewan Science and Mathematics Student Teachers' Society) and other professional development opportunities such as conferences, workshops, and

exhibitions. Their involvement with the SSMSTS was strengthened by their being elected into top posts in the executive. Initially, Tracy and Jeanne had frowned at the politics that existed within the Education Students Society (E.S.S.) and had not wanted to get involved. But little did they know that they would still have to deal with the political reality of the SSMSTS by occupying executive positions. As Tracy and Jeanne confessed:

Tracy:

> We just wanted to be involved with the SSMSTS because we didn't want to be in the E.S.S. as it was thought to be too political and demanded much work and time.

Jeanne:

> We wanted something that was a little less work, but I am not sure that we got it.

As a result of their involvement in the SSMSTS Jeanne and Tracy developed professionally in the following ways:

- they acquired organizational skills through organizing and presenting at a NCTM conference that took place in Edmonton;
- they organized a science fair;
- they gained skills in accountability, something they believe should be encouraged in students;

- they published compendiums that resulted from their presentations at another workshop and from class projects;
- they made presentations not only in mathematics but in other subject areas as well;
- their professional development scope widened as they came into contact with a wide range of teachers and teacher educators;
- they acquired skills in publishing newsletters, something most student teachers would rarely do;
- they also gained a lot of content knowledge through projects, new contacts and conferences, and this helped increase their self-concept as prospective teachers.

Tracy and Jeanne acquired professional and socialization skills through their involvement in the SSMSTS. Their involvement gave them new ways of looking at teaching (e.g. constructivist teaching approach, enaction) and a strong interest in mathematics and mathematics teaching. Jeanne is now looking at mathematics teaching from a different perspective. She professes to being more interested in the processes of problem solving in mathematics than in arriving at the right solution. To Tracy, it has given her a new way of looking at students' differences in a mathematics classroom. All these experiences were enabled through the efforts of their mathematics methods instructor who believed in and encouraged the initiatives of the preservice teachers. Preservice teachers probably need to have this kind of motivation instilled in them.

Reasons for Pursuing a Teaching Career

The students were asked their reasons for entering the teaching profession. To Jeanne and Tracy, their former teachers did not play any significant role in their decision to become a teacher. Their responses to this question could be classified into themes such as: "interpersonal", "material benefits", "dignity of the profession", and "continuation" (Violato & Travis, 1990). The interpersonal theme refers to the opportunity to work with people while the material benefits theme refers to the high chances of securing a job together with the salary from which a high standard of living could be possible. The dignity of the profession theme refers to the high status accorded the teaching profession where a teacher is looked upon as one who is highly knowledgeable. The continuation theme refers to the desire to remain in a school environment.

To Jeanne, the interpersonal and continuation themes melded together. Her interest in the teaching profession came as a result of her working with children at a daycare center (play school). Her interest was caught by this particular age group and so she decided to remain within the school setting. Her interest in becoming a teacher was not vested in any particular subject but rather in the whole profession of teaching.

Jeanne

> Both my parents and grandparents were teachers, so I never thought I would be a teacher, I just didn't think I would. In fact I was pretty convinced that I would never

> be a teacher and I had all kinds of different aspirations right up till grade 12. And I got a job working with kids after school, and we did a great kind of developing program, and I really liked working with kids and so I changed my mind in the month of February and applied in March, got accepted in April and started in September. Ever since that point of working with kids, I have known that that's what I wanna do. Though early on, everyday I kept thinking twice, but I just said to myself that's what I was destined to do, and that's what I wanna do. It was like a big awakening, like it came to me and I just moved, like a moment of clarity and just said go. I mean, I knew I would get in, like deep down in me I just knew it.

To Tracy, the interpersonal theme was not her primary reason for becoming a teacher. Instead, her teaching career was rooted in her childhood. When Tracy was young, her propensity for the teaching profession became evident in a play school incident. So, to her, teaching was like a life-long dream come true. Teaching to her, was quite an honorable profession in her small rural community.

Tracy:

> When I was younger I can remember once we were teachers, we played "school", we had like sort of mini-classroom setup in our basements, all of us. We had sort of notebooks and we pretended that we were the

> teacher. And the *teacher was a big thing* in our community because I lived in a small town and that was sort of *the only profession that was there* and visible, and so it was sort of a status, though not really a status thing but you know, it's a *respectable job* to have. And I coached when I was in high school and I just knew, I thought that was something that I wanted to do.

Tracy's comments about her reasons for entering the teaching profession seem to fall along two themes: the "dignity of the teaching profession" and the "interpersonal" themes. By stating that "teaching was a big thing" in their community leads one to infer the high status accorded the teaching profession which eventually motivated her into becoming a teacher. The "interpersonal" theme reveals her desire to get a job when she graduates as she states that teaching was "the only profession that was there and visible". While Jeanne may have considered these themes, her professed views reveal her inclination towards the usefulness of teaching.

Jeanne:

> I guess it's also because *teaching is useful*, like I could have probably gone to university and gotten my arts degree in lots of things. But what would you do with it? Like there is a direct transference. You've still got to find something else to do more specific. But with a teacher education, you go, do your four years, get a degree and go get a job. It's very direct and that link between your degree and your job is very important.

To Jeanne, the "material benefits" and the "dignity of the profession" were also important. She looked at teaching as useful, and a sure route to getting a job as opposed to graduating with a university degree in a discipline and not having anything to do next. For Tracy, teaching was simply taking something that she was interested in and in which she could be successful.

Summary of Beliefs about the Nature of Mathematics

Mathematics to Jeanne and Tracy was characterized by an exactness, of knowing you were right when you completed a problem. In the early grades, they often found success in doing mathematics. This success was likely due to the level of mathematics understanding that was needed then. To Tracy, when mathematical concepts were not understood, she often overcame this by following the pattern in solving problems of similar types. However, at the high school level, mathematics became more difficult as Tracy encountered non-routine problems where a particular pattern or approach could not be followed.

For Jeanne, mathematics at the end of the early grades had precipitated a re-examination of her abilities and self-confidence in mathematics. Then her beliefs in her abilities began changing as success ceased to continue. In the high school, Jeanne saw her algebra and calculus courses as different from mathematics. She tried hard and found success in high school geometry and trigonometry because according to her, these branches of mathematics were more logical and she was

able to follow the logic. In university, Jeanne progressed through her university mathematics course, intending to strengthen her knowledge in mathematics, with little enjoyment or sense of relevance of the advanced content she was learning.

In high school, Tracy did not really understand mathematics but this didn't stop her from doing well in the classes. Her professed views of mathematics are summarized in the following statements:

- Mathematics is a very technical word having the connotation of algebra. As such, it is a very high-end discipline.
- Mathematics is a pattern-like and very methodical discipline. Its content is interrelated.
- Mathematics is fixed and pre-determined and the simplest way to learn mathematics is through examples.
- With mathematics, it is either right or wrong, it's just one way.
- Everyday activity that involved the concepts of mathematics is not mathematics but simply living.
- In mathematics, use of examples to relate to real life has often been very artificial.
- Though mathematics is artificial, mathematical knowledge is useful when applied to solve everyday situations.
- Mathematical content is useful but mathematics is not everything in life.

- There is more concern about marks in mathematics than in other subjects because mathematics is harder.

For Jeanne, mathematics (especially high school mathematics) had become an object of fear. Little did she think that she would ever like mathematics again, let alone teach it. Her experiences with mathematics could be summarized by the following professed views of mathematics:

- Mathematics is a very mechanical discipline.
- In mathematics, there is always one right answer and all that problem solving is about is trying to arrive at the answer that the teacher has in mind or is at the back of the mathematics text.
- Mathematics content is very incoherent and not inter-related. Each example of a problem in mathematics is always like a journey to an 'uncharted' desert island.
- Algebra is different from mathematics; "it's like a different level and a different level of thought".
- There are two worlds of mathematics: mathematics in the real world and mathematics as a school subject.
- Calculus is for smart people and as such, is different from mathematics. Mathematics involves how many, and how much, and is found everywhere, but not everything.

- Except in geometry and trigonometry, there is no 'what do you think?', 'give your answer', 'what can you relate to the story?' as there is in other branches of mathematics.
- Algebra and calculus are more of a science than other mathematics; there are very specific things like formulas and so there is little or no concern with process.

Summary of Beliefs of What Mathematics Learning and Teaching Should Be

Jeanne and Tracy expressed certain views about what they think mathematics learning and teaching should be. These views are summarized below:

Tracy:

- Mathematics and its teaching should emphasize a consumer or everyday life approach.
- Chapter review exercises are not really as helpful to students as many would think.
- Mathematics methods courses are not content based and that is very relieving.
- Mathematics textbooks should always have answers at the back for student reference.
- Firmness and fairness are qualities of a good teacher.
- Students, especially student teachers, should be encouraged to do what they believe in.

- More theory in mathematics should be given to high achievers in mathematics while more practical applications should be given to low achievers..

Jeanne:

- In mathematics, success breathes success especially when mathematics is made fun.
- a university mathematics course helps to unravel fears and increase the confidence of one's ability.
- Moving away from the textbook approach in teaching to a more activity oriented approach will definitely improve learning, and teacher educators need to give that confidence and assurance to their students.
- Manipulatives are a great way to teach mathematics at the elementary grades.
- Using manipulatives is a great way to teach but one should also learn how to evaluate the manipulatives.

Chapter Summary

There are some clear differences between the two preservice teachers in their beliefs (views and preferences) regarding mathematics and its teaching. Their views also reflect their mathematical histories and the approaches they intend to

use in teaching mathematics in the schools. Both of these preservice teachers identified two distinct categories of mathematics. First, there was the simple useful mathematics of everyday life, much of which was acquired through activities such as grocery shopping or working as a cashier at a shop or restaurant. The second category was the mathematics that had no application to everyday life and never came easily to them. This mathematics was seen as a "hoop", a "gatekeeper to great things in the future". This mathematics was done only in the classroom.

To Jeanne, mathematics was problem solving while to Tracy it was more of a "high-end" discipline. By "high-end", Tracy was probably expressing the view that the nature of mathematics and its learning was more demanding and more challenging than most of the school subjects that she was learning. She also may have been referring again to the "gatekeeping" function of mathematics.

As far as learning mathematics was concerned, it was always a challenge to Jeanne. Although Tracy found success in doing mathematics, she admits to having lost interest in studying it. This lack of motivation in mathematics apparently came about as a result of a lack of liveliness in the learning process. Tracy was not motivated to learn. At this point, one can only infer that these beliefs reflect their teachers' presentation styles and perceived knowledge of mathematics.

Most of the transformation of mathematics beliefs Jeanne and Tracy experienced during their teacher education came out of their mathematics method classes. It was through these classes that Jeanne and Tracy became involved in

student teachers groups from which their professional as well as their social skills were elevated and enhanced. The professor in these classes actively modelled positive beliefs about teaching and learning mathematics and encouraged participation in professional student and teacher groups.

Their motivation by and respect for teachers and professors influenced Tracy's and Jeanne's judgments of excellent teachers and consequently their professional development as prospective teachers. Ball (1988) said that knowledge of mathematics is obviously fundamental to being able to help someone else learn it. Jeanne and Tracy's reflections on their experiences confirm this. It is also clear that positive beliefs about teaching and learning mathematics are equally fundamental.

Chapter five further discusses these descriptions of Tracy's and Jeanne's experiences and provides some possible implications for teacher education.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

Introduction

Jeanne and Tracy's descriptions of their experiences as learners and future teachers of mathematics show that they both had negative feelings about the nature of mathematics and the way mathematics had been taught to them. If beliefs influence action, and therefore instructional behaviour, negative beliefs will influence teaching negatively. Therefore, it is necessary to deconstruct preservice teachers' negative beliefs about the nature, learning and teaching of mathematics if we wish to make positive changes in the teaching and learning of mathematics.

This chapter further extends the interpretation of the findings from chapter four, by organizing the interpretation around the questions guiding the study. Though the representation of this group of preservice teachers can not lead to generalization, implications for mathematics teacher education are suggested to further the conversation of teacher education.

The discussion section presents each question followed by an interpretation of the findings that speak to that question. The interpretation is interwoven with implications for teacher education.

Revisiting the Questions that Guided the Study

Question One: *What are the beliefs and conceptions that preservice teachers have about mathematics and its teaching prior to teacher education?*

The Nature of Mathematics

Mathematics as a 'Hoop'

Analysis of the data gathered by interview and questionnaires provided interesting philosophical orientations concerning Jeanne's and Tracy's beliefs about the nature of mathematics. They both held the view that mathematics was like a "hoop", a "gatekeeper" or a "screening device" to other things in the future such as university entrance examinations or getting a job. This conception of mathematics as a "rite of passage" to a degree or job seemed in contradiction to their beliefs about the usefulness of mathematics. This usefulness of mathematics to Jeanne and Tracy meant the direct application of concepts learned in the mathematics classroom to everyday life.

The fact that Jeanne and Tracy both had faith in the usefulness of mathematics at the elementary level which gradually disappeared as they progressed into the higher grades may indicate that the presentation of mathematics at the higher level does nothing to relate mathematics to everyday life. To them, this rigorous technical or linear, or abstract, presentation of mathematics

apparently fails to relate this higher mathematics to mathematics learned in previous grades. Learners apparently construct negative beliefs about mathematics in this sequence of events. One way in which teachers, schools and society see mathematics is as a technical, linear and abstract discipline.

As well, Tracy and Jeanne were consciously or unconsciously made to believe that mathematics has no other use except as a screening device for admission to other fields of life. It was a "hoop" mechanism. They failed to see the use and usefulness of mathematics they learned in school outside that milieu. The teaching of high school mathematics should not be limited to the classroom. It should bring the environment into the classroom and the classroom into the environment. This way students can see its application beyond being a school subject.

Implication

Mathematics teacher educators need to look at alternative ways of presenting mathematics so that its importance and usefulness, as a theoretical tool, and as a practical one, are clear to student teachers. It is also necessary to help them see the relationships between these two apparently separate uses of mathematics. This could be done in the methods courses during which the instructor spends time actually modeling approaches that presents mathematics as more than a "hoop". Its usefulness could also be demonstrated in other subjects

such as the social sciences. By incorporating mathematics into other disciplines, the preservice teachers will be helped to see the realities of its usefulness and will develop positive feelings and beliefs about mathematics, its teaching and learning. It is possible that these positive attitudes will in turn be transferred to the children in the schools. If Jeanne and Tracy learned negative beliefs from the way they were taught, deconstructing these beliefs with them may help them to ensure that children learn positive attitudes and beliefs in their classrooms. This deconstruction can take place when teacher educators create environment for preservice teachers to explore, identify and understand the implications of their beliefs, and provide activities through which beliefs can be transformed.

Mathematics as Mechanical and Technical

While the preservice teachers shared many common views, there were some differences worth mentioning. Jeanne held the view that mathematics was "mechanical" word, "carrying the connotation of problem-solving". She strongly believed that there were two worlds of mathematics; mathematics in the real world and mathematics as a subject. "Mechanical", to Jeanne, comprised the processes of doing mathematics. While she seemed less concerned with getting the right answer, she was very concerned about seeing the relationships and extending the knowledge from problem to problem. This dichotomy in her views of mathematics, indicates a kind of process-oriented view where mathematics is seen as simply a

problem-solving tool. What this tells us is that teachers may place a lot of emphasis on teaching students problem solving skills in the hope that they will gain an understanding of the uses of mathematics outside the classroom.

Implication

Instead of placing emphasis on the technical problem solving processes that do not ensure that students see the applications, teachers and teacher educators might consider and possibly demonstrate applicability in settings outside the classroom. They could do this by using non-routine problems as examples when introducing new mathematical concepts and skills.

Tracy believed that mathematics was a "technical" word and very "high-end". One interpretation of "high-end" is that it refers to mathematical concepts which are considered very abstract conceptually and only for the very bright students. Tracy's beliefs may demonstrate an 'absolutist' view of mathematics in which mathematical knowledge is seen as infallible or inviolable, as the paradigm or 'measuring rod' of truth and reliability. Schoenfeld (1985) pointed out that teachers' beliefs about the nature of mathematics play a major role in shaping students' experiences with mathematics. Tracy and Jeanne did not see the need to understand the logic of mathematics, but rather they considered mathematics a discipline to be memorized. We can infer from this that mathematics was probably presented to them in an absolutist way. That is to say, mathematics knowledge was presented as external

to self and stress was placed on accuracy and determination of the "one right answer". This rigidity in the presentation of mathematics, which emphasizes what counts as "correct", is still practiced in many of today's schools (Miller, Malone & Kandl, 1992) although there are other emergent views like constructivism which posits knowledge as emerging from meaningful interactions of the learner with the environment (Cobb & Steffe, 1983).

It is interesting to note that both preservice teachers believed that mathematics is "not everything". They believed that there is some relation between the 'outside world' and mathematics. They had difficulty understanding the actual nature of that relationship as is seen by their insistence that they couldn't say that mathematics "is everything". By "everything" they seem to be referring to something puzzling or frustrating about the usefulness of the mathematical knowledge that they learn in school. You don't use mathematics everywhere. You can survive without it.

Implication

Mathematics educators and mathematics teacher educators could work towards transforming their own view of the "one right answer" school of mathematics. Then, they might model new ways and less rigid ways of presenting mathematics. By helping preservice teachers to deconstruct their own beliefs about the rigidity and technicality of mathematics they will help them to acquire a deeper,

more realistic and more useful understanding of the mathematics they will be teaching. Preservice teachers can be helped to develop ways of teaching mathematics which are congruent with these more useful beliefs.

Teaching and Learning Mathematics

Mathematics should be Memorized

It is impossible to separate these preservice teachers' beliefs about teaching and learning in most of the interviews. Jeanne and Tracy believed that teaching and learning mathematics involves memorization and a skill approach. They believed that learning mathematics involved learning a set of skills to arrive at the 'right answer'. Most of these skills revolved around recognizing the patterns of the problem solving strategies. Teaching mathematics, therefore, involved instructing the students and giving them practice exercises from which it was hoped that they would acquire the problem-solving skills needed for the learning of higher mathematics.

Both students preferred a didactic teaching approach in which the teacher paid attention to individual learning capabilities by structuring the learning experiences to meet these capabilities. As Tracy comments:

> I had excellent teachers in grades 5, 6, 7, & 8 and they made the difference for me now. They really pushed me and sometimes very bright or energetic pupils, if they are not pushed, they won't put in the effort. These two teachers were very excellent. They made us work very hard and they gave us (or me) very good work.

Such a preference may come from confidence in the teacher's authoritative knowledge which controls the direction of student learning and gives Tracy confidence that she is progressing. Students need to have confidence in learning and if that confidence is absent there is less motivation to learn. To establish that confidence, a teacher needs to demonstrate a firm grasp of the underlying concepts when teaching related concepts to children and many teachers do not know enough mathematics to help students establish confidence as learners (Post, Harel, Behr, & Lesh, 1991). Unfortunately, not all of Tracy's teachers had that same influential authority of the pedagogical and content knowledge of mathematics. Tracy attributes her ultimate dislike of mathematics in the high school to the teacher she had in grade nine. This teacher was not trained as a mathematics teacher but rather as a physical education teacher. This was an example of what Ringstaff (1987) refers to when she talks of teacher "misassignment", where a teacher is assigned to teach a class that he or she is not technically trained and prepared to teach.

Implication

Teacher educators should explore the beliefs of memorization and skill with their student teachers and find ways to help them become aware that they hold these beliefs and to understand how they acquired these beliefs. It is only through

understanding these beliefs that future experiences in the preservice classroom can result in beliefs being changed or transformed.

Tracy also responded to the physical education teacher negatively because she saw him as lacking in mathematical content knowledge. This point may also indicate another interpretation of the "high-end" theory of mathematics. Tracy and Jeanne believe that mathematics is such a difficult, abstract discipline, and to them only technically-trained mathematics teachers can teach it. Teacher educators must challenge this unrealistic belief in the exclusivity of mathematics, especially for elementary teachers. This may be done by emphasizing active and experiential approaches to mathematics which show how it can be related to other branches of knowledge and to everyday life.

Somewhere in their experience, Tracy and Jeanne seem also to have come to believe that the teacher is the 'knower' of everything and learners are simply recipients of knowledge. Constructivist thought on teachers' cognition holds that teachers are knowing beings and that their knowledge influences their action. We also know, in a common sense way, that it is difficult to teach well that which we do not know well. What is the relationship between these beliefs about knowing ? How can preservice teachers be helped to see that being knowledgeable is indeed important, but that being knowledgeable does not mean being the only knowing being, the only knowledgeable person in the classroom? Teacher educators must find ways to raise this difficulty in thinking about the role of the teacher and learner.

For example, teacher educators may help learners discover mathematical knowledge experientially, in a socially, interactive manner, or they may model a traditional mathematical lesson. What follows is a discussion of the advantages and disadvantages of each of these learning approaches.

Mathematics is Learned in School

Jeanne did not see any interrelationships in the mathematics that she learned in school and did not understand the deep structure of mathematical concepts she was taught and so she hated mathematics. On the other hand, Tracy saw some connections and interrelationships in the concepts and experienced some success in doing mathematics. Both report that mathematics was like a "rite of passage", a "hoop" for them to go through in order to achieve great things in the future. Perhaps they could find no other use for a subject which they didn't understand in any significant way. So mathematics is learned in school for the purpose of screening people's futures. It is not useful in any real way. This should not be the situation.

This failure in the learning of mathematics is attributable in part to teaching styles as well as to the learning styles of the students. Many students are taught mathematics as a routinized discipline where simply following examples was all that was necessary. By seeing an example and doing others in the same way, Tracy successfully went through school mathematics learning. To Jeanne, mathematics

learning was more traditional, where instructions were presented in the form of lectures and worked examples.

This traditional view of learning is being contested by those who believe that knowledge is constructed through the meaningful interaction of the learner and the environment (Maeers ,1995). As revealed in responses to the next two questions, the interaction of the learners (preservice teachers) of this study within the enactivist environment of their mathematics education classes provided a distinct contrast with their previous views about teaching and teacher education. Some transformation of their beliefs about teaching and learning mathematics can be seen to have occurred.

Question Two: *How are these beliefs and conceptions transformed during their teacher education*?

Question Three: *What major "events" or "situations" occasioned this transformation*?

The second and third questions which this study explored centered around the preservice teachers' teacher education years. The two questions will be discussed together since they are related to each other.

Preservice teachers nearing the end of their teacher education experience changes in attitudes; a shift from the progressive, liberal attitudes formed during school and university education years toward the more conservative attitudes of

practising teachers (Copeland, 1980). For Tracy and Jeanne a dominant influence was what I call "eventful learning". This seems to fit with Abelson's argument (1979) that knowledge building occurs through experiential learning in which the learner makes meaning of the events. As Owens (1988) contends, the meaningfulness of the event must be considered in relation to the individual's perception of its nature and importance. From this perception, there are three sets of events that might have led to the transformation of the preservice teachers' beliefs and conceptions.

Transformative Events

Courage and Confidence

Tracy and Jeanne's mathematics methods instructor behaved as if she believed that they (the preservice teachers) were all capable of teaching school mathematics (especially at the elementary and middle grade levels). The instructor demonstrated this belief by providing a classroom environment where mathematical concepts could be explored and where the students' learning (about mathematics and about teaching mathematics) could be discussed in social situations. This gave them the courage and confidence that they had been long lacking in their ability to teach mathematics. Student teachers need to have confidence that they are more capable of teaching than they had initially thought they were.

Implication

Many preservice teachers do not have the kind of experience which produces this courage and confidence. As Prawat (1990) maintains, if we are to bring about reforms in teaching, we need to equip preservice teachers with such a feeling of confidence. Teacher educators need to consider this experience of confidence- and courage-building as an integral component of all teacher education programs and create activities that will promote this. This will open the way to the possibility of transformed views of teaching and learning mathematics as the preservice teachers graduate into schools.

Interrelated Theory and Practice

A strong conviction, demonstrated by their mathematics education professor, that a particular teaching approach would actually work in a classroom reality, and a clear modeling of the associated teaching strategies, helped Tracy and Jeanne to change their belief in the complexity of the task of teaching mathematics. This perception of complexity often comes from having been taught in a traditional manner. Advocates of a traditional view of teaching may argue that this perception is necessary, but teacher educators need to go beyond simply explaining the process of teaching and try as much as possible to present classroom realities that unravel the complexity of teaching.

Implication

Student teachers should be enabled to teach mathematics using a variety of approaches. While memorization and rote-skill teaching approaches may be appropriate, provision should be made for student teachers to teach mathematics using non-skill or non-memorization- oriented approaches. These alternate teaching approaches once practiced in the university have a greater survival rate in classrooms. There is considerable evidence that young teachers are quickly resocialized by school staffs into the beliefs they held before their teacher education (Brown and Borko, 1994). Tracy and Jeanne experienced this resocialization even in their extended internship (which they were doing when interviewed). So even these students, who describe transformation of their beliefs in the class of an enactivist teacher educator, found maintaining the transformed beliefs difficult. It is clear that much more than one class and normal practice teaching is needed if Tracy and Jeanne's negative beliefs about mathematics teaching and learning are to be truly transformed. These preservice teachers were provided an environment where they could try out various teaching strategies. By so doing, they had begun to assume the role of a teacher even before they went out to practice in the schools. More of such an environment would seem likely to be helpful. If teacher education programs are to change mathematics teaching, perhaps they must provide this environment.

Social Interaction and Leadership

Preservice teachers need to acquire experiences in social interaction and leadership. Many do not get this kind of experience before graduating from teacher education institutions. As this study reveals, the preservice teachers increased their confidence and established convictions that they could do anything if they really believed. Confidence in themselves induced by their mathematics education professor, inspired them to participate in student-teachers' groups. As a result, their social lives as prospective teachers became more mature. Their participation in teaching workshops, seminars, and conferences in turn enhanced their confidence as teachers, especially of mathematics. These professional experiences are sometimes overlooked by teacher education institutions which emphasize the acquisition of content and pedagogical knowledge.

Implication

Teacher education programs should provide time and space for student-initiated and directed professional involvements and organizations. Preservice teachers should be encouraged to participate fully in professional organizations, conferences and workshops. This involvement with creative and committed professional educators outside their teacher education environment will serve to enhance and encourage the transformation of beliefs and counteract the effect of socialization sometimes found in internships.

The Individuality of Preservice Teachers

Attempts to provide a satisfying and fortifying teacher education for preservice teachers must take account of their idiosyncratic stances toward those elements of learning to teach which are of special importance to them. Jeanne and Tracy were different as well as similar in their experiences with mathematics. One of such differences (or similarity) is the fact that they each wanted high school mathematics to be taught in a way that they learned mathematics at the elementary grades. This leads us to an old question: Should teachers teach learners what they believe the learners must know or what the learners want to know? It seems likely that in some way teachers must do both. If teachers teach only what the learners want to know, the benefit of the experience of the teacher educator is wasted. If the teachers don't teach the learners what the learners feel they need to know, the learners will not be completely involved in their own learning. Constructivist thought addresses this problem by suggesting that the teacher's knowledge and experience should be used to structure a learning environment within which it is likely that students will come to know not only what they must, but also come to understand why they must know it. Because students are not empty vessels, the knowledge they bring with them to the learning environment will be modified and used to make meaning out of their experiences with the learning environment. In teacher education this would mean structuring course work and internships so that the students will progressively experience teaching and learn from their courses what they need to know when that need becomes apparent in a variety of situations.

Implication

Teacher education programs should be organized so that student teachers will have practical experiences which lead them to problems of practice requiring thoughtful application of theoretical knowledge, which is then provided for in their university courses.

Conclusion

While much more remains to be learned about the beliefs and conceptions that preservice teachers have about mathematics and mathematics learning and teaching this study is a step forward in understanding these complex sets of beliefs without necessarily looking at their manifestation during instructional practice. This exploration of the preservice teachers' beliefs and conceptions about mathematics and mathematics teaching and learning is one potential means for assisting preservice teachers' development in ways beneficial to teacher education. The findings of this study reveal that the preservice teachers' beliefs and conceptions are shaped by their experiences with mathematics and that this could be changed if teacher education institutions take into account the diversity of students' education background and views about the process of teaching. These findings are consistent with those of Thompson (1984), Schoenfeld (1987), Owens (1987), and Shaw (1989) who have also revealed the complex nature of preservice teachers' beliefs about teaching.

The common thread through the description of Jeanne and Tracy's experiences and beliefs about mathematics, mathematics teaching and learning is a mainly negative conviction that mathematics is a mechanical-technical discipline used practically, only to solve technical problems and theoretically, to serve as a screen for advancement in education and careers. Their beliefs about mathematics teaching and learning are generally based on the knowledge and authority of the teacher and that this is done through acquiring specific skills and through memorization.

Mathematics teacher education should be geared towards helping students transform their negative beliefs into beliefs and practice which will enable them to ensure that their students do not develop similar negative beliefs about mathematics. It must be experiential, must help students to be confident and courageous, must help them to see themselves as educational leaders, and must enable them to see themselves as creators and users of mathematical knowledge, and to see their students similarly.

Finally, it is crucial that preservice mathematics teacher educators (1) recognize the likelihood of students in education having a traditional view of mathematical knowledge, (2) be prepared to confront, explore and deconstruct the characteristics and pedagogical implications of this view, and (3) propose an alternative view, modelled in class, acted on in class by student teachers and practised in school. The substitution of an alternative, post-modern, view of teaching mathematics for the traditional view, provided opportunity is given for students to work through this alternative in practice, may result in a healing process - a mathematical therapy or mathematics anxiety reduction (Tobias, 1987).

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APPENDICES

APPENDIX A

HUMAN SUBJECT RESEARCH ETHICS REVIEW COMMITTEE

Application for Approval of Research Procedures

Section I: Identification and Purposes

1. Date: **September 28, 1995**

   Name of Applicant(s): **HENRY KANG**

   Address: **Faculty of Education, University of Regina,**
   Regina, Saskatchewan, Canada S4S 0A2

   Title of Research: **Preservice Teachers' Beliefs and Conceptions of Mathematics Learning and Teaching.**

2. If the project will be part of a thesis, or class requirement, give the name of the supervisor:

   DR. DAVE BALE

   Department or Faculty

   Faculty of Education

3. **Purpose: Give a brief outline of the main features and variables of the research problem. Include a brief statement which describes the significance and potential benefits of the study.**

The purpose of this study is to describe espoused beliefs and conceptions about mathematics and mathematics learning and teaching of Preservice elementary teachers during their teacher education program. Interest in the beliefs and conceptions about mathematics of pre- and in-service teachers has increased over the years, motivated by a renewed interest in teacher preparation - in mathematics teacher preparation in particular. This research project will use filed data collected through a questionnaire as well as two interview sessions to examine and describe some Preservice elementary mathematics teachers' beliefs and conceptions about mathematics learning and teaching. A description of the beliefs and conceptions of these four Preservice teachers will assist in the improvement of the elementary teacher education program. Teacher educators charged with the preparation of teachers will find the description of interest. Literature on the beliefs about mathematics and mathematics learning and teaching will be reviewed.

Section II

1. **Briefly describe the number and kind of subjects required for data collection.**

Subjects for this study will consist of 4 Preservice elementary mathematics teachers at the Faculty of Education. The selection of the subjects will be voluntary. The design of the study limits the number to 4 for purposes of in-depth description of the espoused beliefs and conceptions about mathematics and mathematics learning and teaching of the Preservice elementary mathematics teachers.

2. **What information about the research problem and their role in the project will potential subjects be given?**

The subjects will be informed in a letter of the purpose of the study. They will also be informed that information for this study will comprise data from their mathematical histories collected by their mathematics methods instructor and two follow-up interview sessions. They will also be told that the information will be compiled for a thesis.

3. **How will the consent of the subjects to participate be obtained?**

Following the approval of thesis advisory committee and the ethics committee, the subjects will receive a letter explaining the nature and time requirement for the study. They will be asked for their voluntary participation in the study with the understanding that their instructor for mathematics methods will allow data from their mathematical histories to be used in the thesis and that they will be interviewed twice.

If they sign and return the permission letter, this will be considered voluntary consent.

4. What will the subjects be required to do in the course of the project?

Subjects will be required to clarify some of the data in their mathematical histories which should take less than 30 minutes of their time. Two interview sessions will be set up at the convenience of each subject. Each interview will last approximately 1 hour. Numbered audiotapes will be used to record interview data.

5. What assurances will the subjects be given and what precautions will be taken regarding the confidentiality of the data or information which they provide in this study?

The subjects will be informed through a letter that the data and information they provide will be kept strictly confidential and their names will never be used in the study. In view of the confidentiality and the nature of the required tasks, subjects will be advised to choose a five character alpha-numeric code of their making which will be used in filing and quotations in the study. The researcher will transcribe the recorded data.

6. Will children be used as a source of data?

Yes _____ No_X_

If yes, indicate how consent will be obtained on their behalf.

7. Will the researcher or any member of the research team be in a position of power or authority in relation to his subjects? (For example: A teacher doing research and using her class as subjects or a counsellor collecting research data from his clients.)

Yes _____ No_X_

If yes, indicate how coercion of subjects will be avoided.

8. Will deception of any kind be necessary in the subject?

Yes _____ No_X_

If yes, explain why and indicate how subjects will be debriefed after the study.

Section III: Access to Data and Findings

1. Who will have access to the original data of the study?

Thesis supervisor and the subjects upon request.

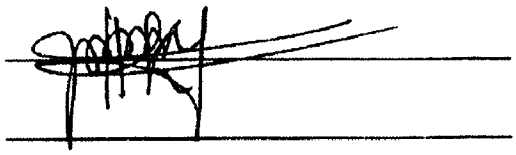
2. Will subjects have some access to the findings of the study?

Subjects will have access to the original data of the study as well as the summary of the findings. Before publication, the study will be presented to the subjects for review and critique and any required changes will be made. This will also be done so that subjects may benefit from the learning which the analysis of histories and interview data may make possible for them.

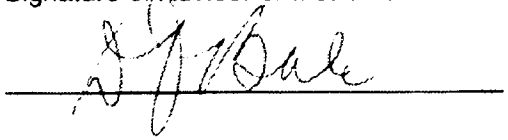
3. What will be the final disposition of the original data after the study is completed?

The original data collected will be destroyed shortly after the study is completed. However, the summary of the findings will be archived in the thesis when it is completed, for future research use.

Signature of Applicant(s):



Signature of Advisor or Instructor:



1238 Elphinstone St.
Regina, Saskatchewan
S4T 3M3
September 28, 1995

Dear Colleague:

My name is Henry Kang and I am a graduate student in the Faculty of Education at the University of Regina. One of the requirements of my Master's program is the completion of a research study. I would like to briefly acquaint you with a few details of the study before it begins.

I am interested in conducting research on Preservice elementary mathematics teachers' espoused beliefs and conceptions about mathematics and mathematics learning and teaching. To date, very little is known about Preservice elementary mathematics teachers' beliefs and conceptions about mathematics learning and teaching.

This study is designed to gather information pertinent to the present-day espoused beliefs of Preservice elementary mathematics teachers about mathematics and mathematics learning and teaching. This information will comprise filed data as well as data from interviews which will be audio taped. I am therefore, writing to you to request your voluntary participation in this study with the understanding that your instructor for mathematics methods will allow data from your mathematical histories to be used. In addition to this data, you will be interviewed twice at times convenient to you. I recognize and respect the value of your time and have therefore made the interview sessions approximately 1 hour each.

Again, participation is on a voluntary basis and you are free to withdraw ant time you wish. Your response will be kept strictly confidential, and you will not be identified in any way in the final report. Since the information will be compiled for a thesis, I will therefore advise you to choose a five character alpha-numeric code of your making that will be used to archive the data (e.g. XY123). You may also want to choose a pseudonym which will be used in verbatim quotations. A summary of the results of the study will be presented to you for review and critique and any changes will be made before publication.

I hope that you will be able to contribute your time and knowledge to this study. Your participation will contribute significantly to an increased understanding of mathematics teaching and learning as you develop as an elementary mathematics teacher. This may also assist in the improvement of the elementary teacher education program.

Please sign and return one copy of this letter at your earliest convenience in the envelope provided. If you have any questions, or concerns, please call. Thank you in advance for your valuable assistance.

Yours sincerely,

Henry Kang
(306)585-4661 (office)
(306)352-5912 (home)

ACCEPTANCE FORM

I have read and understood the design and terms under which the study will be conducted. I understand that my response will be kept strictly confidential, and I will not be identified in any way in the final report. I also understand that I am free to discontinue at any point within the study. I am therefore interested in voluntarily participating in this study.

_____

(Sign.)

UNIVERSITY OF REGINA

FACULTY OF GRADUATE STUDIES AND RESEARCH MEMORANDUM

DATE: October 16, 1995

TO: Henry Kang
Faculty of Education

FROM: Dr. G.W. Maslany, Chair
Research Ethics Review Committee

Re: Pre-Service Teachers' Beliefs and Conception of Mathematics Learning and Teaching

Please be advised that the committee has considered this proposal and has agreed that it is:

✓ 1. Acceptable as submitted.
(Note: Only those applications designated in this way have ethical approval for the research on which they are based to proceed.)

Please ensure that the archived data will be preserved for at least 3 years with personal identifying information removed

_____ 2. Acceptable subject to the following changes and precautions (see attached):
Note: These changes must be resubmitted to the Committee and deemed acceptable by it prior to the initiation of the research. Once the changes are regarded as acceptable a new approval form will be sent out indicating it is acceptable as submitted.
Please address the concerns raised by the reviewer(s) by means of a supplementary memo.

_____ 3. Unacceptable to the Committee as submitted. Please contact the Chair for advise on whether or how the project proposal might be revised to become acceptable (ext. 4161/5186.)

G.W. Maslany

/mm
cc: D. Bale
(Ethics2.doc)

APPENDIX B

PERSONAL MATHEMATICAL HISTORIES

NAME:_____

Please take some time to think about the following questions. There is no one right answer. Please answer as honestly and thoughtfully as you can. At the end of the course I will give you a similar questionnaire and then have you compare the two. If I have not left you enough room please feel free to use the back of the paper or a separate sheet.

1. When you hear the word mathematics, what feelings and thoughts come to mind?

2. What is *mathematics*?

3. Where is *mathematics*?

4. Think back to Grades 1-12. Briefly describe a typical math lesson in any of those grades. What do you remember most about math in those years? What feelings do you associate with math during that time?

5. In what situations do you use math in your daily life? How do you react to those situations?

6. How do you think elementary children best learn math?

7. As a future teacher of elementary-aged students
   A. Do you feel competent now with the elementary grades math content and
   B. What kind of math teacher would you like to be? Try to visualize yourself in the classroom teaching math. Describe how you are teaching.

PERSONAL MATHEMATICAL HISTORIES

NAME:_____

Please take some time to think about the following questions. There is no one right answer. Please answer as honestly and thoughtfully as you can. At the end of the course - **now it is the end** - I will return them to you for your reaction and reflection. If I have not left you enough room please feel free to use the back of the paper or a separate sheet.

1. When you hear the word mathematics, what feelings and thoughts come to mind?

2. What is *mathematics*?

3. Where is *mathematics*?

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7. As a future teacher of elementary-aged students
   A. Do you feel competent now with the elementary grades math content and
   B. What kind of math teacher would you like to be? Try to visualize yourself in the classroom teaching math. Describe how you are teaching.

Interview Session One

This is a transcription of the questions as were recorded in the tapes during the interview sessions.

I am going to ask you a few questions to get some more information regarding your mathematics history to supplement the filed data I already have of your mathematical histories. This should take us approximately 1 hour. Please feel free not to respond to any question you do not like or do not understand. There is no right or wrong answer so I will appreciate it if you answer as honestly and thoughtfully as you can.

1. When you hear the word mathematics what feelings immediately come to your mind? Keep thinking back to school years.

2. Can you recall a particular instance during your school years when in a mathematics lesson you had certain experiences which still live with you up until this date and you will always live to remember?

3. Were these feelings that you've just expressed a usual kind of state that you found yourself in with all other subjects or these were only particular to mathematics?

4. How did it feel like whenever it was the period for mathematics and you could see the mathematics teacher standing by the door ready to come in?

5. When you say algebra was the most lamenting what do you mean by that. Do you mean that it was the most difficult or that it (algebra) was what you enjoyed best?

6. So what do you think might have been the cause of all this hatred of algebra and geo-trig (mathematics) in grade eleven and consequently in grade twelve?

7. What branch of mathematics in grades one to twelve (algebra, geometry, trigonometry, and the like) did you really feel comfortable that you had quite understood it and could also see the direct application?

8. So, it wasn't as a result of the teacher who taught the proofs, like the two-column proofs, but the whole concept of proofs in that two column manner that helped you to easily pick up.?

9. We've talked at length on your grade twelve experiences with mathematics. Now I will like us to move one step up after grade twelve. I am assuming, and I may be wrong, that you did take another mathematics course(s) in the university; say pre-calculus or mathematics at the 100 level. What were your initial feelings about the course and what were your impressions during and after the course?

10. After graduating from grade twelve, you had probably thought that you were done with mathematics. What were your feelings after realizing that it was mandatory that you take a "university mathematics" class?

11. And how were your experiences with the mathematics class? Were they any similarities with the other classes you were taking in education at that same time?

12. Before your first method course in mathematics, if you were asked to respond to the question 'What is mathematics?', what would you have said?

Keep thinking back to that time when you had not yet taken any method course in mathematics.

13. That sounds interesting. You may want to talk to me a little more about the two. Let's take the first; 'mathematics as a subject'. What could you say then?

14. Tracy, what do you think of these different kind of mathematics as Jeanne has identified? Is it the same situation with you or you see it quite different?

15. I would like to assume, I may be wrong and you can tell me, during your mathematics classes you had exercises with problems drawn from everyday experiences like bills during shopping, and the like. How did you think of these in terms of the applicability and usefulness of mathematics to society?

16. From what you've just said it seems to me like you are pointing at certain places. So if I ask you 'Where is mathematics?' How would you response to such a question?

17. What you're saying is everything we do, mathematics is everywhere or everything?

18. After taking a university mathematics course, and you were about to take the first method course in mathematics, what were your feelings and impression about mathematics at that time, knowing that you were going to become a teacher sooner or later and will be teaching mathematics as well?

19. So was it because the course was being taken from this instructor or was it the course itself?

20. Jeanne, what do you think about what Tracy has just said?

21. Talking about worries with marks, I will want to take you back to the university mathematics course that you took. Would you in a way say that part of your fear, or your anxiety or concern with mathematics whenever you talk about mathematics was because of marks?

22. Mathematics being a subject just like any other subject in the school or college, why was there so much concern about marks?

23. What do you mean exactly when you say in the other subjects like social studies, you could just write?

24. From what you both are saying, I understand you like saying "with the other subjects, there was that level of exactness" like was the case with mathematics, where you were afraid that you may not get that exact answer or solution to a problem. Was that the situation?

25. From what you're saying I understand your fears were generated from the fact that you had problems and you were trying to come up with a solution which the teacher had in mind, that this is what he expects. Now if you had a slightly different problem, for example, Show that 6 people, working 4 hours a day will accomplish this job in 10 days. Here the answer is already given and all that's asked of you is to show the process that will lead you to that answer. How will you look at such a situation?

26. If you had a textbook that didn't have answers at the back of the book, following what you are saying, and you were assigned to do some of the problems in the exercises, would you feel more comfortable doing them,

knowing that the teacher was not going to check and there were no answers at the back to disprove your solution outcome?

27. Did you just move straight from the high school into teacher education?

28. What was your motivation to go into teacher education program straight from the high school?

29. Some people like myself got into teacher education and the teaching profession from admiring some of my past teachers. Was that in part the case to any of you?

30. What about you Jeanne?

31. I will still want to ask this question: Generally, was there a teacher at any time you really felt like I wish I were in his/her position, I would be very happy the way he/she taught today. Like is there a teacher who stands out clearly in your memory whom you really admired as a teacher?

32. So even with your parents being teachers, you were never inspired by them nor you never admired their profession at any one time?

33. So what does your father teach?

34. And what does your mum teach?

35. When you were about to take the methods course in mathematics, and considering the knowledge in mathematics you had at that time, was there any concern as to whether you had enough knowledge that would enable

you teach successfully since you were now going to take courses only in the teaching of mathematics which according to your understanding was not content based?

36. There is a commonly held believe that elementary teachers do not possess considerable knowledge in one subject area. That they have just an average knowledge in all the school disciplines. That they are generalists as opposed to secondary teachers who are believed to have a considerable amount of knowledge in one subject or discipline such as mathematics. What do you think of such a belief and was that one of your concerns why you chose to go into elementary teacher education?

37. What were your general feelings and impressions about the method course whose aim was to teach you how to teach elementary or middle years grades, taking mathematics as an example.

38. So there wasn't so much emphasis on getting a lot of content. And to you, it was more of using manipulatives. Was there a feeling that using manipulatives will improve learning and that this was a better way of teaching mathematics in the elementary grades?

39. From my understanding of what your methods course in mathematics was all about, it sounds like it was much more activity oriented. That you carried activities which were similar to what you will be doing with kids in the classroom. Was there a day when an activity that you were doing stroke your anxiety and everything just seemed to kind of click together. A day when an activity helped you understand something that you had never quite understood as a student in the grades school?

40. It seems to me like what you are saying is in support of constructivist approach to mathematics learning, since all along you've talked about mathematics in the real world. What can you say about that Tracy?

41. Coming back to our "mathematics in the real world" I have the understanding that you are referring to activities such as counting money, balancing records, bookkeeping, and things like that. Is that what you mean by "mathematics in the real world"?

42. Do you share in that same understanding Jeanne? The belief that most people have, that mathematics is not real and how the use of manipulatives is artificial in the classroom?

Well, we'll end here for now and next Friday we will continue with exploring your experiences in your second mathematics method course and other activities you participated in while at the university. Thank you very much.

Interview Session Two

1. Could you talk to me about your method classes: like what did you get from the classes in terms of your professional requirements? Take for example the mathematics methods classes.

2. Like teacher made materials?

3. Oh you talking about the mathematics and science group?

4. That's a good point we'll be coming to. Because it is only recently that I heard about it. Just before we get on to that, hmm

5. That you did unit planning?

6. It seems to me like the methods classes seemed to have built a lot of confidence in you as far as the teaching profession is concern. However, what do you think could have been done if any, you think that could have been added to that, to some of those who were still not yet into it? That is, were there any other things which you think may be if this had been done then it would add to what you had already acquired from these classes?

7. Yea, I find that even with the internship that students get very nervous because of the evaluation, when your faculty supervisor is around, you get nervous because you are thinking is he/she going to give me a fail or a pass. You know, that's often the case, almost everybody finds that if we could teach free of marks we could do much better.

8. I read in one of your personally mathematics history and you talked about

giving you the opportunity to go through some of the chapters or the activities that you will be encountering in the classroom that if some of those activities were included, I don't know if it is you Jeanne or Tracy. (Tracy: That's me, maybe). Well let's see here. Jeanne: "Think back to grade 1 - 12, ..." that's not what you are talking about, right? No, I'm talking about question 7 or 8 of the questionnaire.

9. Getting back to what you said earlier Tracy, concerning SSMSTS, what does SSMSTS stand for and what is it all about?

10. And was that your first involvement in a student teachers' society?

11. And so when you got into this society, what exactly was your involvement and contribution?

12. And that was as a result of your involvement in this?

13. So all these wonderful things that you people did: all the presentations and so on, were they coming out of the SSMSTS? Or What do you actually do inside the SSMSTS that aspired you or gave you that urge, or that confidence?

14. It sounds interesting It looks like you both have gained tremendously from your involvement with all these than you would have otherwise?

15. If you were to advice another student teacher who is just coming in as regards SSMSTS, what would you tell the him/her?

16. So like right now your teaching is kind of immaterial of how much you know

because you know how to go about getting the information when it is necessary?

17. That's an interesting point. If I could interject here. It will be interesting to see how this will compromise with the fact that most people think about mathematics as, you know, there is one answer and the answer is in the teacher's head and we have to try to come up with that answer that matches with what the teacher has in his/her head or something like that. Now if we don't know the answer, and one student comes up with an answer and another student comes up with different answer, like you as a teacher now, how would you accommodate those two different answers?

18. You know, because many people think that simply because mathematics has a lot to do with figures, that there is hardly any discussion session in a mathematics class. That all that a mathematics teacher does is write out problems on the chalkboard for students to do.

19. It looks like we've talked a lot about SSMSTS and your mathematics method classes. Now let's talk a little bit about the internship. Now, think back as much as you can, to the very first day when you stepped into the internship school and you knew that you will be in charge of the classroom for the whole day. That may be about a week ago, or a month ago. What were some of those things that you had to do to get ready and what were some of your immediate concerns?

20. How does it feel for example, like as Tracy said, when you enter a classroom and the teacher does not use manipulatives and so on and these are some of the things you believe from what you've been saying that he could have used?

21. The first week when you actually started teaching, what are some of those materials that you used in preparing your lessons. Like the cooperating teacher might have said, you know, if you do this, make sure you also do this. For example, was the textbook your frequent source of information or did you have other resource materials besides the textbook?

22. And when the teacher advised you to use the textbook, what did you think about teaching then?

23. Observing your cooperating teacher during the observation weeks, did teaching appear to you to have been more simplified or more complex than you had earlier envisaged?

24. So with that in mind then, when you started teaching, you didn't even bother about something like the curriculum since you had the textbook. Some of these teachers may not use the curriculum because they have acquired a lot of experience teaching and much of what is needed to get the lesson through is up in their head and so they often do not refer to the curriculum guide. But what about teachers who are just starting like you?

25. Going back to the time when you just started teaching up till now, can you think of some days, or a particular day when something exciting, or something different happened like you had a different feeling when you finished a lesson, for example?

26. From all what you've said, it sounds to me like you all have a pretty much clear idea of what teaching is and what teaching mathematics is now. So if I were to ask you to sum it all up in a few sentences what you think is required for students to learn mathematics better, what would you say?

27. At this moment, if you were to be send to a school to teach just mathematics to elementary grades how do you see yourself taking on such a position?

I want to thank you all very much for accepting to work with me. Once more thank you very much.

APPENDIX C

THE FOUR-YEAR ELEMENTARY B.Ed. PROGRAM

The 4-year (8-semester) B.ED. elementary program requires 124 credit hours. The program consists of both academic courses taken outside the Faculty of Education as well as professional courses taken within.

Course requirements for the 4-year B.ED. program are listed below by semester. While some flexibility exists in the placement of courses by semester, in certain semesters there is little or no flexibility. Students expecting to take the program on a part-time basis will need to plan their program carefully in consultation with an advisor.

Courses in semesters 1 and 2 may be taken in either semester. Most required courses in semester 3 will be offered only in semester 3. Methods courses in semesters 4 and 5 will be timetabled for each section of students; students are expected to be in full-time attendance for these pre-internship semesters. Elective courses in semesters 6 and 8 may be taken at any time,
subject to course prerequisites. Students are strongly encouraged to plan for internship in semester 7 (fall) and to return for a full semester of courses as a post-internship semester.

The Four-Year Elementary B.ED. Program

Semester 1 (Fall)	Semester 2 (Winter)
ENGL 100 (3)	EPS 100 (3)
PAS 152 (3)	Humanities Elective (3) (note 3)
MATH 101 (3)	Fine Arts Elective (3) (note 4)
Nat. Science (3) (note 1)	Elective (3) (note 5)
Soc. Science (3) (note 2)	Elective (3) (note 5)

Semester 3

EPSY 205 (3) (note 6)

ECE or EMY 205 (3)

ELNG 205 (3)

Cross-Cultural Requirement (3) (note 7)

Education Elective (3) (note 8)

Semester 4 (note 9)

EPS 215 (3)

Educational Methods (3) (note 10)

Educational Methods (3)

Educational Methods (3)

Educational Methods (3)

ED 215 (2)

EFLD 050 (0) (O.C.R.E.)

Semester 5

EPS 225 (3)

EPSY 225 (3)

Educational Methods (3) (note 10)

Educational Methods (3)

Educational Methods (3)

ED 225 (2)

EFLD 051 (0) (O.C.R.E.)

Semester 6

EPSY 322 (3)

ELNG 325 (3)

Approved Elective (3) (note 11)

Approved Elective (3)

Approved Elective (3)

Semester 7

EFLD 405 (Internship) (15)

Semester 8

Education Foundations (3) (note 12)

Approved Elective (3) (note 11)

Approved Elective (3)

Approved Elective (3)

Approved Elective (3)

Notes:

(1) Natural science courses are to be selected from astronomy, biology, chemistry, geology, and physics.

(2) Social science courses are to be selected from anthropology, economics, geography, history, Indian studies, political science, and sociology.

(3) Humanities courses are to be selected from a second language, logic, philosophy, 200-level humanities offerings, religious studies, history and philosophy of science, linguistics.

(4) Fine Arts courses are to be selected from ART 100, ARTH 100, FILM 100, INAH 100, MU 100, THEA 100.

(5) Non-education electives are to be selected from faculties other than Education. Approved courses are to be supportive of the role of classroom teachers.

(6) PSYC 210 (Developmental Psychology) is an acceptable alternative to EPSY 205 for all elementary program students.

(7) The cross-cultural requirement is to be selected from ECCU 200 or EFDN 307. This program requirement may be met in either semester 6 or 8.

(8) Education electives are to be selected from ECMP 355, ELIB 206, and ELIB 216. This course component may be exchanged with other electives from semester 6 or 8, provided that the prerequisites for the particular course have been met.

(9) Semester 4 is the first of two pre-internship semesters. Students are expected to be in full-time attendance; courses, labs, field experiences and other activities may be scheduled at any normal class time throughout the semester. To be admitted to pre-internship, students must have completed at least 24 hours of requirements in semesters 1-2 and have credit in EPSY 205, ECE/EMY 205, and ELNG 205 from semester 3. In addition each student's progress to pre-internship is dependent upon achieving a positive assessment in Faculty student reviews.

(10) Educational methods courses and EPSY 225 are timetabled during either semester 4 or 5 to include: EAES 215, EHE 215, EMTH 215, EPE 215, ERDG 215, ESCI 215, ESST 215.

(11) Approved electives will normally be senior courses (300 or higher) in education or courses from outside education (200 or higher) that support teaching subjects. Note: Only one Special Education course beyond EPSY 322 may be selected as an Education elective for credit on the Elementary Program.

(12) One senior EFDN course (300 or higher) is required in the program.

Other requirements of the 4-year B.Ed. degree:

(13) Every program must include a minimum of 124 credit hours.

(14) At least 39 credit hours must be courses from faculties other than the Faculty of Education.

(15) At least nine credit hours must be senior courses (200 or higher) from outside the Faculty of Education. For this requirement courses such as ENGL 110 - 140 and MATH 127 will be considered senior-level courses as such courses have required unit prerequisites.