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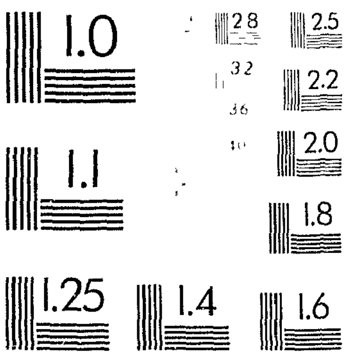

THE EFFICACY OF AN ELEMENTARY MATHEMATICS METHODS COURSE IN CHANGING PRESERVICE ELEMENTARY TEACHERS' MATHEMATICS ANXIETY

by

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Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

at

Dalhousie University
Halifax, Nova Scotia

ISBN 0-612-05166-8

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "The Efficacy of an Elementary Mathematics Methods Course in Changing Preservice Elementary Teachers' Mathematics Anxiety".

by Grace Lynch

in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Dated July 20, 1994

External Examiner [redacted]

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Examining Committee

DALHOUSIE UNIVERSITY

DATE: July 27, 1994

AUTHOR: Grace Carol Lynch

TITLE: The Efficacy of an Elementary Mathematics Methods Course in Changing Preservice Elementary Teachers' Mathematics Anxiety

DEPARTMENT OR SCHOOL: Education

DEGREE: PhD CONVOCATION: October YEAR: 1994

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Abstract

The first purpose of this study was to further an understanding of mathematics anxiety by placing it within a psychological model. The second purpose was to determine if and how an intervention for mathematics anxiety implemented within an elementary mathematics methods course, could reduce levels of mathematics anxiety. The results of this study indicated that mathematics anxiety could be placed within a social cognitive framework.

The sample for this study was 112 preservice elementary teachers enrolled in 3 separate years of an elementary mathematics methods course at a small eastern Canadian University. Data was gathered through the administration of the Fennema-Sherman Mathematics Attitude Scales and Mathematics Anxiety Scale, interviews with the preservice elementary teachers, interviews with the professor who taught the course throughout the span of the research, and observations of one year of the elementary mathematics methods course while it was in progress.

Findings indicated that the mathematics anxiety levels of the preservice elementary teachers were reduced after completing the elementary mathematics methods course. Further it appeared that there was a relationship between confidence in learning mathematics and mathematics anxiety. Self-efficacy expectations were found to be important in the reduction of mathematics anxiety. Specific components of the methods course that aided in the reduction of mathematics anxiety were clearly identified by the preservice elementary teachers. Future research into mathematics anxiety could explore these components further.

Acknowledgements

I am most grateful for the continued support and encouragement of Dr. Norman Watts, my mentor and friend, without whom I would not have come this far. I also wish to express gratitude to Dr. Joseph Murphy, and my committee, for their advice and guidance.

A special thanks to all those preservice elementary teachers who allowed me access to their thoughts and feelings toward mathematics.

Nothing of this magnitude is ever undertaken without the encouragement and love of family. I am grateful to my parents for their confidence and support of all my endeavours. I am especially grateful to my husband, Casey, for his faith, strength and patience. Without his support I would not have been able to complete this doctoral degree.

CHAPTER I

INTRODUCTION

Anxiety has long been a strong research concern both in the psychological and in the educational literature. Because anxiety encompasses such a vast area there have appeared many subconstructs of anxiety. One prominent subconstruct of anxiety in educational research is mathematics anxiety (Dew, Galassi & Galassi, 1983; Fennema & Sherman, 1976; Hembree, 1990; Hunsley, 1987; Tobias, 1978, Richardson & Suinn, 1972, Williams, 1988; Wood, 1988).

This study is concerned with mathematics anxiety. In order to fully understand mathematics anxiety, and to develop the appropriate intervention strategy, a firm grounding in a psychological paradigm unique to mathematics anxiety is necessary. The majority of research into mathematics anxiety has used the theoretical basis for test anxiety claiming the similarity of the two constructs (Hembree, 1990; Reyes, 1984). Yet, mathematics anxiety is a psychological construct that is similar to, but distinct from, test anxiety (Dew, Galassi, & Galassi, 1983, Hembree, 1990; Hunsley, 1987). One objective of this research is to establish such a theoretical basis for mathematics anxiety within a psychological paradigm.

Mathematics anxiety continues to be a research concern because of the perceptions that it threatens both achievement and participation in mathematics (Hembree, 1990). One's mathematics performance is said to act as a "critical filter" (Sells, 1978) not only for university selections but for careers as well. As we move towards the end of this decade the increasing technological world will demand a higher level of mathematical understanding and skills (Morris, 1981; Smith, 1991) Competence in mathematics is being increasingly used as a selection criterion for the workforce (Douglas, 1991). A goal of the education system is to be preparing and providing the best possible learning environment for all students. The study of mathematics anxiety then is an important educational research concern, as schools are where most mathematics learning takes place.

Mathematics anxiety as a construct appears in the literature as early as 1957, when Dreger and Aiken defined a syndrome of emotional reaction to mathematics as number anxiety. Like most psychological constructs, mathematics anxiety has many definitions. Richardson and Suinn (1972) have defined mathematics anxiety as involving "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical tasks" (p. 551). Lazarus (1974) uses the term 'mathophobia' when he sees the problem as an irrational and impeditive dread of mathematics. Tobias (1976) defines mathematics anxiety as the term used to describe the "panic, helplessness, paralysis and mental disorganization that arise among some people when they are required to solve a mathematical problem" (p. 56). Fennema and Sherman (1976) define mathematics anxiety on similar lines as Richardson and Suinn (1972) as "feelings of anxiety, dread, nervousness related to doing mathematics" (p. 4). The definition of mathematics anxiety for the context of this research will be a negative emotional and cognitive reaction to mathematics that interferes with a person's ability to do mathematics.

Mathematics anxiety is believed to have many causes but schooling is considered a major factor in the development of math anxiety (Greenwood, 1984; Stodolosky, 1985; Williams, 1988). Children are generally not anxious about mathematics until after they reach school. Therefore mathematics anxiety seems to be a learned response since people do not develop it until after they have contact with mathematical environments (Fennema, 1984). If it can be learned then it can be 'unlearned' and interventions for mathematics anxiety could be successful if they are based on the appropriate psychological paradigm. But a major question should be what is happening in schools that is causing mathematics anxiety?

Firstly, mathematics anxiety is found in all facets of the population regardless of age, occupation and gender, but when university students across all disciplines are studied, the largest percentage by discipline of mathematics anxious individuals are found in preservice elementary school teachers (Battista, 1986; Bulmahn & Young, 1982; Hembree, 1990; Kelly & Tomhave, 1985). Bulmahn and Young (1982) and Schofield (1981) feel that mathematics anxiety is transmittable by teachers and that there is a definite relationship between teacher mathematics anxiety and students mathematics anxiety.

Secondly, elementary school teachers are predominantly female so the majority of mathematics anxious individuals in the university setting appear to be female. The relationship between mathematics and gender has consumed a vast amount of research time and effort (Benbow & Stanley, 1980; Orr, 1985; Pratt, 1985; Spear, 1985). It is important to explore this issue and the role that the social construction of gender may have in the development of not only mathematics anxiety, but negative attitudes toward mathematics as well. Chapter II will explicate the research in the area of mathematics and gender.

Thirdly, people who have mathematics anxiety report negative attitudes towards mathematics learning and the mathematics environment (Hembree, 1990; Williams, 1988). Teachers' negative attitudes and behaviour towards learning may contribute to the development of negative attitudes in students towards learning (Meyer, 1980; Stodolosky, 1985; Stodolosky, Salk, & Glaessner, 1991). More specifically, teachers' negative attitudes toward mathematics may be transmitted to their students or may negatively affect students' mathematics achievement (Bulmahn & Young, 1982; Larson, 1983; Morris, 1981; Schofield, 1981).

There are several influences on the development of an attitude toward mathematics. Confidence in the ability to do mathematics may have an impact on the development of attitudes toward the learning of mathematics and on the development of mathematics anxiety (Fennema & Sherman, 1976). As well, whether or not mathematics is perceived as being in the masculine domain may affect how some people respond to mathematics learning (Block, 1981; Fennema, 1980; Schofield, 1982). Another influence on an attitude toward mathematics is the perception that one has of the teacher towards one as a learner of mathematics (Fennema, 1984; Schofield, 1981). These possible influences on mathematics attitude and mathematics anxiety will be investigated during this research.

Finally, the actual teaching methodology of mathematics may also have a role in the development of mathematics anxiety (Clute, 1984; Downie, Slesnick, Stenmark, & Hall, 1982; Greenwood, 1984; Stodolosky, 1985). Some adults can trace the start of their mathematics anxiety to negative experiences with mathematics during early school years (Morris, 1981). The "explain-practice-memorize" teaching paradigm could be a source of mathematics anxiety, since memorization is promoted using this method while understanding and reasoning are neglected (Greenwood, 1984). Therefore, the very nature of mathematics teaching may produce mathematics anxiety (Greenwood, 1984).

The findings that preservice elementary teachers report the highest levels of mathematics anxiety, that teachers with mathematics anxiety may transmit that anxiety to their students, and that the actual teaching methodology of mathematics may promote mathematics anxiety give cause for concern. Research then into mathematics anxiety with the goal of reducing and preventing such anxiety would focus on the population that is perceived to be at risk, that is, preservice elementary teachers. One setting that might be appropriate to study the mathematics anxiety and attitudes of preservice elementary teachers is an elementary mathematics methods course.

This research studied the mathematics anxiety and attitudes toward mathematics of preservice elementary teachers in an elementary mathematics methods course that was designed to reduce mathematics anxiety. The first research question concerns whether or not the preservice elementary teachers' mathematics anxiety levels are reduced after completing the elementary mathematics methods course. The second research question explores whether or not attitudes toward mathematics of the preservice elementary teachers are changed after completing the elementary mathematics methods course. The influences on the development of an attitude toward mathematics that were studied are confidence in learning mathematics, the perception of the teacher toward one as a learner of mathematics, the perception of mathematics as a male domain, and the attitude toward success in mathematics. One weakness of earlier research into interventions for mathematics anxiety, was the failure to identify what strategies were successful in reducing the mathematics anxiety. An attempt was made in this research study to identify those strategies that successfully aided in the reduction of mathematics anxiety.

Mathematics anxiety has been linked to mathematics self-efficacy (Hackett & Betz, 1989; Randhawa, Beamer & Lundberg, 1993). The theory behind mathematics self-efficacy is social cognitive theory of Bandura (1986). Social cognitive theory may provide the theoretical basis for mathematics anxiety. This theory as well as three psychological theories - psychoananytic, behavioural and social learning - will be explored in Chapter II in an attempt to explicate the theoretical basis of mathematics anxiety.

There has been research conducted on the mathematics anxiety levels of preservice elementary teachers before and after an elementary mathematics methods course. However, that research did not explore the attitudes that also surround the learning of mathematics, or the explication of a theoretical basis for the development and therefore the intervention of mathematics anxiety (Battista, 1986; Kelly & Tomhave, 1985). Because of the lack of a theoretical basis for mathematics anxiety, further research is necessary to ensure that interventions for mathematics anxiety coincide with its psychological underpinnings. An elementary mathematics methods course could be considered an intervention for mathematics anxiety if one of the intentions of the course was to decrease mathematics anxiety and promote positive attitudes towards mathematics.

Since this research explores not only the mathematics anxiety levels of preservice elementary teachers but also attitudes towards mathematics, the instruments that were the most appropriate for the gathering of the data were the Fennema and Sherman Mathematics Attitude Scales and Mathematics Anxiety Scale (1976). These scales are: a) confidence in learning mathematics; b) perception of teacher towards one as a learner of mathematics; c) perception of mathematics as a male domain; d) attitude toward success in mathematics; and e) mathematics anxiety.

In order to gain a greater understanding of the attitudes of the preservice elementary teachers as they progressed through the methods course and practice teaching experiences, interviews and classroom observations took place. As well an indepth analysis of the elementary mathematics methods course through class observation and instructor interviews was necessary to explore the setting and development of an intervention strategy for mathematics anxiety.

The research questions then are:

1) Are the mathematics anxiety levels of preservice elementary teachers reduced after completing the elementary mathematics methods course?
2) Are the attitudes toward mathematics of the preservice elementary teachers changed after after completing the elementary mathematics methods course?
3) What are the components of the elementary mathematics methods course that aid in the reduction of mathematics anxiety?

Definition of Terms

Anxiety: A conscious feeling of fear, involving physiological arousal, and disruptive or disorganization of effective problem solving and cognitive control, including thinking clearly and coping effectively with environmental demands (Barlow, 1988).

Attitude toward mathematics: Feelings of like or dislike for mathematics. For this study the influences on an attitude toward mathematics are confidence in learning mathematics, perception of mathematics as a male domain, perception of the teacher toward one as a learner of mathematics, and feelings toward success in mathematics.

Attitude toward success in mathematics: A measure of how much individuals desire to be successful in mathematics. For this study an operational definition of attitude toward success in mathematics is the score received on the Attitude Toward Success in Mathematics Scale (Fennema & Sherman, 1976). The higher the score the more positive the attitude toward success in mathematics.

Confidence in Learning mathematics: A measure of the confidence in one's ability to learn and to perform well on mathematical tasks. For this study an operational definition of confidence in learning mathematics is the score received on the Fennema-Sherman Confidence in Learning Mathematics Scale (Fennema & Sherman, 1976). The higher the score, the more positive the confidence toward learning mathematics.

Mathematics Anxiety: A negative emotional and cognitive reaction to mathematics that interferes with a person's ability to do mathematics. For this study an operational definition of mathematics anxiety is the score received on the Mathematics Anxiety Scale (Fennema & Sherman, 1976). The higher the score, the more positive or lower anxiety levels.

Mathematics as a Male Domain: A measure of the degree to which individuals see mathematics as a male, neutral or female domain. For this study an operational definition of mathematics as a male domain is the score received on the Mathematics as a Male Domain Scale (Fennema & Sherman, 1976). The higher the score, the less mathematics is perceived as a male domain.

Perception of Teacher: A measure of students' perceptions of their teachers' attitudes toward them as learner of mathematics For this study an operational definition is the score received on the Teacher Scale (Fennema & Sherman, 1976). The higher the score, the more positive one perceives the teacher towards one as a learner of mathematics.

Preservice Elementary Teacher: An individual enrolled in a teacher degree program and courses which prepare him/her to acquire elementary certification for teaching.

Limitations

The characteristics of the sample may restrict the generalization of findings from this study to different groups, settings, and situations. The sample under investigation was primarily female preservice elementary teachers with limited mathematical backgrounds. Further, only preservice elementary teachers attending one university were studied. Another possible limitation is that the same instructor taught all sections of the elementary mathematics methods course throughout the study.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Even though mathematics anxiety is a construct that has been widely explored in the literature there is still an ambiguity and a lack of consistency with which people use the expression (Woods, 1988). Therefore an understanding of what mathematics anxiety is and how it develops, is required. Before mathematics anxiety can be understood, general anxiety itself needs to be explored. Thus, in this chapter first a brief explanation of anxiety is given, followed by a definition of mathematics anxiety. Next, biological, environmental and psychological explanations for how mathematics anxiety develops are explored. As the explanations evolve it becomes clear that they are not distinct but are intertwined.

Biological explanations attempt to explain mathematics anxiety on the basis of differences between the sexes. These explanations pose that males are innately more mathematical than females, and in support of this stance present theories to prove that sex differences favouring males in mathematics exist. If males are innately superior in mathematics to females, then they could also be innately less anxious about mathematics. Biological theories such as brain hemispheric organization (Burbank, 1981; Loviglio, 1981), spatial visualization (Springer & Deutsch, 1981), and the presence of a math gene (Benbow & Stanley,1980, 1982), hypothesize that males are innately superior and less anxious in mathematics than females.

Environmental explanations for mathematics anxiety attempt to show that any differences that do occur in the area of mathematics are actually gender differences. That is, differences arise through a variety of socialization factors, not through biology. Therefore differences in mathematical performance and mathematics anxiety exist as a result of environmental factors such as differential course taking (Bleier, 1986; Brophy, 1986; Chapline, 1980; Fennema, 1984; Kimball, 1982; Maple & Stage, 1991, Smith & Walker, 1988), the perception of mathematics as a masculine domain (Baker, 1987; Crockett & Petersen, 1984; Gaskell, 1987, Sells, 1973), differential teacher expectations and behavior (Avery & Walker, 1993; Feldheusen & Willard Holt, 1993, Lockheed, 1984; Ohrn, 1993; Stanworth, 1983), confidence in and perceived usefulness of mathematics (Fennema, 1984; Fennema & Sherman, 1977; Randhawa, Beamer & Lundberg, 1993), and the methodology of teaching mathematics (Battista, 1986; Greenwood, 1984; Kelly & Tomhave, 1985; Stodolosky, 1985).

The psychological explanations for mathematics anxiety are intertwined with the environmental explanations of mathematics anxiety. If mathematics anxiety is a distinct form of the psychological phenomenon of anxiety, then it should be explained by a psychological theory. Thus, the psychoanalytic, behavioral, social learning, and social cognitive theories of anxiety are discussed and mathematics anxiety is examined within each of the theories. Once mathematics anxiety is defined and placed within a psychological model, treatments for mathematics anxiety may be developed. A psychological theory should then not only provide an explanation for anxiety, but also techniques and strategies for the intervention and prevention of such anxiety. Therefore interventions for mathematics anxiety and their psychological rationales are reviewed. This review of intervention programs for mathematics anxiety illuminates the placement of mathematics anxiety within a specific psychological explanation.

Anxiety

Despite the fact that anxiety has long been a research concern, there remain many definitions of anxiety (Michels, Frances & Shear, 1985; Warren & Zgourides, 1991). Several definitions of anxiety indicate that it generally has an unpleasant nature (Spielberger & Sarason, 1975). As Ruebush (1963) points out, "almost everyone agrees that anxiety is an unpleasant feeling state, clearly distinguishable from other emotional states and having physiological concomitants" (p. 461). Anxiety can also be defined as a "painful or apprehensive uneasiness of mind usually over an impending or anticipated ill" (Webster, 1976, p. 51). Levitt (1980) summarized his views on anxiety as follows:

> anxiety is timeless; but only in recent years, with the growth of sophistication in the mental health professions and the behavioral sciences, have we begun to realize its enormous impact on human life. The list of phenomena in which it has been claimed that anxiety plays a role is imposing. Nearly every identifiable form of pathology - psychological, physical and social - is included. Almost every corner of human endeavor is thought to be affected somehow by anxiety. . . Anxiety is not only our official emotion; it is the primary focus of a concerted effort aimed at the improvement, and perhaps the perpetuation of human life. (p. 2)

Barlow (1988), suggests that anxiety is comprised of three major components: (a) a conscious feeling of fear; (b) physiological arousal, and

(c) disruptive or disorganization of effective problem solving and cognitive control, including difficulty in thinking clearly and coping effectively with environmental demands.

When individuals encounter similar situations to those that previously provoked anxiety reactions, they respond with increased levels of anxiety. These anxiety reactions are characterized by feelings of apprehension and tension. When people are anxious they may try to avoid the anxiety producing situation. If placed in such a situation, anxiety arises and the level increases. Therefore, in an educational setting when anxious people avoid a certain subject, they have increased anxiety levels when placed in a situation where they must deal with such subject matter because they have not acquired the prerequisite skills (Greenwood, 1984; Hodges, 1983). When children are anxious in an educational setting, the detrimental effects of the anxiety "often permeate some of the children's educational and classroom experiences and may cripple or interfere with their intellectual functioning" (Branch, 1968, p. 62). A cycle may result because the child is ashamed to display his/her ignorance in the classroom and so absents him/herself from the class. Such absences may be physical (removal from the classroom) or cognitive (daydreaming). The child falls further and further behind in skills and stays away more and more as the anxiety escalates. This is an instance of how the effects of anxiety on academic performance could be cumulative (Spielberger & Sarason, 1975), because the more anxious the child becomes, the more work that is missed or not learned.

Anxiety, then, is a negative emotional state. This emotional state is unpleasant and often exaggerated in proportion to the threat (Hembree, 1990). Anxiety also shows heightened anticipation so that when similar situations are encountered to those that caused anxiety before, anxiety levels increase. But as Branch (1968) states, "whatever its source, anxiety is so unpleasant an emotion that the instinctive tendency is to eliminate it as swiftly as possible or at least remove it from conscious awareness (p. 16)

All of the definitions appear to have three components in common These are a conscious awareness of fear, physical responses, and an interruption of cognitive functioning. Anxiety then is a conscious negative response, has physiological aspects such as rapid heartbeat and sweating, and interferes with intellectual functioning. Barlow's (1988) definition most clearly describes these common components Therefore, for the context of this research the definition of anxiety is "a conscious feeling of fear, involving physiological arousal, and disruptive or disorganization of effective problem solving and cognitive control, including thinking clearly and coping effectively with environmental demands".

Since, people do not mainly experience general anxiety, the investigation of anxiety has led to the studying of specific situational anxieties (Sarason, 1985). Such situational anxieties include anxiety about taking tests, being evaluated, social situations, and a variety of phobic reactions (Sarason, 1985). The study of mathematics anxiety arose from the outgrowth of the movement to study specific forms of anxiety rather than global anxiety (Sovchik, Meconi, & Steiner, 1981,

Mathematics Anxiety

Part of the lack of consistency with the study of mathematics anxiety involves the many definitions for mathematics anxiety that exist As early as 1957, Dreger and Aiken argued that mathematics anxiety was a distinct anxiety and defined an emotional reaction to arithmetic as number anxiety. Mathematics anxiety was later defined as involving "feelings of tensions and anxiety that interfere with the manipulation of numbers and the solving of mathematical tasks" (Richardson & Suinn, 1972, p. 551). Lazarus (1974) uses the term "mathophobia" when he sees the problem as an irrational dread of mathematics. Tobias (1976) defines mathematics anxiety as the term used to describe the "panic, helplessness, paralysis and mental disorganization that arise among some people when they are required to solve a mathematical problem" (p. 56). Brush (1980) gives this view of mathematics anxiety in an educational setting:

> an extreme negative reaction in the face of mathematics classes and assignments which results in discomfort and may also cause restlessness and irritability. It is a reaction that takes dislike a step further, adding a suggestion of fear. Many people experience some annoyance with an assignment that is too long or boring, but it is one more step to anxiety - when the student feels sure that he [sic] cannot do mathematics and does not want to be anywhere near the places where mathematics is done. (p. 13)

Mathematics anxiety then seems to involve both an emotional and cognitive dread of mathematics (Williams, 1988).

Two main components of mathematics anxiety have been identified: emotionality and worry (Dew, Galassi & Galassi, 1984; Hendel & Davis, 1978; Morris, Kellaway & Smith, 1978; Morris, Davis & Hutchings, 1981; Wigfield & Meece, 1988). The first component, emotionality, concerns the negative physiological and affective arousal. The second component, worry, is cognitive in nature, and involves concern about performance. These components of mathematics anxiety are consistent with the components of anxiety as explained earlier. These components were a conscious feeling of fear, physiological arousal and cognitive disruption. Emotionality can be seen to be similar to conscious feelings of fear, and physical manifestations of that fear, while the worry or cognitive component has been shown to lead to debilitating performance in mathematics and to mathematics anxiety (Hunsley, 1987; Wigfield & Meece, 1988).

Mathematics anxiety then involves conscious negative feelings, feelings of discomfort or restlessness, and mental disorganization. The descriptors for mathematics anxiety are similar to the components of anxiety described by Barlow (1988). The conscious feeling of fear, physiological arousal and the interference with mental processes are all found within mathematics anxiety. Thus, a definition of mathematics anxiety consistent with the psychological definition of anxiety used in this research is necessary. But since many of the current definitions for mathematics anxiety involve circular reasoning by the usage of such terminology as "feelings of tension and anxiety", "fear", and "dread" to describe anxiety, a more appropriate definition is required. Therefore a definition needs to be used that avoids circular description. A definition for mathematics anxiety then is a negative emotional and cognitive reaction to mathematics that interferes with a person's ability to do mathematics.

In summary, anxiety is a psychological phenomenon that involves a conscious negative emotional state, physiological concomitments, and a disruption of cognitive functioning. Since anxiety is such a varied construct it has many subconstructs for specific forms of anxiety. Mathematics anxiety is one such subconstruct. Mathematics anxiety possesses the same components of anxiety such as a conscious feeling of fear, physical manifestations and cognitive interruptions. Therefore mathematics anxiety is defined as a negative emotional and cognitive reaction to mathematics that interferes with a person's ability to do mathematical tasks.

Biological Explanations

Some theories attempt to explain mathematics anxiety on the basis of biological sex differences. Since more females report mathematics anxiety than males it is perceived that there may be biological reasons why females are more anxious with regards to mathematics than males. Biological theories in the area of mathematics have concentrated on trying to find reasons for sex differences in cognitive abilities. Since mathematics anxiety involves a cognitive reaction to mathematics, differences in cognitive abilities may explain the development of mathematics anxiety.

Biological arguments for sex differences in cognitive ability share many common features:

1. they propose a biological basis for socially observed difference.
2. they imply that if a difference is biological it is unchangeable.
3. they assign to a socially constructed trait a physical attribute.
4. they support the idea that the dominant sectors of society (male) are superior.
5. they come at a time when society is convulsed over questions of sex.

6. they are scientifically invalid. (Beckwith, 1983, p. 159)

Several other researchers agree with Beckwith over the difficulties found in biological explanations for sex differences in cognitive abilities. One contention is that scientists have tried to make their data fit their ruling assumptions (Bleier, 1986; Rose, 1986). This means that since it is believed that males are biologically superior, research will find this result. The assumption is that significant cognitive sex differences exist and may be explained by biological factors. As Namenwirth (1986) observes, the distortion in this area of research "can be found in the near-obsessive focus on discovering a biological basis for small average differences between the sexes in behavior, or in the scores achieved on some kind of cognitive test" (p.25). Such theories (as explored below) that attempt to explain sex differences in mathematical ability have focused on brain organization, spatial visualization, and a math gene on the male chromosome. Why bother to continue exploring such theories? Because they point to the social biases inherent in doing research, and they highlight the strong preconceptions of society (Beckwith, 1983).

Brain Organization

Brain organization refers to the degree to which the two hemispheres of the brain differentially execute various functions, or the "degree to which functions are lateralized or organized asymmetrically" (Crockett & Petersen, 1984, p. 90). Males appear to be more lateralized than females for both spatial and verbal tasks (Burbank, 1981; Loviglio, 1981; Weintraub, 1981). This means that in females, cognitive functions are more likely to be processed in both hemispheres, while in males a single hemisphere predominates. The hypothesis is that male lateralization is the more effective method of brain organization. This hypothesis then, that links greater lateralization (or specialization) with greater efficiency, should also predict a male superiority in verbal tasks; this is contrary to research in which females tend to outperform males in verbal tasks (Feingold, 1992; Hyde, 1981; Maccoby & Jacklin, 1974).

Several researchers, in conducting reviews of the literature in the area of brain organization for sex differences (Alper, 1985; Caplan, MacPherson & Tobin, 1985; Fairweather, 1976; Kimball, 1981; McGlone, 1980), found that the majority of studies were flawed due to uncontrollable factors, non-random selection of subjects, and false assumptions. Furthermore, there was no general agreement among the various studies. There is as much or more variation in brain organization among members of each sex as there is between the sexes (Crockett & Petersen, 1984; Feingold, 1992).

The results obtained in tests of lateralization of cognitive functioning are strongly influenced or negated by such uncontrolled or uncontrollable factors as age, task difficulty, test procedures, information-processing strategies by the subject, practice during the test, memory duration, and general aptitude. The fragile nature of the findings do not support a lateralization theory of cognitive sex differences (Bleier, 1986). The basic patterns of male and female brain asymmetry are more similar then they are different (McGlone, 1980). As Fairweather (1976) concluded in his review of the research in sex differences in cognition, "what had before been a possibility at best slenderly evidenced, was widely taken for fact; and 'fact' hardened into a 'biological' dogma" (p. 233). Even with these criticisms, the research into cognitive sex differences continues.

Spatial Visualization

One cognitive trait explored to explain why males may be superior in mathematical ability is spatial visualization, that is, the ability to rotate three-dimensional figures mentally (Crockett & Petersen, 1984). The research is this area is divergent and inconclusive Even if sex differences in brain lateralization of visuospatial functioning were clearly demonstrated, there is no evidence of any correlation between visuospatial ability and brain lateralization (Bleier, 1986). Even if males and females have different hemispheric lateralizations, this does not indicate that the male lateralization (information processed in one hemisphere) is superior over female lateralization (information processed in both hemispheres). The assumption is made that male lateralization must be superior since it is found in males. This illustrates the claim made earlier that scientists fit their data to their ruling assumption (Beckwith, 1983; Bleier, 1986; Rose, 1986). In meta analytic reviews of the literature in the area of sex differences in mathematical ability Kimball (1981, 1989), and Jacklin (1989) found that there are no notable sex differences found in spatial visualization. There are studies that find sex differences in spatial abilities but no sex differences in lateralization, studies that find sex differences in lateralization but not in spatial abilities in the same test groups, and studies that find no sex differences in either lateralization or ability (Kimball, 1981).

The biological argument is that right hemispheric lateralization of visuospatial processing in males accounts for their superiority in visuospatial skills. But this assumption is a product of circular reasoning:

> men are superior in visuospatial skills because their
> right hemispheres are specialized for visuospatial

> cognitive processing; we know that right hemispheric specialization provides superior visuospatial skills because men have better visuospatial skills than women, who use both hemispheres for visuospatial processing.
>
> (Bleier, 1986, p. 154)

If it is true that women use both hemispheres for processing visuospatial information, there is no reason to believe that this situation makes them inferior rather than superior for visuospatial processing. In fact, females tend to outperform males in verbal tasks even though the hemispheric argument would predict male superiority (Feingold, 1992; Maccoby & Jacklin, 1974). Therefore if the hypothesis cannot explain why males are inferior in verbal tasks, how can it purport to explain male superiority on mathematical tasks?

The implications of this research are even more problematic when mathematical ability is assumed to be synonymous with visuospatial processing and ability. Friedman (1989) in a meta-analytic review of sex differences in mathematical tasks found that the research is inconclusive in the area of sex differences and spatial visualization. The results from empirical studies that have explored the relationship between mathematics ability and spatial visualization are not consistent (Fennema, 1984). Several studies indicate that spatial visualization does not account for differences in mathematical performance (Armstrong, 1981; Fennema & Sherman, 1977; Fennema & Tartre, 1985; Pattison & Grieve, 1984). Other studies have found spatial visualization to be a significant predictor of mathematical success for girls, but not for boys (Fennema & Tartre, 1985; Smith, 1964; Weiner, 1984), while yet other studies found the opposite (Connor & Serbin, 1985; Very, 1967). In summary, theories of brain organization and spatial visualization do not indicate that biological sex differences exist in mathematical ability

Mathematics Gene

Another biological theory in the search for reasons for sex differences in mathematical ability concerns the possibility of a mathematics gene. The mathematics gene theory arose mainly from the Benbow and Stanley (1980, 1982) studies of mathematically precocious youth. Benbow and Stanley (1980, 1982) suggest that there is an innate superior mathematical ability in males. They base this assumption of the larger number of seventh-grade boys scoring above 600 on the mathematics section of the SAT (Scholastic Aptitude Test) than seventh-grade girls. The study found that the number of boys who had scores over 600 on the SAT in 1979, was 3.5 times the number of girls. These results are contrary to differences found in other studies on mathematical performance. Friedman (1989) in a meta analysis of studies of sex differences in mathematical tasks from 1974 to mid 1987, concluded that the average sex difference is very small, on the side of male advantage, and that sex differences are decreasing over the years. Friedman's (1989) analysis agreed with Alper (1985), Kimball (1981), and McGlone (1980), that any differences that are found, up to approximately age 10, favour females. During the junior high school years a mixed pattern develops in which some studies report small differences in favour of girls, while other studies favour boys, and yet others find no differences (Friedman, 1989).

Criticisms of the Benbow and Stanley (1980, 1982) research have been numerous (Beckwith & Woodruff, 1984; Bleier, 1986; Chipman, 1981;

Crockett & Petersen, 1984; Fox, 1984; Friedman, 1989; Kimball, 1982; Schafer & Gray, 1981). One such criticism is that if the SAT-M (Scholastic Achievement Test - Math) was administered in the United States to students previously identified as being in the top 3.0 percent of all students in mathematical reasoning ability (Kimball, 1982), and almost half (43 percent) of these superior students were female, how can there be a male mathematics gene for superior ability?

Another criticism is that no known test, including the SAT, measures innate mathematical ability, nor is it clear how innate mathematical ability could even be measured or exist apart from experience (Bleier, 1986). The SAT is not a test of mathematical ability but a test of mathematical reasoning skills (Educational Testing Service, 1980). Therefore conclusions cannot be drawn about innate mathematical ability from this test (Crockett & Petersen, 1984). The SAT was developed and has evolved to be a predictor of academic performance in college. "Nowhere in the construction of these tests does a mechanism appear for connecting test scores with an innate ability" (Beckwith, 1983, p. 167). Performance on any test is a result of the interaction between the brain and experience. Environmental factors provide as reasonable an explanation for the test scores as do genetic factors (Beckwith, 1983).

The biological argument, offered by Benbow and Stanley (1982) as an explanation for their results has two strands, one negative and one positive. The negative strand negates a socialization argument, while the positive strand promotes biological differences. The negative strand contends that socialization cannot explain the differences found in junior high school for two reasons. One reason is that differential coursework has not yet taken place, the other reason is that sex-role socialization is just beginning to operate in junior high school and it could not produce such large differences so quickly.

The positive strand of the biological explanation relates to a study by Geschwind and Behan (1982), and Geschwind (1984), of an association between left-handedness, certain disorders of the immune system, and developmental learning disabilities more common in boys (e.g., autism, dyslexia, or stuttering). Geschwind and Behan proposed that testosterone (male hormone), present in the fetal environment, accounts for the right hemispheric dominance of males. Since Benbow and Stanley found a high rate of auto-immune disorders and left-handedness among their population, they concluded that there is a biological explanation for male dominance in mathematical performance. The argument is again a circular one:

> The argument is a kind of transitive "go-together" one; males "go-together" with left-handedness and auto-immune disorders, left-handedness and auto-immune disorders "go together" with giftedness in mathematics. "Go-together" and its nearly synonymous phrases "are correlated" and "are related" do not denote transitive relations. For instance, we cannot conclude that height and amount of exercise are related because height is related to weight and weight is related to amount of exercise. (Friedman, 1989, p. 186)

This criticism of a circular argument to support a biological theory is similar to the circular argument pointed out by Bleier (1986) and Crockett and Petersen (1984) concerning hemispheric lateralization and visuospatial ability. There is no direct evidence of genetic factors underlying mathematical ability. The relationship between spatial ability, mathematics and a mathematics gene remains ambigious (Crockett & Petersen, 1984).

However, the magnitude of the sex differences found by Benbow and Stanley may also be called into question. Fox, Brody and Tobin (1980), found in their analysis of the same data that sampling bias may have contributed substantially to the sex difference in mathematics scores. When students were recruited on a volunteer basis the sex difference was the largest, and nearly disappeared when recruitment was based on randomness. The possibility that the observed sex differences that Benbow and Stanley (1980) found was due partly to sampling bias cannot be ignored since the Benbow and Stanley sample was a subsample of the larger Fox study (Crockett & Petersen, 1984). Ethington (1990) using recent data from the Second International Mathematics Study, found that there were no substantial gender effects in any of the mathematical content areas, and the slight effects shown, favoured girls more often than boys. This study involved over 40,000 participants from twenty-four countries. In a review of mathematical ability tests, Low and Over (1993) found that the distribution of scores for boys and girls overlap extensively. Even when the mean scores do differ statistically, the magnitude of this difference is small in relation to the extent of within gender variability in scores.

Benbow and Stanley ruled out the differential course taking theory to account for differences in mathematics scores on the SAT. Since elective courses in mathematics are not available until high school, these researchers concluded that the boys and girls in their sample had similar mathematics preparation. Therefore, they concluded that sex differences in mathematical ability can be attributed to genetics. A problem with this Benbow and

Stanley (1980) conclusion is that the ruling out of differential course taking, is not the same as ruling out the effects of all experiential factors on SAT mathematics scores. The experiences of boys and girls differ substantially prior to seventh grade. The different kinds of toys girls and boys are given to play with, the encouragement of boys interests in sports, and parental attitudes towards their children's schoolwork all contribute to differential experience (Beckwith, 1983). Such differences could account for differences in mathematics scores (Lockheed, 1984). Benbow and Stanley (1980) admit that not all environmental explanations have been discounted, but they still support a biological argument.

In a further analysis of the Benbow and Stanley (1980) results, Becker (1990) concluded that girls may in fact be better mathematical reasoners than boys. The girls excelled on those items (miscellaneous and data sufficiency) that were more independent of classwork and problems to which they had been exposed to, through textbooks or readings, and performed less well on algebra items. Therefore, the girls may be better mathematical reasoners since the items on which they scored higher required better reasoning skills (Becker, 1990)

<u>Summary</u>

The conflicting nature of the findings of sex differences does not indicate biological reasons for females to be more math anxious than males, or for any part of the population to be more predisposed to mathematics anxiety The biological theories of brain organization, spatial visualization and a math gene are inadequate for explanations of sex differentiated mathematical cognitive ability. The use of circular arguments as proof of biological sex differences discredits any scientific basis for such theories.

The dichotomy between heredity and enviroment underlies efforts to measure and define sex differences and to discover forces shaping sexually differentiated behaviours and characteristics. The criticisms of the biological arguments for sex differences in cognitive abilities support environmental explanations. Thus, the influence of environmental factors on the development of human behaviour and cognitive mathematical ability are examined next.

Environmental Explanations

When sex differences in cognitive abilities are present, environmental factors may provide an explanation for these differences (Beckwith, 1983; Fennema, 1977, 1984). When sex inequity exists in mathematics it becomes necessary to know what factors influence the development of such differences. Being able to identify where these differences exist is relatively simple, understanding why they exist is more complex (Fennema, 1984).

Sex differences in mathematics in favor of males are decreasing over time and any differences found are so small as to be of little, if any, educational significance (Friedman, 1989; Robitaille, Schroeder, & Nicol, 1991). Friedman (1989) conducted a meta-analysis of studies on sex differences (from 1974 to 1987) and concluded that environmental factors rather than biological factors have had an impact on mathematics achievement. In a study on sex differences in mathematical performance involving over 77,000 students in 19 countries, Baker and Perkin Jones

(1993) found that on average boys do not do better than girls everywhere. Where variations in mathematical performance do appear across nations, this variation correlates to variation in women's access to higher education and the labour market. That is, in countries that approach equal opportunities for females and males, smaller sex differences in mathematical performance are found. These researchers also found that sex differences in mathematical performance have declined and that this decline appears associated with an expansion of opportunities for females. Because the differences in male and female abilities are becoming smaller so rapidly, evolution would not have time to take place, therefore something else, besides biology, must account for the narrowing of the differences.

The wide variation that is found across cultures, individuals, ages, settings, and historic periods indicate that many aspects of sex differences are acquired rather than biologically determined (Serbin, Powlishta, Gulko, 1993). Therefore any differences that are found between the sexes may be due to socialization and not to heredity. In an attempt to understand such a social construction of mathematics inequality environmental factors studied are differential course taking, perception of mathematics as a male domain, differential teacher expectations and behavior, confidence and perceived usefulness of mathematics, and the methodology of teaching mathematics.

Differential Course Taking

The differential course taking hypothesis is that because females take fewer mathematics courses than males, gender differences favouring males, would be found. The attrition rate in mathematics for females is considerably higher than for males, serving to compound the problem of achieving equity in gender in mathematically related careers (Ronau, 1994). The mathematics achievement of females is equal to or higher than that of males for the first several years of schooling, but then females gradually fall behind during the junior and senior high school years (Brophy, 1986; Friedman, 1989). Brophy maintains that these gender differences are due not only to the differences in beliefs about the relevance and importance of mathematics but also in the enrollment in mathematics courses. Women take fewer mathematics courses than males (Bleier, 1986; Brophy, 1986; Chapline, 1980; Fennema, 1984; Kimball, 1982). Even when women are achieving well in mathematics they do not continue their mathematics education (Maple & Stage, 1991). Farkas, Sheehan, and Grobe (1990) found that when coursework mastery was held constant, girls actually receive higher course grades than boys.

In Benbow and Stanley's (1982) study of mathematically gifted students, of those students who went to college, 81 percent of the males and 68 percent of the females took at least one mathematics course beyond their first semester. Even though this difference was significant, Benbow and Stanley (1982) concluded that it was not worthwhile to ponder on reasons for this differential course taking because they did not consider it important. Other researchers such as Kimball (1982) and Bleier (1986) would say that this difference is important since it points to environmental reasons for continuing with mathematics education. These are the girls who are mathematically talented and report receiving significantly better grades than their male counterparts (Benbow & Stanley, 1982), and yet they still do not pursue mathematics courses or careers to the same extent as males. Similar results were found in a study of 229 gifted high school students by

Feldhusen and Willard-Holt (1993). They found that boys showed a greater preference for mathematical or science careers even though the girls were equally capable.

The findings of Smith & Walker (1988) support the differential course-taking hypothesis for sex differences in mathematics achievement. They found that when female students have a similar instructional history to that of male students, they appear to perform as well on curriculum specific tests. Moore and Smith (1987) studied the mathematics test achievement of 11,914 young men and women aged 15 to 22 to analyze sex, education, and ethnic group effects. They found that differential course taking appears to be a significant factor in intergroup differences. The underlying issue here is why women take fewer courses. The differential course taking hypothesis may explain why sex differences in mathematical performance and mathematics anxiety exists, but it does not answer why females do not continue with mathematics education or careers. Other environmental explanations may provide some answers. One possible reason that may preclude females from taking mathematics courses may be the perception of mathematics as a male domain.

Mathematics as a Male Domain

Students' interaction with family, school, and society may develop gender related differences in mathematics and science achievement (Reyes & Padilla, 1985). Males receive greater peer, parental and teacher support than females in regards to mathematics education (Baker, 1987; Crockett & Petersen, 1984; Gaskell, 1987; Maple & Stage, 1991; Sells, 1973). The lack of women in most scientific fields may be a result of their perception of mathematics as a male domain (Baker, 1987; Fox, Tobin & Brody, 1979; Jacobwitz, 1983). Schoenberger (1980) sees the lack of women in certain careers as a Catch-22 situation. Females are shut out of technological careers because they lack the prerequisite mathematical skills, they lack these fundamental skills as a result of the bias against females to study mathematics, and the lack of support from female role models. Therefore females do not continue taking mathematics courses because of the perception of mathematics as a male domain. Ethington (1992) found that while stereotyping mathematics as a male domain influences whether or not female students decide to continue taking mathematics courses, it has no effect on male students decisions. A survey of stakeholders in the provision and delivery of public school education in the three Maritime provinces found that over 80 percent of respondents felt that problems with self-perceptions do not enable females to choose non-traditional (i.e., mathematical) careers (MPEF, 1991).

Little attention has been paid to the ways in which the organization of social relations in school contributes to the creation of sex-role expectations (Corrigan, Curtis & Lanning, 1987). There is an inherent danger to this lack of attention because these patterns of social relations which are socially produced patterns eventually come to be accepted by individuals as part of a natural inevitable order (Gaskell, 1987). The fear is that it becomes a tendency for educators and the public to accept as natural the absence of girls from mathematics (Kimball, 1982).

One example of how society may accept as natural that mathematics is not for girls (women) involves the recent introduction of a new product on the toy market. This new product is a female doll with a microchip which enables it to speak. Mattel, a major toy manufacturer, is the developer of this new toy, a Barbie doll, called Teen Talk Barbie. Teen Talk Barbie says "Math class is tough". Once the doll hit the market (1992) criticism quickly arose from the Canadian Advisory Council on the Status of Women, and the Canadian Mathematics Society. (Toronto Globe and Mail, October 10, 1992). Their fear was that this toy would perpetuate the stereotype that girls cannot do mathematics and that mathematics is too difficult for girls. Mattel's response was that while it reflects society's values, Mattel does not set them (Toronto Globe and Mail, October 10, 1992). Furthermore, when Mattel marketers surveyed teenagers and the negative reference to mathematics was made, "no bells went off", and the decision was made to include the comment in Barbie's repertoire. This is the real concern. It was accepted as natural that girls find mathematics class difficult (or tough) and therefore a teen Barbie (that reflects society's values) should also find mathematics class tough. Mattel further responded that since the chance of getting a negative mathematics Barbie was only 1 in 4000, due to the fact that there were 64 different "looks" to Teen Talk Barbie, and 80 different voice chips saying 4 different things there really was no cause for concern. (Toronto Globe and Mail, October 10, 1992). Mattel did acknowledge that it had no intentions of promoting negative feelings towards mathematics, nor of presenting a stereotype that females find mathematics difficult and recalled the dolls from store shelves. This return policy made the dolls instantly collectible (Halifax Chronicle Herald, February 11, 1993). The furor over the Barbie doll is really anger over the acceptance of mathematics being perceived as being in the masculine domain, and of it being natural that women would find mathematics difficult.

Belenky, Clinchy, Goldberger, and Tarule (1986), in their research on "women's way of knowing", found that most women could recall actual incidents in which they were discouraged from pursuing some mathematical work on the grounds that it was "unfeminine". Psychologists argued for years that sex roles were biologically based and therefore it was important for boys to be clear that they were boys and for girls to be clear that they were girls (Gaskell & McLaren, 1987). The process of schooling was to reinforce these differences and as Gaskell and McLaren (1987) point out, "teachers were encouraged to use books which represented the world of little boys in an attempt to cater to their needs in the classroom" (p. 7).

Several reviews of studies about women and science have drawn the conclusion that society has been discouraging to girls with an interest in, and talent for, science and mathematics (Bleier, 1986; Ernest, 1976; Fennema & Sherman, 1977, 1978; Kelly, 1979; Namenwirth, 1986; Sherman, 1980). Girls were discouraged from developing interests in science and mathematics because an aptitude for mathematics implies a bent for analytical intelligence and objectivity, and such characteristics are considered unfeminine and thus, socially unacceptable (Namenwirth, 1986). In a critique of modern science, Fee (1986) concludes that women:

> have been convinced that they are incapable of understanding science and mathematics. The sciences are presented as quintessentially male forms of knowledge: abstract, depersonalized, objective, authoritative. The woman who engages in scientific knowledge, who struggles and debates the meaning of its claims and pronouncements, is confronting power, breaking the taboo, eating the apple in the garden. (p. 44)

The wonder is *not* that there are not more women in mathematics but, that there are *any* at all (Fee, 1986).

Maccoby and Jacklin (1974) found a strong indication that parents tend to encourage "feminine" activities in girls and "masculine" activities in boys, while discouraging their children (especially boys) from engaging in gender-inappropriate activities. Children are clear from a very early age whether they are boys or girls. By the time they are four or five, children hold highly sex-typed occupational aspirations as well as play interests (Serbin, Powlishta, & Gulko, 1993). By the age of ten, children make stereotypical judgements based upon behaviour, traits, occupation, or physical characteristics (Lobel, Bempechat, Gewirtz, Shoken Topaz, & Bushe, 1993). A child's experience is tied to his or her gender label. Behavior then, is guided by gender-role expectations because not only are they the basis for differential reinforcement and punishment, but these expectations are also internalized in the older child as part of her or his self concept (Crockett & Petersen, 1984; Thomas, 1990). Once a child understands the category of gender, subsequent information may be integrated in terms of this classification. Concepts such as masculine or feminine are extremely resistant to change (McAninch, Manolis, Milich, & Harris, 1993).

Gender differences in mathematical achievement start to appear during adolescence (Feingold, 1992; Maccoby & Jacklin, 1974), at the same time as the onset of puberty Possibly the emergence of secondary sex characteristics strengthen adult expectations and self perceptions. Girls may now be encouraged to act "feminine", and this may mean discouraging achievement in areas that are deemed to be masculine such as mathematics (Becker, 1990; Fennema & Sherman, 1977). "Especially in the case of mathematics, it seems likely that adolescent sex-role conformity affects attitudes towards the subject in a way that contributes to sex differences in performance" (Crockett & Petersen, 1984:p. 108).

Both the Fox, Brody, and Tobin (1980) and the Benbow and Stanley (1982) studies found that mathematically gifted girls were less likely than boys (with similar talent) to continue with mathematics courses. Fox and associates concluded from interviews with the students that some of the girls felt it would hurt them socially to participate in an accelerated mathematics program. As Crockett and Petersen (1984) conclude:

> Thus, gender labels, deriving ultimately from biological differences between males and females, and sex-role stereotypes based on cultural tradition combine to limit the achievement domains of boys and girls, their educational preparation, and their career opportunities. (p. 109)

Living in a gender differentiated society, girls and boys develop different social expectations based upon different social experiences (Ohrn, 1993). If mathematics is perceived as a male domain then females will believe it is an inappropriate activity for them, and at odds with their gender-role identity.

Differential Teacher Expectations and Behaviors

The field of classroom interaction and gender has been the focus of much research. The general picture is that boys have a more prominent position in the classroom than girls (Avery & Walker, 1993; Feldhusen & Willard-Holt, 1993; Lockheed, 1984; Ohrn, 1993; Stanworth, 1983). Gender differences are found not only in students' own behaviour but as well as in the way students are treated by teachers. "Boys participate more in the public life of the classroom as compared to girls, they behave in a more assertive, demanding manner and they are more readily identified by teachers, and receive a greater proportion of the teachers attention' (Ohrn, 1993, p. 147). The male child in the classroom has greater leadership experiences and prominence (Lockheed, 1984). 'Both teachers and other students behave as if boys were more important than girls in the classroom' (Lockheed, 1984, p. 123). Teachers sex-stereotype academic courses by making more academic contacts with boys in mathematics and girls in reading (Kelly, 1988; Leinhardt, Seewald, & Engel, 1979, Mifsud, 1993). 'Sex segregation and male preeminence may also be attributed to unconscious beliefs held by children regarding sex differences in competence (Lockheed, 1984, p. 126). Males are expected to be more competent than females in mathematics and therefore society ensures that they are encouraged to participate longer in mathematical courses.

Kelly (1988), in a meta-analytic review of gender differences in teacher-pupil interactions, found a consistent under representation of girls in teacher-pupil interactions (both positive and negative). The smallest gender differentiation in instruction occurred in reading while the larger gender differences were in science, social studies and mathematics A disturbing revelation was that even when 'girls were in the majority in class the few boys who were present still received a disproportionate amount of teacher attention" (p. 10). The meta-analytic review showed that despite teachers' frequent contention that they treat and wish to treat both sexes the same, teachers (male and female) consistently interact more with boys than with girls (Kelly, 1988). Holden (1993) found similar results. That is, girls talk less in mixed sex classrooms, and boys tend to dominate discussions, especially during mathematics classes. A further finding was that when girls are in small groups, and in the majority, they finally have their 'fair share' of talk in mathematics and technology tasks.

An important component of the learning environment is the teacher. A student's development of gender-role standards is influenced in part by the teacher. This influence of the teacher includes definitions of acceptable achievement levels in various subjects (Fennema, 1984). Boys seem to be more prominent than girls in the teacher's view (Lockheed, 1984). The hypothesis of differential teacher expectation as explained by Fennema (1984) is:

> because of societal beliefs that males are better at mathematics than females, teachers expect that boys will understand high cognitive level mathematics better, and girls will do better on low-level mathematics tasks such as computation. This belief is communicated in a variety of subtle and not so subtle ways to both boys and girls. For example, a teacher might encourage boys more than girls to stick with hard mathematical tasks until solutions are found . . . Not only could students conclude that high level tasks are easier for boys, they could also conclude that such mathematics was more important for boys since teachers encouraged boys more than girls to succeed in such tasks. (p. 154)

Becker (1990), in a research study involving the same data that Benbow and Stanley (1980) used with mathematically precocious youth, found that some of the differences in mathematical performance may be explained by differential treatment of the sexes within the same formal classes. Although questions regarding treatment of these classes cannot be examined, future research should keep this possibility in mind. In seemingly answer to this question Feldhusen and Willard Holt (1993) found that teachers' biases favouring boys may have a particularly negative impact on gifted girls, since girls show a greater concern for the reactions of teachers. In a review of related literature Becker (1990) reports that women as mathematics students 'reported being treated by their peers 'as though they were strange,' being told 'boys do not like or are afraid of smart girls'; they also reported receiving less attention from teachers, who they believed had lower expectations for them than for boys (p. 67).

There is a general causal connection from teacher expectations through classroom processes to students achievement (Reyes & Stanic, 1988). The sex of a student is an important determinant of teacher student interaction (Hart, 1989). Not only are boys receiving subtle messages about the importance of mathematics, they are also *practicing high level cognitive tasks more* than girls would. The very nature of learning through practice, develops better problem solving abilities in boys than in girls. The problem of differential treatment of male and female students by teachers is well documented (Becker, 1979; Brophy & Good, 1974, Feldhusen & Willard Holt, 1993; Ohrn, 1993; Thomas, 1990) but this is only one factor among many that may contribute to the problem of mathematics anxiety.

Confidence and Perceived Usefulness of Mathematics

Essential to success is confidence in one's abilities. Confidence in mathematics is the belief that one has the ability to perform well on mathematical tasks (Fennema, 1984). If people are not confident about their mathematical ability, they may avoid careers or avenues that require such abilities (Fennema & Sherman, 1977). Such factors as perception of mathematics as a male domain, differential course taking, and/or sex-role socialization may inhibit in females the development of confidence in the ability to do mathematics. When females do succeed in mathematics they attribute their success to factors other than ability, such as luck (Reyes & Padilla, 1985; Wolleat, Pedro, & Fennema, 1980). There does appear to be gender related differences in confidence in learning mathematics (Fennema, 1984). Boys often score higher than girls in confidence in learning mathematics (Hart, 1989).

Mathematics self efficacy is an assessment of confidence in ability to successfully perform a mathematical task (Hackett & Betz, 1989). Confidence in learning mathematics is global in nature, while mathematics self-efficacy is more specific to the task at hand. Hackett and Betz (1989) found that students with high scores on mathematics self-efficacy, tended to report higher levels of confidence in learning mathematics, and lower levels of mathematics anxiety. Girls, as a group, tend to have lower perceptions of mathematics self efficacy and thus are at greater risk than boys of not continuing their engagement with mathematics and mathematics related courses (Randhawa, Beamer, & Lundberg, 1993). Girls have less confidence than boys in their abilitities, particularly in mathematics and science. While both boys and girls face problems with self esteem during adolescence, girls exhibit a marked and long-lasting decline in their self esteem (Harris & Pickle, 1992). Boys in fact tend to overestimate their abilities more than girls (Mura, 1987). During elementary school, girls who are highly capable tend to lose self-confidence and downplay their abilities and achievements

(Feldhusen & Willard-Holt, 1993). Girls are more concerned than boys about appearing "dumb" during mathematics classes (Newman & Schwager, 1993). Thus because girls have a lower expectancy for success and greater anxiety in relation to boys in mathematics class, girls may not seek help from the teacher to avoid appearing "dumb".

Another variable that may explain why females opt out of mathematics earlier than males is the perceived usefulness to females of mathematics (Fennema, 1978; Fox, 1977; Robitaille, Schroeder, & Nicol, 1991). If mathematics does not have a place in future careers then it is not perceived as useful. A report by the Status of Women Canada (1982) on the participation of girls in mathematics, science and technology reports that "the students' perception of the need for and usefulness of mathematics for themselves is found to be the strongest influence on the mathematics course-taking plans of both boys and girls" (p. 15). Therefore if girls do not see mathematics as useful, they will not continue taking mathematics courses - which could lead to mathematics anxiety when placed in situations where mathematics must be done. As well, as early as twelve years of age (grade six) mathematics is stereotyped as a male domain by students (Fennema, 1984).

Therefore confidence and perceived usefulness of mathematics may contribute to a perception of mathematics as a male domain, which may in turn lead to differential mathematics course taking. By opting out of mathematics courses, females may be setting the stage for mathematics anxiety. Females also report that parents, teachers, and counselors are not positive toward them as learners of mathematics (Fennema, 1984).

Methodology of Teaching Mathematics

Since people are generally not mathematics anxious until they go to school (Battista, 1986; Sovchik, Meconi, & Steiner, 1981; Williams, 1988), mathematics anxiety may have its roots in the teachers and the teaching of mathematics (Battista, 1986; Greenwood,1984; Kelly & Tomhave, 1985; Lazarus, 1974; Peterson & Fennema, 1985). Greenwood (1984) feels that the principal cause of mathematics anxiety may lie "in the teaching methodologies used to convey the basic mathematical skills to our youngsters" (p. 663). The teacher is an important influence on the learner in school (Reyes & Padilla, 1985). Stodolosky (1985) stresses the development of mathematics anxiety through the nature of the instruction itself, as it "seems a powerful force in the shaping of later attitudes, expectations and conceptions of learning" (p. 131). Stodolosky offers an explanation for the development of mathematics anxiety through the negative attitudes gained by students through repetitive school experiences of learning mathematics in particular ways.

> There is little doubt that many students perceive math learning as a problem area, cease studying math as soon as they are given the choice, and that math is not viewed favorably by a substantial number of adults. Even if studies do not demonstrate math anxiety at epidemic proportions, by high school it is among the subjects liked least by students. (Stodolosky, 1985, p. 327).

Teachers may be important influences in the development of mathematics anxiety since it may arise through the process of learning mathematics. As well, the mathematics anxiety of the teachers themselves may be an influence in the development of mathematics anxiety of the students. Preservice elementary teachers report the highest levels of mathematics anxiety when university students across all disciplines are studied (Battista, 1986; Bulmahn & Young, 1982; Hembree, 1990; Kelly & Tomhave, 1985). These individuals have generally not taken mathematics during senior high school and/or university (Battista, 1986; Meyer, 1980). Since elementary teachers are primarily female, their mathematics anxiety may be caused by some of the environmental factors just discussed: differential course taking, the perception of mathematics as a male domain, perceived confidence and usefulness of mathematics, and their own learning of mathematics.

Summary

Environmental factors may explain why mathematics anxiety exists. Differential course taking may account for some mathematics anxiety but the more important concern is why differential course taking occurs. One reason given to explain why females do not continue to take mathematics courses and why persons may develop mathematics anxiety is the perception of mathematics as a masculine domain. Women may not continue with their mathematics education because it is perceived as being "unfeminine" to possess mathematical ability. Confidence in one's ability to be successful at mathematics may also contribute to the development of mathematics anxiety. If people are not confident of their ability they will not place themselves in situations where that ability, of lack thereof, will become apparent. Because females do not perceive mathematics as being useful for their future, again females may halt their mathematics education early and develop mathematics anxiety.

The situational context and the nature of the relationship between the teacher and the child are important variables that affect learning and performance. If teachers believe that boys will achieve higher levels in mathematics, then they probably will do so, and if the teachers believe that girls will not achieve as well as boys, then they will also probably not do so. The actual methodology used to teach mathematics may also contribute to the development of mathematics anxiety. Therefore the subtle messages transmitted and received in the classroom and elsewhere, may contribute to the development of mathematics anxiety.

Psychological Explanations

Psychological explanations for mathematics anxiety may assist in the understanding of this construct. Since mathematics anxiety similar components and structure to anxiety in general, a psychological theory of anxiety may provide an explanation for the development of mathematics anxiety. Anxiety will be explored under the following psychological theories; psychoanalytic, behavioral, social learning, and social cognitive.

Each exploration begins with a brief introduction to that psychological theory, and then describes how anxiety develops within that theory. Next, an explanation of how mathematics anxiety is perceived by that theory is developed. Finally, a decision is reached as to whether or not that psychological explanation adequately explains mathematics anxiety based upon an understanding of mathematics anxiety garnered from the related literature.

Psychoanalytic Theory

Psychoanalytic theory centers on evidence of a forbidden impulse threatening to break into consciousness. The Freudian approach argues that phobic reactions result from unresolved conflicts beyond our awareness (Houston, Bee, & Rimm, 1983). Anxiety then is a result of this conflict among the personality components. The personality components are the id, ego, and superego. Simply put the id says, "gimme, gimme, gimme," the ego says, "I'll get it for you if I can," and the superego says, "Don't! It's wrong." (Houston, Bee, & Rimm, 1983, p. 34). Freud developed several models of anxiety, that were partly complementary and at times contradictory (Michels, Frances, & Shear, 1985).

In his first conceptions of anxiety Freud (1915), saw objective anxiety as "an expression of the instinct of self-preservation" (p. 608). It was a natural and rational feeling in response to an external danger. Freud thought that objective anxiety was clearly defined by danger - an external threat is known and the danger is perceived to be high. Freud accepted objective anxiety for what it was, fear of a known external danger and saw no need to explore this area in depth. Therefore he concentrated the development of his psychoanalytic theory of anxiety on neurotic anxiety. Freud (1926/1952) hypothesized that neurotic anxiety "arose from the libido belonging to the repressed instinctual impulses" (p. 749). In further understandings, he stated that the ego was the source of the anxiety and anxiety was seen as a "reaction to a situation of danger" (Freud, 1926/1952,

p. 735). The psychoanalytic theory of anxiety was further developed as being "something felt" that is accompanied by definite physiological sensations. Freud (1926/1952) further elaborated that in humans, anxiety is "modelled upon the process of birth" (p. 737). The traumatic process of being born, also gave birth to anxiety in humans. This anxiety arises as a consequence of moving abruptly from a calm sheltered environment (the womb) into an unfamiliar environment full of stimulation (Levitt, 1980).

In the New Introductory Lectures, in particular Lecture 32 on Anxiety and Instinctual Life, Freud (1932/1952) reconceptualized the notion of anxiety. He further developed the notion of the ego as the seat of anxiety and three main varieties of anxiety - moral, neurotic, and objective. Moral anxiety is perceived as guilt or shame rather than fear. The ego (rational referee) loses control over the superego (the conscience) and the superego threatens punishment for inappropriate id (basic and immediate drives) expressions. Moral anxiety would arise if a child did something that he/she had learned was "wrong" (such as telling a lie), then the child would be punished by his/her conscience (superego) by feelings of guilt and shame. Neurotic anxiety has more of a general apprehensiveness about it, a free floating anxiety as well as the more identifiable phobias. Neurotic anxiety is always related to unconscious fantasies that stem from childhood (Michels, Frances & Shear, 1985). These fantasies deal almost exclusively with sexual instinct. Objective anxiety has a clear identifiable source and is proportionate to the threat posed by the externally feared situation. Freud saw the distinction between neurotic and objective anxiety as being whether or not the danger was known and whether the anxiety arose from an internal or external stimulus. In objective anxiety the danger is obvious, external, and known to the individual. The avoiding of real dangers because of objective or realistic fears is not neurotic, but rather good sense (Michels, Frances, & Shear, 1985). But realistic fears may be exaggerated and used defensively to displace, disguise, and rationalize neurotic anxiety (Michels, Frances, & Shear, 1985).

Since only objective anxiety deals with an external known danger, within the psychoanalytic theory of anxiety, mathematics anxiety would be an objective anxiety. The only other possible explanation (within this theory) could be that mathematics anxiety is displaced anxiety. This would mean that the person is really not fearful of doing mathematics or of being placed in a situation where he or she must do mathematics, but that the person is placing another fear onto mathematics. The most likely source of such a threat would be the environment in which the student finds him/herself. This environment would include the impact of the teacher. This is similar to conditioning in the behavioral model where the neutral stimulus mathematics is paired with a highly charged negative stimulus - the teacher. Freud would argue though that an internal process is going on, in which the fear of the teacher is displaced onto the subject matter. The danger from doing mathematics could be seen as a threat to psychological safety, or that individual's self-esteem. Mathematics could then be perceived as a danger to a person's feelings of self-worth. But why do only certain individuals perceive mathematics as posing a danger? What else must be occurring during mathematical situations? The answers to these questions are not found within the psychoanalytic theory.

To avoid or reduce any danger, an individual would avoid situations that cause such danger. Therefore a person with mathematics anxiety would avoid situations that cause the danger, for example situations where mathematics would have to be done. From the standpoint of psychoanalytic theory this is a successful method of coping with the anxiety. Individuals would be encouraged to concentrate on areas where they were comfortable. It is not perceived as necessary for everyone to be successful in all facets of their lives. The avoidance of objective fears is seen as good common sense and there is no need to develop interventions (Michels, Frances & Shear, 1985). This is not acceptable for mathematics anxiety. If individuals are avoiding mathematical situations or limiting their career choices because of mathematics anxiety, this situation cannot persist. Everyone deserves the right to have the widest possible avenues open for career decisions. The other alternative is to have the individual recognize that the anxiety originated in the teacher's behavior (for example). Recognizing the misplaced anxiety however has not been overly successful in eliminating the anxiety. Further work would need to be done to reduce the mathematics anxiety present and would involve a different psychological perspective.

Because psychoanalytic theory concentrates on neurotic anxiety and on the internal drives for anxiety, it is inadequate when faced with an objective external anxiety such as mathematics anxiety. Freudian theory overemphasizes sexual concerns as the root of anxiety (Houston, Bee & Rimm, 1983). Another concern with a psychoanalytic explanation is the focus on internal influences for personality. Individuals are also shaped by their environment, and by cultural and social influences. There needs to be an explanation for how the external environment interacts to produce anxiety, for an understanding of mathematics anxiety to be complete. Furthermore, psychoanalytic theory does not lend itself to developing a successful intervention program for mathematics anxiety. Behavioral theories concentrate on the external environment for the explanation of anxiety. Possibly these theories can provide a more complete explanation for mathematics anxiety.

Behavioral Theories

Behavioral theories emphasize that behavior is a result of environmental influences (Sarason, 1985), and concentrate on the area of learning and conditioning. Just as Freud is the original major psychoanalytic theorist, Pavlov and Skinner were the first major behavioral theorists. The behavioral theory of classical conditioning was developed by Pavlov (1903). Pavlov emphasized the physical basis of learning and the relationship between conditioning and behavior. In classical conditioning a stimulus known as the conditioned stimulus (CS), is used as a signal that an unconditioned stimulus (US), is arriving, and provokes an unconditioned response (UR) that in turn becomes the conditioned response (CR). The time elapsed between the CS and US influences the speed at which CR's become established (Sarason, 1972). When conditioned responses are not reinforced they usually weaken and eventually disappear.

Aversive classical conditioning assists in understanding how anxiety develops in response to nonthreatening events. Individuals may become "afraid or anxious of neutral things or situations as a result of their close association with painful or noxious stimulation" (Mischel, 1971, p. 64). In this explanation, a person could develop mathematics anxiety as a result of equating doing mathematics with a painful (or embarrassing) situation such as ridicule by a teacher. A direct relationship between the actions of the teacher and the act of doing mathematics must be perceived for such conditioning to take place. In order to reduce anxiety the subject would be gradually exposed to the fearful stimulus through a process of desensitization. The final outcome would be the loss of anxiety in such situations.

B.F. Skinner (1953), in developing a theory of operant conditioning, focused on observed events or instrumental learning. While classical conditioning depends on behaviors elicited by an US, instrumental conditioning depends on the "voluntary" occurrence of behaviors which are either ignored, punished or rewarded (Beck, 1982). Operant behavior is determined by its consequences. If the consequences are reinforcing, then the behavior will be more likely to take place again. The reverse is also true, that is if the consequences are not reinforcing then the operant behavior will not take place in the future.

Skinner (1953) concentrated on the role of reinforcement (or rewards) as determinants of behavior change. Reinforcers can be used either positively or negatively to strengthen responses. A positive reinforcer is presented following a response to strengthen and encourage that response in the future. Examples of positive reinforcers are food, money, and praise. A negative reinforcer is something unpleasant that is removed following a desired response to increase the probability of that response occurring in the future. Examples are the removal of pain or loud noise. The removal of a negative stimulus can be as rewarding as the presentation of a positive stimulus (Beck, 1982; Houston, Bee & Rimm, 1983). While reinforcers strengthen responses, punishers reduce responses. Punishers, as negative reinforcers, involve unpleasant stimuli, but they are meant to decrease the probability of that behavior occurring again. A verbal reprimand, spanking or the taking away of privileges are examples of punishers (Beck, 1982; Houston, Bee & rimm, 1983). Behavior then, is thought to be shaped by the stimuli that follow the behavior.

How does mathematics anxiety fit within a behavioral framework? Mathematics anxiety may develop through punishers that involve the actions of teachers, parents, or others in situations involving mathematics. If a teacher ridicules or speaks harshly to a child during the learning or doing of mathematics, the child may equate the negative experience of being reprimanded with the doing of mathematics. In order to reduce the possibility of being spoken to harshly, or of being criticized, the child may avoid situations that involve mathematics. The child has equated the mathematics behavior to the unpleasant stimulus, and will decrease the probability of that behavior occurring again. But not all individuals in negative situations develop mathematics anxiety. In those cases there is not direct causation between behavior and response for all participants. Something else, must be occurring for only certain individuals to develop mathematics anxiety.

Psychoanalysts concentrate on internal motives, while behaviorists concentrate on external motives. Both psychoanalytic and behavioral approaches see the relief of anxiety through avoidant behavior (Michels, Frances, & Shear, 1985). The conditioned response is similar in usage to the concept of signal anxiety. The differences though between these two models are important. In the psychoanalytic theory anxiety is attributed to unconscious fears, there is a greater emphasis on displacement as opposed to conditioning, and defense mechanisms are mediating variables in anxiety formation (Michels, Frances, & Shear, 1985). Behaviorists attribute the development of anxiety to stimulus and response. Human behavior is more complex than simple causation, otherwise humans would all behave the same way. Therefore, individual's perceptions of the strengths of the importance of reinforcers or punishers must be considered. Behaviorists do not deny that inner events are linked to behavior, but they do negate the importance of such events because these events are presumably caused by external stimuli (Bandura, 1986). Not only do individuals respond to stimuli, but they also process and evaluate such stimuli (Sarason, 1985). A theory of anxiety, in order to be complete, needs to consider the behavior of people as products of ideas, thoughts, understandings, and interpretations of themselves and their environment (Sarason, 1985).

Social Learning Theory

In social learning theory psychological functioning is explained in terms of an interaction of personal and environmental determinants. Bandura (1977) stressed the importance of learning through observed events and attempted to incorporate internal and external motives. Bandura's argument for social learning theory identifies a weakness in the behaviorists' stimulus-response theory. Given the same stimulus there may be several responses that occur, so why do only some responses become reinforcers?, or punishers? Why do only some individuals develop anxiety in certain situations? The answers to these questions may lie within social learning theory.

The focus of social learning theory in attempting to explain human behavior relies on a reciprocal interaction among an individual, behavior, and the environment. The term reciprocal refers to a sense of mutual action between events rather than simple counter-reactions. Response consequences are selected on the basis of success in a similar manner as responses were strengthened or weakened in behavior theory. Since Bandura (1977) sees learning by response consequences as a cognitive process, "consequences generally produce little change in complex behavior when there is no awareness of what is being reinforced" (p. 18). The importance attached to cognitive processes is the major difference between social learning theory and the behavioral model. Therefore it is the awareness an individual has of the environment in conjunction with his or her behavior that allows him or her to decide whether or not that behavior continues.

Observational learning takes place principally through modelling, "from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action" (Bandura, 1977, p. 22). Social learning theory explains the development of anxiety through contingent experiences; humans interpret stimuli, they do not simply respond to them. People will fear and avoid things or events that have been associated with aversive situations, but like and seek those with pleasant associations (Bandura, 1977). This is similar to operant or instrumental conditioning, but the difference arises in the importance placed on the interpretation of the stimuli. That is, behaviorists did not attempt to explain why some responses are attended to and others are not, while social learning theorists do. For example, certain people may come to fear mathematics or feel anxious in mathematics situations because they equate an aversive experience (ridicule by a teacher or peer) with the processes of mathematics. The person has interpreted the event through cognitive processes and consequently avoids situations where he/she must perform mathematics. This may start a cycle of inadequate mathematics learning; because the persons have avoided mathematics, they are unable to perform certain functions in mathematics, and consequently in a mathematics situation are mathematically inadequate, generating further anxiety.

This model could explain why only some people develop mathematics anxiety in similar situations, but just what is occurring cognitively? Bandura (1986) in further research attempted to explore these cognitive processes in more detail.

Social Cognitive Theory

Social cognitive theory arose from the recognition of the importance of cognitive understanding of a situation. The social portion refers to the social origins of human thought and action; the cognitive portion acknowledges the influential causal contribution of thought process to human action (Bandura, 1986). In the social cognitive theory, as Bandura (1986) states:

> people are neither driven by inner forces nor automatically shaped and controlled by external stimuli. Rather, human functioning is explained in terms of a model of triadic reciprocality in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other (p. 18)

The term reciprocal used within the confines of this theory, is not used in the narrow meaning of similar or opposite counter reactions, but rather as a sense of mutual action between determinants.

Because of the interaction of behavior, cognition, and environment, people may "missample or misread events in ways that give rise to erroneous conceptions about themselves and the world around them" (Bandura, 1986, p. 19). This could indeed be the situation with the development of mathematics anxiety. Due to erroneous perceptions about the nature of mathematics, people may develop mathematics anxiety. Because of the erroneous perception that mathematics is a masculine domain, some individuals (women in particular) believe that it is not "right" for them to be successful in this discipline and opt out of mathematics courses at an early stage. Therefore when forced into a situation where they must perform mathematics the prerequisite skills have not been developed and anxiety may result. Another erroneous perception could be that people who are "good" in mathematics can do it quickly and therefore individuals who take more time to solve mathematical problems may perceive that they are not "good" in mathematics and consequently develop mathematics anxiety.

According to the social cognitive theory, human behavior is also regulated by forethought. "People do not simply react to their immediate environment, nor are they steered by implants from their past" (Bandura, 1986, p. 19). Individuals usually anticipate the consequences of their actions and act accordingly. Thus, this could be the situation in the perpetuation of mathematics anxiety. Mathematics anxious persons do not want to place themselves in situations where they may be embarrassed by their perceived inability to be successful in mathematics so they do not allow themselves to be potentially embarrassed. Once a person has a negative experience in mathematics, by continuing to anticipate consequences of doing mathematics in a negative manner, he or she will eventually increase the mathematics anxiety level because the prerequisite skills for being successful in mathematics will not have been learned.

People can learn how to behave vicariously, by observing other people's behavior and its consequences (Bandura, 1986). This vicarious capability is a vehicle for learning to occur through observation. Therefore people can learn to fear mathematics by observing the reactions of various people around them. Conversely, individuals may also learn to enjoy mathematics by observing how other people respond to mathematical situations. As Bandura (1986) states:

> apart from the question of survival, it is difficult to imagine a social transmission system in which the language, lifestyles, and institutional practices of the culture are taught to each new member just by selective reinforcement of fortuitous behaviors, without the benefit of models to exemplify these cultural patterns. (p. 20)

Since the external environment assists in the development of human behavior patterns, it is the interaction between the self, behavior and environment that determines how one acts in any situation (Bandura, 1986).

How people perceive themselves, or think how they should perceive themselves, may impact on their behavior. Self-efficacy is one such perception. Self-efficacy refers to an "individual's situationally specific belief that he or she can successfully perform a behavior required to produce a given outcome" (Bandura, 1977, p. 531). Therefore a person's belief in his/her ability to successfully perform a task (self-efficacy), is a major mediator of behavior. Efficacy involves a "generative capability in which cognitive, social, and behavioral subskills must be organized into integrated courses of action to serve innumerable purposes" (Bandura, 1986, p. 391).

Self-efficacy may also explain the development of mathematics anxiety since there is a marked difference between possessing skills and being able to use them under a variety of circumstances (Bandura, 1986). For example, even though people may possess the same mathematics skills they do not perform equally well in all mathematics situations, or the same person may be able to perform mathematics in one situation (the classroom) and not in another (a test). As Bandura (1986) explains, "different people with similar skills, or the same person on different occasions, may perform poorly, adequately, or extraordinarily" (p. 391). For example one research study on children's mathematical self-efficacy examined:

> children who perceived themselves to be of high or low mathematical self-efficacy, at each of two levels of mathematical ability. They were then given difficult [math] problems to solve. While mathematical ability contributed to performance, at each ability level, children who regarded themselves as efficacious were quicker to discard faulty strategies, solved more problems, chose to rework more of those they failed, did so more accurately, and displayed positive attitudes toward mathematics. (Bandura, 1986, p.391)

Bandura's (1977, 1986) self-efficacy theory provides a useful model for explaining the maintenance and modification of phobic behavior (Warren & Zgourides, 1991). Within the self-efficacy theory the "expectations of personal efficacy determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experience" (Warren & Zgourides, 1991, p. 9). In a continuing examination of his theory, Bandura (1988) has expanded on the role of self-efficacy in the regulation of anxiety arousal. As Bandura (1988) notes, "it is not the sheer frequency of frightful cognitions but rather the perceived self-inefficacy to control their escalation or perseverance that is a major source of anxiety arousal" (p. 89). This sense of low self-efficacy increases the tendency to withdraw from anxiety arousing situations, as these anxious individuals are unable to estimate their ability to cope effectively with such situations (Warren & Zgourides, 1991).

To further understand the cognitive portion of the triad (behavior, cognitions, and environment), Mogg, Mathews and Weinman (1987), state that anxiety is commonly characterized by a "vigilant monitoring of the environment for potentially threatening events combined with active efforts to avoid or reduce the impact of those events" (p. 97). Therefore, the early awareness of an anxiety causing situation and the subsequent inhibition of information processing, could result from a "cognitive avoidance strategy that would be consistent with behavioral avoidance" (p. 97). This vigilance-avoidance pattern of cognitive processing in anxiety may occur in people who are mathematics anxious. The disorder is maintained because anxious individuals are more likely to identify potentially threatening events, and since subsequent cognitive avoidance will prevent a more accurate understanding or evaluation of those events, the disorder perpetuates itself (Mogg, Mathews, & Weinman, 1987).

Cognitive symptoms in anxiety disorders are similar to thinking difficulties. These thinking difficulties include: confusion, lack of recall, blocking, difficulty in reasoning, and difficulty in concentration (Sarason, 1985). One must be able to reason and concentrate, as well as remember certain concepts to be successful in mathematics. A mathematics anxious individual while grappling with questions or instructions, may tend to exaggerate flaws in his/her knowledge and understanding. The negative appraisal of self and of the performance, increases the anxiety, which serves to further interfere with performance, and reinforces the notion of deficiency (Beck & Emery, 1985).

Several researchers have found connections between low mathematics self-efficacy and mathematics anxiety (Hackett & Betz, 1989; Randhawa, Beamer, & Lundberg, 1993), further strengthening a social cognitive understanding of mathematics anxiety. Confidence in learning mathematics which is a more general feeling than mathematics self-efficacy, has also been found to be related to mathematics anxiety (Feldhusen & Willard-Holt, 1993; Fennema & Sherman, 1977; Harris & Pickle, 1992; Hart, 1989; Newman & Schwager, 1993). This is further support for the placing of mathematics anxiety within a social cognitive framework.

Summary

Psychoanalytic, behavioral, and social learning theories provide inadequate explanations for mathematics anxiety. Psychoanalytic theory focuses on internal influences for behavior, and ignores the effects of cultural and social influences. Behavioral theories place too much emphasis on external factors for the development of anxiety. Human behavior is more complex than simple cause and effect, else all humans would behave the same way. Social learning theory begins to provide an explanation for mathematics anxiety. This theory acknowledges the interaction of personal and environmental influences on the development of behavior, but a cognitive interpretation and understanding of events is lacking. Social cognitive theory seems to provide the best explanation for mathematics anxiety.

Mathematics anxiety, according to social cognitive theory, develops and continues because of the interaction of an individual's cognition, behavior, and environment. The contention is that mathematics anxiety is learned and cognitively maintained. It is not inherent or predisposed in certain segments of the population. This anxiety develops not only because of an individual's behavior in mathematical situations but also because of the perceptions of those situations.

Social cognitive theory explains how learning occurs through vicarious capability, conceptions (accurate or erroneous) of individuals or events, forethought, the influence of the popular culture, and self-efficacy. Social cognitive theory ties the internal cognitions of an individual to behavior and environment to provide for an explanation of mathematics anxiety. This theory encompasses those facets of the behavioral theories that contribute to anxiety (i.e., the influence of the environment), and acknowledges the importance of internal cognitions (i.e., thoughts, feelings, self-efficacy) in developing and maintaining mathematics anxiety. Social cognitive theory has incorporated the internal notions from psychoanalytic theory and the external impact of the environment from behavioral theories to provide the most encompassing explanation for mathematics anxiety. Mathematics anxiety has been found by several researchers to be related to mathematics self-efficacy, further strengthening the placement of mathematics anxiety within social cognitive theory.

An exploration of intervention programs for mathematics anxiety may illuminate whether or not social cognitive theory does provide the best explanation for mathematics anxiety. An examination of several interventions for mathematics anxiety are reported next.

Interventions for Mathematics Anxiety

Programs for the reduction of mathematics anxiety take varying forms, such as curriculum changes or psychological interventions and arise from a variety of theortical backgrounds (Hembree, 1990). Curriculum changes as a means of reducing mathematics anxiety include the use of special equipment such as manipulative materials, or calculators; small group or self-paced work, and instructors who emphasize the problem solving process rather than algorithmic instruction. The psychological treatments appear to be either behavioral, cognitive-behavioral, cognitive, or social cognitive in nature. The behavioral treatments tend to utilize systematic desensitization as the primary method with relaxation techniques as a component. Cognitive-behavioral strategies combine thought monitoring with systematic desensitization. The cognitive interventions focus on cognitive modification and self-talk to restructure faulty beliefs and build self-confidence. The social cognitive treatments seem to involve curricular changes with a self-efficacy component. These treatments also utilize modelling and cognitive restructuring of faulty perceptions. Bandura's concept of self-efficacy has received increasing attention as a likely explanation for the effectiveness of exposure, modelling and several other therapies of anxiety reduction (Sarason, 1985). Positive behaviour changes are noticed and interpreted by the individual and lead to favourable self-evaluations (Sarason, 1985).

Siegel, Galassi and Ware (1985) concluded that a social learning model designed to increase mathematics skills and confidence should be based on direct teaching rather than counseling to improve students' mathematics performance. They theorized that interventions based on skill building would be more effective than those based on reducing anxiety. Bandura (1977, 1986) also concluded that performance treatments are more effective than just cognitive treatments in reducing anxiety. Dew, Galassi and Galassi (1984) found a relationship between mathematics anxiety and mathematics performance and advocate interventions that combine remedial skills with a low anxiety environment to increase mathematics performance. Hembree (1990) found that neither relaxation training nor cognitive modification to build self-confidence in mathematics were successful on their own to reduce mathematics anxiety. A combination of behavioral and cognitive techniques may be successful in reducing mathematics anxiety (Hembree, 1990). Eddy (1985) also supports the notion that interventions for mathematics anxiety need to be multi-faceted due to the nature of mathematics anxiety.

Most interventions are generally used in the treatment of post-secondary students and adults who experience mathematics anxiety (Williams, 1988). As preservice elementary teachers report the highest levels of mathematics anxiety among university students (Battista, 1986; Bulmahn & Young, 1982; Hembree, 1990; Kelly & Tomhave, 1985), many treatments for mathematics anxiety focus on this population. To help reduce thei anxiety many interventions for mathematics anxiety are included within elementary mathematics methods courses for preservice teachers.

Interventions for mathematics anxiety are reviewed by their psychological paradigm. First, behavioral treatments are examined followed by cognitive-behavioral treatments. Then interventions that are primarily cognitive are explored. Finally, interventions grounded in social cognitive theory are examined. The interventions studied are reported on their adherence to scientific research methods such as, the selection of subjects, determination of treatment groups, identification of effective strategies, the reduction of anxiety, and grounding in a psychological theory.

Behavioral Interventions

Behavioral interventions typically use desensitization either in a systematic or an accelerated manner. Richardson and Suinn (1973) compared traditional systematic desensitization and accelerated massed desensitization (AMD), in the treatment of mathematics anxiety. Twenty university students volunteered for treatment after responding to announcements for a mathematics anxiety reduction program offered under the auspices of a University Counseling Service. An attempt was made by the researchers to select students with severe levels of mathematics anxiety as determined by a mathematics anxiety rating scale (MARS). The two control groups consisted of thirty-two students from introductory education courses. The traditional systematic desensitization treatment group was exposed to nine sessions over three weeks, treatment included training in deep muscle relaxation. The (AMD) group met once, in a massed treatment session for three hours and one earlier hour for relaxation training. The control groups did not have any treatment. It was found that there was a significant reduction in mathematics anxiety among the two treatment groups and one of the control groups. But there may be weaknesses in this research since the level of mathematics anxiety in one of the control groups was significantly higher than the levels of either treatment group. This made the groups difficult to compare. There was no significance difference in the reduction of mathematics anxiety between the two treatment groups.

Therefore only tentative support can be shown for this intervention based upon a behavioral strategy.

Hendel and Davis (1978) investigated the effectiveness of a combined curricular-counseling intervention strategy for reducing mathematics anxiety. Their subjects were 69 adult women returning to college who were enrolled in a Math Anxiety Program. There was no control group. The program consisted of three components: a diagnostic clinic, special mathematics courses, and a support group led by a counseling psychologist. The instructors for the mathematics courses were chosen for their sensitivity to students who had difficulties with mathematics. The counseling/support group met for seven weeks for ninety minutes each week. The following interventions and techniques were utilized during the support group meetings: a mathematics autobiography and diary, readings, cognitive restructuring, goal setting, mathematics study skills, desensitization, relaxation exercises, and mathematics games. Hendel and Davis (1978) concluded that the program was most effective when participants completed all three components of the program. But their results can be questioned because only 47 of the 69 (68%) participants completed the mathematics anxiety rating scale twice (as a pre- and post-test), and only 11 (16%) participants completed all three components of the program. Another failure of this research was the lack of identification of particularly effective strategies among the many techniques used. It was perceived that a multi-model approach is effective in reducing mathematics anxiety, but it was not known which approaches were effective.

Olsen and Gillingham (1980) used systematic desensitization through deep muscle relaxation as an intervention for mathematics anxiety for preservice elementary teachers. The program was offered to students (on a volunteer basis) who reported high levels of mathematics anxiety. Four groups were tested, two treatment groups and two control groups. There was a total of 24 students in the treatment groups and 117 in the control groups at the beginning of the program. The treatment lasted a total of nine weeks, after which only 15 students remained in the treatment group and 86 in the control group. This intervention did lower the levels of perceived anxiety but it did not change the attitudes of the preservice teachers toward mathematics. A weakness of this research was that the treatment students were selected on the basis of having higher anxiety levels than the control students, and this may have biased the results since the higher mathematics anxiety scores may show an artificial reduction due to regression toward the mean and not to treatment effects.

Bander, Russell and Zamostny (1982) compared cue-controlled relaxation and study skills counseling in the treatment of mathematics anxiety. The purpose of the study was to determine the effectiveness of three interventions for mathematics anxiety, plus a no treatment control group. The interventions were: cue-controlled relaxation training, mathematics study skills counseling, and a combination of relaxation and study skills instruction. The subjects were 53 undergraduate college students who volunteered as mathematics anxious individuals. All treatments were administered in small groups of four to six participants. Each treatment group met for five consecutive weeks, for one hourly session each week. The cue-controlled relaxation technique involved two steps: training in progressive muscle relaxation, and pairing the cue word 'calm' to the relaxed state. The study skills training involved training in problem solving strategies, along with instruction in test preparation and test-taking techniques. Bander, Russell and Zamostny (1982) found initially that the study skills training was most effective in reducing mathematics anxiety while cue-controlled relaxation was most effective in reducing generalized test anxiety. After three weeks had elapsed, the relaxation group had the lowest mathematics anxiety levels. The deterioration in the study skills group may have been due to a failure to continue using the problem solving strategies. There are several weaknesses in this study due to the small sample size, the exclusion of the control group in the follow-up, and the transparency of the instruments used. But this study does provide some tentative support for behavioral treatments in mathematics anxiety and points to further research in multi-component treatment strategies for mathematics anxiety.

Cognitive Behavior Interventions

Cognitive behavior therapies have also been tried for the reduction of mathematics anxiety. Genshaft (1982) states that the cognitive processes involved in mathematics anxiety have far reaching consequences. These cognitive processes need to be interrupted and corrected through therapeutic intervention. Genshaft (1982) investigated the use of a cognitive behavioral program for the reduction of math anxiety with thirty-six girls in the seventh grade. These students were all identified by their teachers as experiencing mathematics anxiety. The subjects were randomly divided into three groups: (1) a no treatment control group, (2) a group that was tutored in mathematics, and (3) a group that received tutoring plus training in self-instruction intended to reduce anxiety and increase self-reinforcing verbalizations. The tutoring group met twice weekly for eight weeks for forty minutes of tutoring in addition to their regular math class. The girls assigned to the self-instruction group met also for eight weeks and developed positive self-instructional statements for mathematics. The no treatment control group attended their regular mathematics class and received no remediation. All three groups (including the control group) reduced their mathematics anxiety levels. The only difference among the groups was that the self-instruction group developed more favorable attitudes toward mathematics while the other two groups did not change their attitude. Genshaft (1982) concluded that since all three groups improved, including the control group, cognitive therapies on their own were insufficient to account for the improved performance in all groups.

DeBronac-Meade (1982) also used a cognitive behavior modication approach for the reduction of mathematics anxiety. The treatment included self-instruction, thought monitoring, relaxation, and desensitization. Again college students volunteered for a mathematics anxiety reduction program. Significant decreases in mathematics anxiety were found in the treatment group, but there was no identification of which techniques were particularly effective. It was impossible to determine which strategies were effective in reducing mathematics anxiety.

Cognitive Interventions

Interventions for mathematics anxiety have also been grounded in cognitive theory. Fulkerson, Galassi and Galassi (1984) investigated the cognitions of mathematics anxious undergraduate students to test some basic assumptions of cognitive theory. As these researchers state "cognitions and cognitive processes have been postulated as being particularly important in generating and maintaining anxiety and thereby disrupting performance in a variety of situations" (p. 376). A total of seventy-one subjects participated in the study. These seventy-one subjects were randomly selected from a pool of 582 students in introductory level courses at a large university. Thirty-four of these students were randomly selected from the top one third (high anxiety) and thirty-seven were selected from the bottom one third (low anxiety) of the pool. There was no control group but students were financially reimbursed minimumly for participating in the study. The students were asked to complete two sets of mathematics problems and instructed to think aloud while solving the first set of problems. Students did not think aloud while solving the second set of problems. There were no significant differences found among the cognitions of high and low mathematics anxious students. The only significant effects found were that males reported more irrelevancies and more neutral statements, while females used more strategic calculations. The researchers caution though that these results may be questioned due to the absence of a significant F value for sex and that these results are contrary to earlier research. Fulkerson, Galassi and Galassi (1984) found cognitive theory inadequate to explain the cognitions of mathematics anxious undergraduate students.

Hunsley (1987), counter to Fulkerson, et al., found that mathematics anxiety was related to negative thoughts about performance. Hunsley (1987) studied 96 students in an undergraduate psychology statistics course. No control group was used. He examined the ability of mathematics anxiety to explain individual differences in subjects' appraisals, negative internal dialogue and performance attributions. Students completed questionnaires before and after four exams held throughout the course. There were no gender differences found among the course grades. Only mathematics anxiety contributed significantly to the students' ratings of exam importance. Mathematics anxiety was also found to be related to lower expected grades, greater preexam anxiety, and lower ratings of preparedness. There is a strong parallel here to Bandura's (1986) social cognitive theory since "perceived self-efficacy is a significant determinant of performance that operates partially independently of underlying skills" (p. 391). The use of Bandura's (1986) theory may explain why cognitions interact with behavior and environment and therefore why interventions based on social cognitive theory may prove successful in reducing mathematics anxiety. Therefore a combining of cognitions with behavior (i.e.. social cognitive theory) may prove to be a more effective explanatory paradigm for mathematics anxiety.

Interventions that simply taught stress management techniques were not as successful in significantly reducing the mathematics anxiety levels of students as those interventions that tried to understand the ways students perceived and learned mathematics (Hembree, 1990; Woods, 1988). The studies that were successful can be seen to be acting consistently within the self-efficacy model of social cognitive theory (Bandura, 1986). Unfortunately, remediation programs for mathematics anxiety have not been grounded sufficiently in theoretical models of anxiety reduction (Genshaft, 1982; Reyes, 1984). As Eddy (1985) reports the multi-faceted nature of mathematics anxiety is confirmed by the fact that interventions ranging from simple instructional changes to desensitization and self-instruction have proven successful. Therefore, the most comprehensive interventions may lie within a framework that is also multi-faceted.

Social Cognitive Interventions

As Sarason (1985) indicates Bandura's concept of self-efficacy has received increasing attention as an explanation for the effectiveness of exposure, modelling, and several other therapies. Sarason (1985) states:

> behavioral achievements change both self-perceptions and personal expectations and the behavior of significant others who notice the behavioral changes. At the same time, increases in self-efficacy enable the individual to consider behavioral avenues that previously may have seemed impossible. (p. 101)

Warren and Zgourides (1991) concur that Bandura's (1986, 1988) theory of self-efficacy is an effective explanation for, and treatment of anxiety disorders.

An intervention for mathematics anxiety (Siegel, Galassi & Ware,1985) explored the possibility of social learning theory (Bandura, 1977) as an explanatory paradigm. These researchers focused on Bandura's self-efficacy component of social learning theory. Siegel, Galassi and Ware (1985), studied 143 students enrolled in the second semester of an introductory mathematics course at a university. Participation in the study was voluntary with the result that about half of the course participants were involved in the research. The students attended different sections of a standard lecture course taught by graduate teaching assistants, used common course materials, and wrote the same final exam. The course was not open to students majoring in mathematics, engineering or the physical sciences. There was no control group. Data collection occurred during the last class before the final exam and immediately prior to beginning the mathematics final exam after reading it through once. Students were asked to complete questionnaires on incentives, efficacy and outcome expectations. The researchers concluded that social learning theory does represent a powerful explanatory paradigm and interventions based on social learning theory might be expected to reduce anxiety towards mathematics through increased performance and efficacy expectations. Social learning theory in conjunction with direct teaching, as opposed to counseling, is more likely to result in performance changes. Self-efficacy is also a component within Bandura's (1986) social cognitive theory. Therefore, interventions based on social cognitive theory might be expected to be successful in reducing mathematics anxiety.

The remaining interventions to be discussed within the social cognitve section all are concerned with preservice elementary teachers and as such, most of the interventions involve elementary mathematics methods courses. The Teacher Education and Mathematics (TEAM) project was designed to "effect a qualitative change in the teaching of mathematics and the resulting educational experience of children in the critical area of mathematics" (Chapline, 1980, p. 1). More specifically, the goals of the program are to reduce mathematics anxiety among preservice teachers, to increase their mathematical competency, to increase their perception of mathematics as a female domain, and to develop their skills in recognizing sex bias in mathematics materials and in the classroom. The rationale for TEAM arose from the perception of an inverse relationship between mathematics knowledge and mathematics anxiety (Chapline, 1980). This program attempted to integrate cognitive and affective learning opportunities in mathematics. Three groups of students participated in TEAM during the two years of the program. In the first year forty-four students participated, during the second year thirty-four students participated in the fall, and twenty-nine were enrolled in the spring semester. There was no control group.

The underlying philosophy of the teaching strategy used in the TEAM approach is that an inductive approach enhances the confidence and knowledge of the learner (Tittle & Denker, 1981). The learners are not given the problem solving rules immediately, but are to arrive at them through generalizing solutions in a number of sequenced problems. This is designed to encourage the students to form an understanding of mathematics, rather than just absorbing facts and rules from the teacher. An important goal of this program is to increase mathematics competency, and at the same time, build confidence in one's ability to use mathematics, and decrease anxiety toward mathematics. It is hypothesized that with improved confidence and competence in performing mathematics, mathematics anxiety levels will decrease.

Modules were developed which covered mathematical topics and students' attitudes. The mathematics modules focus on concepts and problem-solving processes and are: (1) Number Patterns, (2) Approximation and Estimation, (3) Metric Measurement, (4) Choice and Chance, and (5) Space. The modules designed to deal with students' attitudes are: (6) Demystifing Math, (7) Sex-role stereotyping in Mathematics, and (8) Women and Mathematics.

Tittle and Denker (1981) evaluated the mathematics anxiety reduction program TEAM for preservice teachers and found consistent and significant decreases in the mathematics anxiety levels. It was hypothesized that the development of mathematics skills, and the recognition of mathematics as an important area of study for women, increased confidence and competency in mathematics. The improved performance of the individuals increased their own notions of being able to do mathematics successfully. In other words, their self-efficacy towards mathematics was increased and enabled them to reduce their mathematics anxiety. This is further support for Bandura's (1986) social cognitive theory.

Sovchik, Meconi and Steiner (1981), investigated the effect of a mathematics methods course in reducing the degree of mathematics anxiety present among preservice elementary teachers. Fifty-nine preservice elementary teachers enrolled in a mathematics methods course were the participants in the study. There was no control group. The students were in three separate sections with common course outline, tests, books, and methods of instruction. The instructors of the course utilized active learning methods with concrete materials. It was hypothesized that increased confidence in the ability to do mathematics would reduce the levels of mathematics anxiety. The course did result in a reduction in mathematics anxiety (Sovchik, Meconi & Steiner, 1981), but the components of the course that were successful in reducing mathematics anxiety were not identified. The reduction in anxiety could be explained through Bandura's (1977, 1986) self-efficacy component of social cognitive theory. For corrective learning or anxiety reduction to take place, Bandura (1977,1986) states that treatments which involved actual performance (such as the doing of mathematics) achieve results consistently superior to those which only attempted to eliminate fear through cognitive representations. Therefore, the interventions that are successful in reducing mathematics anxiety rely on improving mathematical understanding and skills and notions of success in mathematics.

An elementary mathematics methods course investigated by Teague and Austin-Martin (1981) was found to have a positive effect on the attitudes of preservice elementary teachers. The subjects for the study consisted of sixty-six female college students enrolled in either a mathematics methods course or a children's literature course. There were thirty-five students in the mathematics methods course while the remaining thirty-one students were enrolled in the children's literature course and were the control group. The mathematics methods course took the preservice teachers through a sequence of developmental mathematical concepts, reviewed understandings, and discussed applications of the concepts for work with children. Piagetian conservation tasks for the developmental stages of children was an important part of the course. Films were viewed that showed the use of concrete materials in British open schools, and laboratory exercises were conducted using concrete materials. Teaching episodes with children were incorporated within the context of the course. Teague and Austin-Martin (1981) summarize that their findings did not support a relationship between attitudes about mathematics and the global experience of a mathematics methods course, but levels of mathematics anxiety were lowered possibly as a result of being successful at actually teaching mathematics. Since the majority of the children taught were of primary age, the level of mathematics ability required by the preservice teachers may have generated little anxiety. The successful nature of this course agrees with Bandura's (1986) social cognitive theory. By actually performing mathematics in a teaching setting, it may have shown the preservice teachers that they were able to be successful at 'doing' mathematics and thus their increased self-efficacy towards mathematics reduced their mathematics anxiety.

The EQUALS program was developed at the University of California at Berkeley, to attract and retain women and minority students in mathematics. This program, developed in 1977, was designed to provide training in three areas: awareness, competence, and confidence in mathematics. Amodeo and Emslie (1985) studied the effect of using the EQUALS program with a group of preservice elementary and secondary teachers. The sample included fifty-seven preservice teachers enrolled in a student teaching block. The students were divided into three groups: elementary, secondary, and library media. The library media group served as the control group while the other two were the experimental group. The program EQUALS, conducted as a 30-hour workshop had four main components. One component involves the solving of word problems starting with simple computational ones and gradually moving up to more complex questions. A second component concerns gender awareness. The participants are presented a series of questions relating to numbers and percentages of women and minorities in different occupations, and then asked to estimate the answers. This is followed by a discussion of the data gathered. A third component of the EQUALS program involves the use of small groups. All activities are completed in small groups to instil in the preservice teachers that it is 'all right' to allow students to solve problems in groups. Working in groups will enable the preservice teachers to gain confidence in their abilities to do mathematics and reduce their anxiety levels (Amodeo & Emslie, 1985). The fourth component, similar to the first, also deals with word problems and the importance placed on the process of problem solving, not on finding the one answer.

Amodeo and Emslie (1985) concluded that the EQUALS program was effective with preservice teachers. Mathematical competence increased for all groups as did positive attitudes toward mathematics. These researchers hypothesized that by concentrating on improving the mathematical skills and thereby increasing confidence in mathematics, mathematics anxiety can be reduced. This intervention also concurs with Bandura's (1986) social cognitive theory. As Bandura (1986) defines, self-efficacy is a person's belief that he or she can successfully perform a task. Therefore an intervention that is formally grounded in social cognitive theory may prove successful in reducing mathematics anxiety.

Sherard (1985) promotes the use of a laboratory setting for the teaching of an elementary mathematics methods course. The emphasis in a course such as this is on the active involvement with concrete materials. Sherard claims that this course is effective because students report that they understand mathematical concepts better after having worked through several laboratory activities. The rationale for such a course seems to be that increased confidence and competence in mathematics will reduce mathematics anxiety. The use of Bandura's (1986) self-efficacy component of social cognitive theory also supports this rationale.

Battista (1986) also examined the hypothesis that a mathematics methods course can reduce the mathematics anxiety of preservice elementary teachers. Battista investigated thirty-eight preservice elementary teachers enrolled in two sections of a mathematics methods course taught by him. Partial results were also obtained for two mathematics methods courses taught by another instructor involving thirty-six preservice elementary teachers. The courses were similar but differed in their evaluation tools. Both courses incorporated a five-week field experience with lecture-discussion sessions, and small group activities with concrete materials. The population in this study may be different from other elementary mathematics courses since all students must have taken either one or two college level mathematics courses. Preservice elementary teachers have generally not taken mathematics in senior high school, much less at the university level (Battista, 1986; Meyer, 1980). Battista interpreted his results as indicating that the higher the initial level of mathematics anxiety, the greater the reduction in anxiety. Caution must be used in interpretating this result because of the possibility of an artificial reduction through a regression towards the mean. Several hypotheses were put forth to explain the observed reduction in anxiety. The first was, that since the literature suggests that mathematics anxiety may be reduced by illustrating the usefulness of mathematics (Brush, 1979; Sherard, 1981), the field experience made the preservice teachers aware of the usefulness and importance of mathematics in their future careers. Teague and Austin-Martin (1981) also reached the conclusion that the actual teaching of mathematics may reduce mathematics anxiety. The second hypothesis for the reduction in anxiety also refers to the field experience, in that it proved to be a vehicle for the preservice teachers to improve their self-confidence in mathematics (Sherard, 1981; Tobias & Weissbrod, 1980). The increase in confidence is assumed to be correlated with a reduction in mathematics anxiety. This conclusion may also be supported by Bandura's (1986) social cognitive theory, through the component of self-efficacy.

In summary, many of the interventions for mathematics anxiety are consistent with Bandura's (1986) self-efficacy component of social cognitive theory (Battista, 1986; EQUALS, 1985; Sherard, 1985; Sovchik, Meconi, & Steiner, 1981; Teague & Austin-Martin, 1981; TEAM, 1980). TEAM's philosophy is that confidence in mathematics is improved through increasing competence in mathematics. This approach hypothesizes a relationship between mathematical knowledge and mathematics anxiety. Fennema and Sherman (1977) hypothesized that confidence in one's ability to perform mathematics may be related to mathematics anxiety. This hypothesis can be grounded in Bandura's (1986) self-efficacy theory as one factor that contributes towards human behavior. Self-efficacy in mathematics performance relates to confidence in one's ability to perform mathematics.

Several researchers have pointed out the lack of grounding in psychological paradigms for intervention programs of mathematics anxiety (Genshaft, 1982; Mathison, 1977; Reyes, 1984; Siegel, Galassi & Ware, 1985; Tobias & Weissbrod, 1980). The above review suggests that many of the successful interventions for mathematics anxiety could be grounded in social cognitive theory. This reinforces the positioning of mathematics anxiety within social cognitive theory, since any intervention for anxiety should be grounded in the same explanatory paradigm that defines the anxiety.

Summary

Environmental explanations for mathematics anxiety provide a picture of the development of mathematics anxiety. The conflicting findings of the research into cognitive sex differences do not indicate biological explanations for mathematics anxiety. Various environmental factors do provide explanations for the existance of mathematics anxiety. Differential course taking, the perception of mathematics as a male domain, confidence in one's ability to learn mathematics, the perception of usefulness of mathematics, the effects of the teacher upon student learning, and the actual teaching methodology of mathematics may contribute to the development of mathematics anxiety. Psychological explanations assist in the understanding of the impact of such environmental factors on the development of mathematics anxiety.

Psychoanalytic, behavioral, and social learning theories were all inadequate in providing an explanation for mathematics anxiety. Social cognitive theory provides an explanation for the development of mathematics anxiety through the interaction of an individual's cognition, behavior, and environment. Mathematics anxiety develops not only because of an individual's behavior in a situation, but also because of the perceptions of that situation. Therefore the environment is extremely important in the development of mathematics anxiety.

Many successful interventions for mathematics anxiety can be seen to be consistent with the components of social cognitive theory. In particular, the self-efficacy component provides an explanation for the development and reduction of mathematics anxiety. Social cognitive theory then seems to provide the best explanation for mathematics anxiety, and also provides the theoretical background of successful interventions for mathematics anxiety.

If mathematics anxiety can be grounded in social cognitive theory, then an intervention for mathematics anxiety also grounded in social cognitive theory might prove to be successful in reducing mathematics anxiety. Since mathematics anxiety can be seen to be a function of an individual's cognitions, behavior, and environment, the environment becomes an important factor in the reduction of mathematics anxiety. And since preservice elementary teachers are generally mathematics anxious, an appropriate environment to reduce mathematics anxiety may be a place where preservice elementary teachers encounter mathematical situations, such as an elementary mathematics methods course.

This research then attempted to discover if an intervention for mathematics anxiety within an elementary mathematics methods course could successfully reduce the mathematics anxiety levels of preservice elementary teachers. Further, if cognitions, behavior and environment all interact to produce mathematics anxiety, perceptions or attitudes toward mathematics may also contribute to the development of mathematics anxiety. Therefore this research also attempted to discover whether or not attitude toward mathematics would also be changed after completing an elementary mathematics methods course designed to reduce mathematics anxiety. The dimensions of this attitude toward mathematics were confidence in learning mathematics, the perceptions of mathematics as a male domain, the perception one has of the teacher toward one as a learner of mathematics, and the attitude toward success in mathematics. These dimensions were all indicated as possible environmental factors on the development of mathematics anxiety. Earlier research into interventions for mathematics anxiety failed to identify what strategies actually aided in the reduction of mathematics anxiety. The third and final research question attempted to rectify this omission in earlier research by identifing the components of the elementary mathematics methods course that aid in the reduction of mathematics anxiety.

CHAPTER III

METHODOLOGY

This study examined the mathematics anxiety and attitude toward mathematics of preservice elementary teachers. An intervention for mathematics anxiety was presented as a preservice teacher education course in elementary mathematics methods. The course was given at a small eastern Canadian university that offers a two-year Bachelor of Education degree for both prospective elementary and secondary teachers. To begin this chapter, a description of the subjects, the method of their selection, and the instruments utilized are given. Then, the research design of the study is explained. Finally, a description of the elementary mathematics methods course is given. Included within this description is the theoretical background for the various components of the course.

Subjects

The sample involved in this study consisted of a total of 112 (18 male, 94 female) preservice elementary teachers over a three year period. During the study 42 (37 female, 5 male) preservice elementary teachers participated in the first year, 31 (26 female, 5 male) in the second year and 39 (31 female, 8 male) in the third year. The preservice teachers in each year of the study were enrolled in an elementary mathematics methods course that was taught by the same professor and presented in the same manner.

The educational background of the preservice elementary teachers also provided descriptive data. It was found that only 4% of all of the

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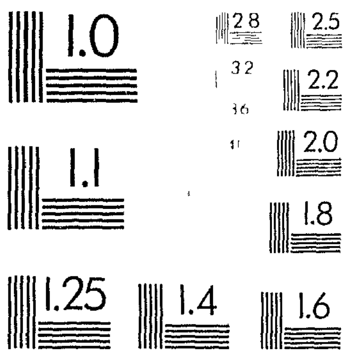

preservice elementary teachers came from a Mathematics or Science background. Individuals with a Psychology or Sociology background comprised 29% of the total population while another 24% had either an English or History Background. The remaining 43% came from a variety of backgrounds including French, Recreation, Child Studies, Physical Education, Political Science, or general arts with no specific major.

A further analysis of the preservice teachers' mathematical course background showed that only 38% of the subjects had taken mathematics past high school and that was generally only a half credit in statistics for the psychology and sociology majors. The majority of the preservice elementary teachers (62%) had not taken any mathematics courses beyond high school, and over 13% of these had not even taken mathematics in their final year of high school.

During the second year of the study, 13 of the 31 preservice elementary teachers volunteered to participate in interviews. Of these 13 preservice elementary teachers interviewed, 11 were female and 2 were male. Twelve were from and Arts and Humanities background (92%) and one came from a Science background (8%).

Selection of Subjects

The researcher gave an introduction to the research study in the first class of each section of the elementary mathematics methods course. The preservice elementary teachers were told that the researcher was concerned with investigating their feelings towards mathematics. The decision to participate or not had no effect on their course grades. All of the preservice elementary teachers in each section of the elementary mathematics methods course volunteered to participate. The subjects completed pre and/or post course questionnaires assessing their attitudes toward mathematics and their mathematics anxiety. Additionally, during the second year of the study, volunteers were asked to take part in a series of indepth interviews with the researcher, regarding their experiences during the methods course and any thoughts or feelings towards mathematics in general. This involved a time commitment on behalf of the volunteers to meet a minimum of three times, outside of class time, for 30 to 45 minutes each time, with the researcher during the span of the elementary mathematics methods course. Thirteen of the thirty-one preservice elementary teachers in the second year of the study volunteered to participate in the interview part of the research. Due to the time commitments of the preservice elementary teachers, only 10 were able to each meet three times with the researcher. The professor who taught the elementary mathematics methods course was also interviewed near the later part of the course in the second year of the study.

Also during the second year of the study, the researcher observed the elementary mathematics methods course as it was in progress. This observation covered both sections of the elementary mathematics methods course with 15 and 16 preservice teachers in each section respectively. Each section met twice a week for one and a half hours each session, for a total of 13 weeks. That meant a total of 6 hours of mathematics methods course observation each week for 13 weeks. The observation of the methods course provided information and data that could be explored to greater depth during the interviews.

Instruments

One questionnaire was developed from the Fennema and Sherman Mathematics Attitudes Scales (1976) (found in Appendix A). The questionnaire contained seven subscales designed to measure attitudes toward the learning of mathematics and one subscale designed to measure mathematics anxiety. Each scale contained 12 statements about mathematics, six stated positively and six negatively. The total questionnaire contained eight separate scales (with items listed randomly) of 12 items each, for a total of 96 statements about mathematics. Each item was answered on a5-point Likert scale from strongly agree, agree, undecided, disagree, to strongly disagree. The scales were (a) confidence in learning mathematics, (b) perception of father towards one as a learner of mathematics, (c) perception of mother towards one as a learner of mathematics, (d) perception of teacher towards one as a learner of mathematics, (e) attitude toward success in mathematics, (f) perception of mathematics as a male domain, (g) usefulness of mathematics, and (h) mathematics anxiety. Each scale is further described below.

The Confidence in Learning Mathematics Scale (C) ranges from a distinct lack of confidence to definite confidence. It is "intended to measure confidence in one's ability to learn and to perform well on mathematical tasks" (Fennema & Sherman, 1976:p. 4). [The following quotations regarding the descriptions of the scales will all refer to the Fennema & Sherman reference].

The defined dimensions and items for the Mother (M) and the Father (F) scales are identical except for the substitution of father for mother in the appropriate locations. The (M) and (F) scales are intended to "measure the students' perception of their mother's/father's interest, encouragement, and confidence in the students' [mathematical] ability" (p. 3).

The Teacher (T) scale was designed to "measure students' perceptions of their teachers' attitudes toward them as learners of mathematics" (p. 4). Within the context of this research the subjects used remembrances of past experiences with teachers of mathematics. The Attitude toward Success in Mathematics Scale (AS), was developed to measure how much subjects desire to be successful in mathematics.

The Mathematics as a Male Domain Scale (MD) is "intended to measure the degree to which students see mathematics as a male, neutral, or female domain" (p. 3). The Mathematics Usefulness Scale (U) was developed to "measure students' beliefs about the usefulness of mathematics currently and in relationship to their future education, vocation, or other activities" (p. 5).

Finally, the Mathematics Anxiety Scale (A) is "intended to measure feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics. The dimension ranges from feeling at ease to those of distinct anxiety" (p. 4).

The results of only five of these scales are reported in depth in this research study. Those scales reported in depth are confidence in learning mathematics, perception of teacher toward one as a learner of mathematics, perception of mathematics as a male domain, attitude toward success in mathematics, and mathematics anxiety. The mean scores from the other three scales, perception of mother and father toward one as a learner of mathematics, and usefulness of mathematics are reported in Appendices C, D, E.

Each scale as stated earlier, consisted of twelve items, six stated positively and six negatively stated with five response alternatives: strongly agree, agree, undecided, disagree, and strongly disagree. Each response was scored from 1-5 with the weight of 5 given to the response that is hypothesized to have a positive effect on the learning of mathematics. The higher the score, the more positive the attitude. For the Mathematics as a Male Domain Scale, the higher the score, the less a person stereotypes mathematics, since that is considered to be the more positive attitude. For the Mathematics Anxiety Scale, the higher the score, the lower the mathematics anxiety. Since eight scales were used in total, the items were randomly distributed into one instrument. Table 1 illustrates the split half reliabilites for the scales.

Broadbrooks, Elmore, Pederson, and Bleyer (1981), in a construct validation study of the Fennema-Sherman Mathematics Attitudes Scales provided empirical evidence through a factor analysis that supported the theoretical structure of the Fennema-Sherman scales. Analysis of the items led to the interpretation of eight factors. These eight factors indicate that the scales do measure eight different constructs within the domain of mathematics attitudes and support the construction of multidimensional scales to measure attitudes towards mathematics.

Table 1

Split Half Reliabilities of the Fennema & Sherman Mathematics Attitude Scales

Scale	Reliability	Scale	Reliability
Attitude towards Success in Mathematics (AS)	.87	Father (F)	.91
Mathematics as a Male Domain (MD)	.87	Mother (M)	.86
Confidence in Learning Mathematics (C)	.93	Teacher (T)	.88
Usefulness of Mathematics (U)	.88	Mathematics Anxiety (A)	.89

(Fennema & Sherman, 1976)

Dew, Galassi and Galassi (1983) investigated the internal consistency and test-retest reliabilities of three mathematics anxiety measures. They concluded that the Mathematics Anxiety Rating Scale (MARS, Suinn, 1972) and the Fennema-Sherman Mathematics Anxiety Scale (MAS, Fennema & Sherman, 1976) possessed acceptable internal consistency and test-retest reliability. For the MARS internal consistency was .96 while test-retest reliability was found to be .87. For the MAS test-retest reliability was .87 while internal consistency was .72. The third mathematics anxiety measure, the Sandman Anxiety Toward Mathematics Scale (ATMS, Sandman, 1979) was found to be weak with an internal consistency of .21 and a test-retest reliability of .75. In a further investigation Dew, Galassi and Galassi (1984) found that the MARS tends to assess test anxiety more so than other mathematics anxiety measures and that this tendency is not desirable when one is concerned about mathematics anxiety. Wood (1988) also concluded that the MARS does measure test anxiety much more often than it measures anxiety associated with doing mathematics. Bander and Betz (1981) found a split half reliability for the MAS of .92 and provide further evidence of its validity as a mathematics anxiety measure.

Therefore the decision was made to use the Fennema and Sherman Mathematics Attitudes Scales and the Mathematics Anxiety Scale. Several other studies have also utilized these scales in various combinations (Bander, Russell & Zamostny, 1982; Becker, 1986; Chapline, 1980; Pedersen, Bleyer & Elmore, 1985; Tittle, 1981).

Research Design

The research design was based on the Recurrent Institutional Cycle Design (Campbell & Stanley, 1963). This design is "appropriate to those situations in which a given aspect of an institutional process is, on some cyclical schedule, continually being presented to a new group of respondents" (p. 57). This is applicable to the elementary mathematics methods course which is offered every year to new students. The design is shown in Figure 1.

Figure 1

Institutional Recurrent Cycle Research Design

Year One	**M**	Post						
Year Two			Pre	**M**	Post			
				M	Post			
Year Three						Pre	**M**	Post

Note. **M** = mathematics methods course
Pre = questionnaires administered at the beginning of the course
Post = questionnaires administered at the end of the course

In the first year of the study 42 preservice elementary teachers completed the Fennema-Sherman Mathematics Scales at the end of the mathematics methods course generating a set of posttest scores. In the second year of the research, one section of the mathematics methods course (N=16) completed the Fennema-Sherman Mathematics Scales both at the beginning and the end of the course generating a set of pretest and posttest scores. The other section of the mathematics methods course (N=15) in the second year of the study, only completed the Fennema-Sherman Mathematics Scales at the end of the course for another set of posttest scores. In the third year of the study 39 preservice elementary teachers completed the Fennema-Sherman Mathematics Scales at the beginning of the mathematics methods course (for pretest scores) and 35 completed the scales at the end of the course for the final set of posttest scores.

Since the experimental variable (the elementary mathematics methods course) is recurrent and is continually being presented to a new group of respondents, some degree of experimental control is possible. It is not necessary within this research design to have an experimental control group (Campbell & Stanley, 1963). The design combines longitudinal and cross-sectional approaches used in developmental research. The assumption is that a group that has been exposed to a treatment, in this instance, the elementary mathematics methods course, and a group which is about to be exposed can be compared. For example, this is the comparison of the posttest scores of the preservice teachers in year one to the pretest scores of the preservice teachers in year two of the study. Remeasuring the preservice elementary teachers after completing the mathematics methods course provides a one group pretest posttest segment. Effects due to mortality can be diminished since no preservice teachers repeated the elementary mathematics methods course and only 4 out of 55 preservice teachers failed to complete both a pretest and posttest when requested.

The effects of pretest versus no pretest have been controlled by the preservice elementary teachers in the second year of the study, being split randomly into two comparable sections and only one section receiving a pretest, while both sections received a posttest. The introduction of another group receiving the Fennema-Sherman Mathematics Scales at the beginning of the elementary mathematics methods course, in the third year of the study, provided another pretest measure to be compared. This is intended to eliminate test-retest effects and increase the validity of the study by avoiding the possibility of eccentric performance. The reason for administering the Fennema-Sherman Mathematics Scales again, in the third year of the study, at the end of the elementary mathematics methods course, allows for another posttest comparison to be made with the other pretest scores to control further for the possibility of an eccentric group. Since students are not selected on the basis of their extreme scores statistical regression should not be a threat to the internal validity of this study.

The design as represented through the measurements of pretests to posttests, fails to control for maturation. But the hypothesis of maturation, re that just growing older or more experienced in normal everyday ways, would produce gains seems unlikely. Maturation may be controlled through a cross-sectional approach if there is heterogeneity in age (or years away from home, etc.) within the population entering the institutional cycle. This was true in the case of the preservice elementary teachers in the mathematics methods course. There was a wide range of ages in the course (21 to 45), and there was also a considerable variety of timing between completion of the first undergraduate degree, and entering the Bachelor of Education program. Therefore effects due to maturation can be ruled out.

The Recurrent Institutional Cycle Design was appropriate for this research project since one course, the elementary mathematics methods course, was compared in three consecutive years. In utilizing this design strategy though, the experimenter must be alert to rival interpretations (other than an effect of the mathematics methods course) and must look for extensions of the data that will rule these out. By extending the design to include observations of the course under study, and intensive interviews with the preservice elementary teachers while they were taking the course, rival interpretations could be ruled out. The collection of data from these sources permitted the researcher to have an insight into the preservice elementary teachers' thoughts and feelings as the intervention took place and also allowed the subjects the opportunity to explain what they thought was successful and what was ineffective in reducing their mathematics anxiety.

Previous research into mathematics anxiety has relied almost exclusively on quantitative methods to determine whether or not the levels of mathematics anxiety were changed (Battista, 1986; Dew, Galassi & Galassi, 1983; Sovchik, Meconi & Steiner, 1981; Teague & Austin-Martin, 1981). None of these studies attempted to explain what actually took place during the intervention for mathematics anxiety. What is missing is a sense of how preservice elementary teachers feel about mathematics. If one of the aims of this research was to understand what makes an intervention for mathematics anxiety successful, as well as reducing the mathematics anxiety, then further information was needed. Since it is difficult to explain, predict, and control situations with people (Gay, 1987), several sources of data were utilized. This research attempted to obtain rich descriptions of situations, people and observed behaviors as well as direct quotations from preservice elementary teachers about their experiences, attitudes and beliefs about mathematics. The methods of interviewing and observation were used to gather such data. One cannot understand human behavior without understanding the framework within which people interpret their environment, thoughts, feelings, values, and actions (Burgess, 1985; Owens, 1982; Wilson, 1977). The setting itself generates regularities in behaviour that are more powerful than individual differences. If an aim is to generalize research findings to a setting, then the research is best conducted within that setting.

The purpose of interviewing is to find out from the participants those things that cannot be directly observed (Patton, 1980). There are many types of interview situations but the ones that yield the richest data are those that allow for open-ended answers. An interview guide is used when basically it is desired to explore the same issues with everyone undergoing the interview process and there is limited time available to gather information (Patton, 1980). Therefore for this research an interview guide was utilized for the first interview with all of the preservice elementary teachers (see Appendix B). The first interview was intended to set the students at ease and establish a feeling of rapport between the preservice teachers and the researcher. The students were aware that the research was concerned with feelings towards mathematics. Following interviews became more individualized as questions arose from classroom observations and the previous interviews. The questions were open-ended to allow for the widest response possible.

Participant observation is defined as a "process in which the observer's presence in a social situation is maintained for the purpose of scientific investigation. The observer is in a face-to-face relationship with the observed" (McCall & Simmons, 1969, p. 91). There are several levels of participant observation from passive to active. The level selected depends upon the type of data required, the observational situation, the nature of the subjects, and the observer's capabilities. The role of passive participant observer is chosen when it is desired to interact as little as possible with the observed. The assumption here is that the less the observer affects the situation, the greater are the opportunities to observe events as they develop (Morris, 1981; Schwartz & Schwartz, 1955).

There are certain problems that have to be recognized and dealt with when taking on the role of the passive observer. The observer may feel impulses to abandon the role and interact in the situation and these feelings will have to be restrained. Or the observer may become so involved in restraining these feelings that she or he starts becoming evaluative of others and ceases observing. Another problem may be that the observer does not become truly part of the setting and remains an outsider.

The ideal active participant observer attempts to integrate him/herself into the research setting. The assumption here is to experience life as the observed experience life so that he/she can better understand it. There are dangers here as well since the researcher can become so involved in the setting that he/she unwittingly accepts the assumptions and values which characterize the observational situation and therefore they go unnoticed and unrecorded (Schwartz & Schwartz, 1955). As researchers, it must be kept in mind that our presence has an impact on any research situation and not just research settings involving participant observation (Morris, 1981). For this research setting, since I was neither a student in the course nor the professor, the more passive participant observer role was chosen. This role was chosen to attempt to reduce researcher influence on the research situation as much as possible and to observe what typically took place in the elementary mathematics methods course.

The observation-interview method facilitates extensive data gathering of all forms of overt behavior as well as gaining access to individuals' thoughts, feelings, conceptions, and social perceptions. There are criticisms of this method such as the cost factor in terms of time and effort, as well that the data is difficult to analyze and interpret. But the benefits of rich data outweigh those other factors. Because of the limitations of the observation-interview method such that only a small number of students can be adequately observed and interviewed, data was gathered in other ways as well. The pre- and post-course questionnaires allowed for a wider data base, as did the classroom observations.

This research design then includes the administration of the Fennema-Sherman Mathematics Scales as pretests and/or posttests; observations of the elementary mathematics methods course, interviews with individual preservice elementary teachers at the beginning, middle, and end of the mathematics methods course, and an interview with the professor who taught the elementary mathematics methods course. Data triangulation is the checking of inferences drawn from one set of data sources by collecting data from others (Hammersley & Atkinson, 1983). Triangulation is an attempt to relate different types of data to counteract any possible threats to the validity of the analysis. Since no single method of data collection can adequately solve the problem of rival causal factors, the use of multiple methods of data collection reveals different aspects of empirical reality (Patton, 1980). Triangulating the data from the varied sources, questionnaires, observations, and interviews is an attempt to ensure the validity of this research.

Procedure

The elementary mathematics methods course was compulsory for all first-year preservice elementary teachers and was taught each year in the fall semester. The course required three hours of class time per week (two one and a half hour classes) for thirteen weeks. Participation in the research study was voluntary and had no effect on course grades. As explained earlier in the description of the research design, all 112 preservice elementary teachers completed the Fennma-Sherman Mathematics Scales as either pretests, posttests, or both. In total, 163 questionnaires were administered. In the first year of the study, all preservice teachers (N=42) completed the Fennema-Sherman Mathematics Scales at the end of the elementary mathematics methods course. This provided a posttest.

The second year of the study provided data through several techniques. The elementary mathematics methods course was randomly split into two sections, one with 16 preservice teachers, and the other with 15 preservice teachers. Both sections were observed by the researcher throughout the span of the mathematics methods course. Also, 13 preservice elementary teachers across the sections volunteered for a series of intensive interviews at the beginning, middle, and end of the mathematics methods course. Six students were from one section while seven were from the other. The professor who taught the elementary mathematics methods course was also interviewed towards the later end of the course. As well, all preservice elementary teachers in the first section (N=16) completed the Fennema-Sherman Mathematics Scales at the beginning and end of the mathematics methods course, providing pretest and posttest scores, while the second section (N=15), completed the Fennema-Sherman Mathematics Scales only at the end of the course generating a set of posttest scores. All preservice elementary teachers in the third year of the study, completed the Fennema Sherman Mathematics Scales at the beginning and end of the mathematics methods course providing another set of pretest and posttest scores. In total then, there were two different sets of pretest scores, and four sets of posttest scores.

The Elementary Mathematics Methods Course as an Intervention for Mathematics Anxiety

A multi-model intervention strategy for mathematics anxiety involving curricular intervention, remediation, and cognitive learning strategies was recommended by Rounds and Hendel (1980). They postulated that curricular interventions such as mathematics labs, individualized instruction and mathematics games would develop more favourable attitudes of teachers toward mathematics. Remediation was to be used to increase confidence through the building of mathematics skills. Finally, the cognitive therapies are important in changing negative feelings toward mathematics. A significant point in the multi-model approach is the fact that the mathematics anxious person may have varied difficulties in mathematics, and this model could more effectively address those differences. The multi-faceted nature of mathematics anxiety is further confirmed by that fact that a variety of interventions, ranging from desensitization and self-instruction to simple instructional changes have been successful in reducing mathematics anxiety (Eddy, 1985). As Eddy further concludes "due to the prevalence and the complexity of this anxiety, educators need to be aware of the different aspects of the problem and be prepared to meet the varied needs of math anxious students" (p. 27).

Mathison (1977), in a review of intervention strategies for mathematics anxiety, summarized three types of interventions: remediation, content manipulation, and an integrated approach utilizing math coursework and counselling. The first two types appeared to be most effective where student mathematics anxiety was low, and simply restructuring the material would make it easier to understand. This restructuring was carried out through mathematics labs, games, individualized instruction, and discussions. The integrated approach was found by Mathison to be most effective with individuals with high levels of mathematics anxiety since it accommodated a wide range of activities and included techniques for the transfer of learning. Therefore an intervention for individuals with high levels of mathematics anxiety, such as preservice elementary teachers, should incorporate a multi-model approach.

The elementary mathematics methods course that was investigated in the context of this research concentrated on the reduction of mathematics anxiety and the improvement of attitudes toward mathematics of preservice elementary teachers. This methods course can be seen as being structured in a multi-model approach to the reduction of mathematics anxiety. It was discovered through an interview with the professor who taught the course and through observations of the methods course by the researcher, that there were six components of an intervention for mathematics anxiety. These six components seem to be consistent with a model that includes curriculum strategies, remediation, and social cognitive therapies. These six components were the acknowledgement of mathematics anxiety as real, the utilization of small group work, the use of concrete materials as mathematics manipulatives, the use of videotapes, content mastery tests, and modelling.

Acknowledgement of Mathematics Anxiety as Real

During the elementary mathematics methods course there was an attempt to acknowledge the fact that the mathematics anxiety the preservice elementary teachers possessed was real. Social cognitive theory (Bandura, 1986) emphasizes the need for individuals to be cognizant of their thoughts and understandings about their anxieties. Other interventions for mathematics anxiety also stress the need to be aware of the anxiety before it can be reduced or eliminated (Larson, 1983; TEAM, 1984). The TEAM (1984) approach to the reduction of mathematics anxiety, emphasizes the need to "demystify math". By encouraging individuals to talk about their feelings and anxieties toward mathematics, they soon learn that they are not alone in such feelings and start to eliminate the myth that mathematics is difficult and something to fear. The concept of demystifying mathematics is similar to the correcting of erroneous perceptions about mathematics. When people misunderstand events, they may develop erroneous conceptions about themselves and the world around them (Bandura, 1986). One of the main ideas behind the development of the TEAM (1984) approach was that elementary teachers must be free of their own mathematics anxiety so that they could help their students and future students avoid or overcome discomfort with mathematics. By talking about their feelings towards mathematics and their mathematics anxiety, the preservice elementary teachers are taking the first steps towards reducing their own anxiety, and preventing it in their future students.

Discussion took place from the very first class of the elementary mathematics methods course between the professor and the preservice teachers, and between the preservice teachers, regarding the importance of positive attitudes toward mathematics and the possible links between teacher attitudes, behavior and student performance. During every class preservice teachers were encouraged to talk about their feelings toward mathematics. This is consistent with the Battista (1986), Larson (1983), TEAM (1984) and NCTM (1989) approaches to how mathematics should be taught with an awareness of the importance of attitudes towards mathematics. Mathematics anxiety was included within these discussions.

During the elementary mathematics methods course the professor also discussed with the preservice teachers how mathematics anxiety may be created. The preservice elementary teachers share and discuss what made them mathematics anxious while they were in school. Then they discuss how to avoid such situations in future. Throughout the mathematics methods course the professor spoke to the class about the need to provide a non-threatening environment for learning mathematics, not only in the methods course itself, but in any elementary mathematics classroom. By being aware of their mathematics anxiety, the preservice elementary teachers can then try through the other components of the mathematics methods course to reduce their anxiety levels.

Utilization of Small Groups

The use of small group work helps to instil an atmosphere of cooperation rather than competition (Larson, 1983; NCTM, 1989; TEAM, 1984). Working in small groups of three or four reduces anxiety by lessening individual responsibility for finding an answer or completing a task (Larson, 1983). Also, working in small groups enables everyone to have an opportunity to speak in an non-threatening environment, further reducing any anxiety that may be present. There were opportunities in almost every class of the elementary mathematics methods course for the preservice teachers to work in small groups: when learning to work with concrete materials in an elementary classroom, during discussions of reading assignments and topics raised in class such as mathematics anxiety, during problem-solving sessions, and while peer teaching.

The use of small group work during problem-solving actually serves two purposes. One is the importance of problem solving in the learning of mathematics, and the second is the opportunity to see a variety of solutions to a problem. The recent standards for mathematics education published by the NCTM(1989) stress the importance of problem solving and the relevancy of mathematics to the everyday world. Problem solving should be the primary goal of all mathematics instruction and a part of all mathematical activity (NCTM, 1989). While in small groups, the preservice elementary teachers solve problems that are relevant to elementary children such as deciding to purchase a ski pass or to pay daily rates depending on the individual's nature of skiing. Preservice teachers explore all possible solutions to such problems and then demonstrate the varied solutions to other members of the class. Working in small groups enable the preservice teachers to successfully solve problems and begin to feel confidence in their ability to solve problems.

Use of Concrete Material as Manipulatives for Mathematics

Through the exploration of concrete materials in contrast to rote instruction and memorization, the preservice teachers come to develop a better understanding of mathematics. The use of concrete materials help to bridge the gap between concrete and abstract concepts in mathematics. Several researchers have endorsed the use of manipulative materials as effective tools in the mathematics classroom (Lampert, 1990; Stodolosky, 1985; Stodolosky, Salk, & Glaessner, 1991). Exposure to the materials is not enough to correct the faulty perceptions and organizations of knowledge of mathematics anxious teachers but it is one component in a multi-model approach to the reduction of mathematics anxiety. In some mathematics classrooms, mathematics is assumed to be a fixed body of knowledge, and the focus is on competition, management, and group aptitudes (Romberg & Carpenter, 1986). This way of thinking only serves to perpetuate the development of mathematics anxiety by stressing the methodology of memorization and not of understanding.

Teacher educators must model the teaching skills and behaviors that they hope their students will emulate (Pennick & Yager, 1988). The instructor of the mathematics methods course studied concurs as she states:

> I think sometimes there can be a gap between what happens in a methods course and what happens in a school. I want these students to see how the philosophy that I have talked about in class, and had them explore in the readings, relates to some of the materials that are out there in the field, because sometimes people will go out from a methods course and research has shown, that they will forget about what's in the methods course and adopt almost the teaching strategy that they were taught with when they were in school. So I want them to maybe view materials through a different lens and that is why I bring them [classroom materials] in rather

than have them [preservice teachers] come up against them [materials] when they have a job.

During the methods course the preservice teachers participated in demonstration lessons conducted by both the professor and themselves involving manipulative materials such as: geoboards, base ten blocks, unifix cubes, attribute blocks, and cuisenaire rods. The fact that preservice teachers can discover the reasoning behind rules they had previously memorized, and that they can understand it, helps in the development of self-confidence (Larson, 1983; TEAM, 1984). Improved self-confidence in their ability to do mathematics reduces their mathematics anxiety (Bandura, 1986; Fennema & Sherman, 1977).

Use of Videotapes

A fourth component of this multi-model approach was the use of videotapes of actual elementary classrooms working with concrete materials. The purpose of incorporating the videotapes into the mathematics methods course was to provide opportunities for the preservice elementary teachers to actually see how children respond to the mathematics manipulatives. The original intent by the professor of using the videotapes was to continue the exploration of concrete materials through the observation of children working with them. The preservice elementary teachers were able to learn how to use the manipulative materials in a non-threatening environment by observing another teacher (on the videotape) working with children. By learning to use the concrete materials in an elementary classroom and through the learning of mathematical concepts themselves, the preservice elementary teachers were able to gain confidence in their ability to do mathematics and reduce their mathematics anxiety.

There were four videotapes utilized in this methods course covering the use of pattern blocks to learn fractions, pattern blocks to learn concepts in geometry, base ten blocks to learn multiplying and dividing, and cuisenaire rods to learn about percent and ratio.

Content Mastery Tests

Another part of a multi-model approach to the reduction of mathematics anxiety is a remediation component. Typically preservice elementary teachers with high levels of mathematics anxiety possess poor mathematics skills (Battista, 1986). Improved performance is related to reduced anxiety about having to do the task again in the future (Bandura, 1986; Beck & Emery, 1985). The intent of the content mastery tests was to provide a means to allow the preservice elementary teachers to improve their mathematical skills. As the professor explained, it was important for the preservice elementary teachers to possess a sound understanding of elementary mathematical concepts. The content mastery tests were decided upon by the professor as the most efficient way to cover a wide variety of topics in a short period of time.

There were three content mastery tests throughout the mathematics methods course. The first one assessed calculator problems, word problems, area, perimeter and volume. Knowledge of fractions, decimals, percent and place value were evaluated on the second mastery test. The final content mastery test assessed knowledge on geometry. The preservice elementary teachers had as much time as necessary to write the tests, and could write them as many times as possible to achieve a mastery level of 90%. The preservice elementary teachers would prepare for the tests through the work that was ongoing in the methods course and through seeking extra help outside of class time from the professor, each other and the education resource center in the library.

Modelling

The final component of an intervention to reduce mathematics anxiety included within the mathematics methods course was the use of modelling. The development of a non-threatening environment that stimulates curiosity is a necessary component of a mathematics methods course and the professor tried to provide such an environment. The professor was always conscious of how she appeared to the preservice teachers and she tried to model appropriate teacher behaviour. For instance, regarding gender roles and gender stereotypes she was always careful giving examples concerning teachers so that she was always referring to both male and female, such as using women as farmers, and men as nurses. The importance of modelling, especially in the area of mathematics and gender was to ensure that individuals did not perceive mathematics as belonging in the masculine domain. It was necessary for the preservice elementary teachers to develop skills that would enable them to recognize and counteract gender bias. "Otherwise they are likely to perpetuate the problems associated with math anxiety by repeating stereotypic teacher behaviour and providing biased learning experiences for children" (Chapline, 1984, p. 23).

Modelling as a component was connected with many of the other components of the elementary mathematics methods course. For example in the use of the videotapes, the preservice elementary teachers observed a teacher using the concrete materials with elementary children. The preservice teachers were able to see through modelling how to interact with a class of children using the concrete materials, and also how to provide a non-threatening environment in which to learn mathematics. In the use of small groups, the preservice elementary teachers were able to learn from each other as they modelled different approaches to solving problems. Through the observation of how others solve problems the preservice teachers learned new strategies and techniques to approach problems with, and could reduce their mathematics anxiety by expanding how they could successfully solve problems.

Summary

This intervention for mathematics anxiety is based on the literature on teacher education, mathematics education, social cognitive theory, and mathematics anxiety. In developing this elementary mathematics methods course information from all of these sources was incorporated. It was hypothesized that an elementary mathematics course with the following components would reduce preservice elementary teachers mathematics anxiety and enable these same teachers to reduce and avoid mathematics anxiety in their future students. The components of the course include, the acknowledgement of mathematics anxiety as real, the utilization of small groups, the use of concrete materials as mathematics manipulatives, the use of videotapes, content mastery tests, and modelling.

Chapter IV

RESULTS

The study examined three concurrent years of an elementary mathematics methods course and utilized the institutional recurrent cycle research design (Campbell & Stanley, 1963) as the basis for collecting information on research questions regarding mathematics anxiety and attitudes towards mathematics. The recurrent institutional cycle research designed as utilized in this study was shown in Figure 1, in Chapter III. Questionnaires were administered at the beginning and end of the elementary mathematics methods course. Interviews were conducted concurrently with the elementary mathematics methods course during the second year of the study.

Each year of the study involved preservice elementary teachers enrolled in the first year of a two year post undergraduate degree Bachelor of Education program. In total 112 (18 male, 94 female) preservice elementary teachers participated over the three years of the study. The questionnaire data were collected from six different administrations of the Fennema-Sherman mathematics scales, two pretests and four pretests. There were 163 questionnaires administered and completed during the research. The interview data were collected during the second year of the study. Of the 31 preservice elementary teachers participating in the second year of the study, 13 volunteered to also undergo a series of interviews while taking the elementary mathematics methods course. These preservice elementary teachers were each interviewed three times during the course: at the beginning, in the middle, and near the end. The professor who taught the course was also interviewed during the course.

In reporting the results, the demographic data for the preservice elementary teachers are presented first. Then the three research questions are answered through a reporting of the questionnaire and interview data. The first research question asks whether this elementary mathematics methods course reduces the mathematics anxiety levels of the enrolled preservice teachers. The second research question concerns whether or not this elementary mathematics methods course changes specific attitudes of preservice elementary teachers towards mathematics. These attitudes are confidence in learning mathematics, perception of teacher towards one as a learner of mathematics, perception of mathematics as a male domain, and perception of success in mathematics. Finally, the third research question asks, "what are the components of the elementary mathematics methods course that are successful in reducing mathematics anxiety identifable?"

Demographic Data of the Questionnaire Subjects

The research involved 112 preservice elementary teachers over a three year period. During the study 42 (5 male, 37 female) preservice elementary teachers participated in the first year, 31 (5 male, 26 female) participated in the second year, and 39 (8 male, 31 female) preservice elementary teachers participated in the third year. Altogether 18 male and 94 female preservice elementary teachers participated in the research. All of these preservice elementary teachers completed the Fennema-Sherman mathematics scales at the beginning and/or at the end of the mathematics methods course.

The educational background of the preservice elementary teachers provided descriptive data. It was found that only 4% of all of the preservice elementary teachers came from a Mathematics or Science background. Individuals with a Psychology or Sociology background comprised 29% of the total population while another 24% had either an English or History background. The remaining 43% came from a variety of backgrounds including French, Recreation, Child Studies, Physical Education, Political Science, or general arts with no specific major.

A further analysis of the subjects' mathematical course background showed that only 38% of the preservice elementary teachers had taken mathematics past high school and that was generally only a half-credit in statistics for the psychology and sociology majors. The majority of the preservice elementary teachers (62%) had not taken any mathematics courses beyond high school, and over 13% of these had not taken mathematics in their final year of high school.

During the second year of the study, 13 of the 31 preservice elementary teachers volunteered to participate in interviews. Of the 13 preservice teachers interviewed, 11 were female and 2 were male. Twelve were from an Arts and Humanities background (92%) and one came from a Science background (8%). Over half (7 of 13) of the preservice teachers interviewed had either a Psychology or Sociology background. The remaining preservice elementary teachers had an English (4 of 13), History (1 of 13), or Biology (1 of 13) as their undergraduate degree major. Therefore the interview group, which was a subsample of the larger population, was similar in academic background to the larger population. That is, over 90% of the preservice elementary teachers interviewed had an

Arts and/or Humanities background as did the preservice elementary teachers who completed questionnaires.

Descriptive Questionnaire Data

The Fennema and Sherman Scale provided information on five separate subscales: (a) mathematics anxiety; (b) confidence in learning mathematics; (c) perception of teacher towards one as a learner of mathematics; (d) perception of mathematics as a male domain; and (e) attitude toward success in mathematics. All of the subjects in the first year of the study (N= 42) completed the questionnaires at the end (posttest) of the elementary mathematics methods course. The second year of the study involved half of the preservice elementary teachers, known as group (a), (N= 16) being administered the Fennema-Sherman Scales at the beginning (pretest) and end (posttest) of the mathematics methods course, while the other half of the subjects (N= 15) in the second year of the study, known as group (b), completed the Scales only at the end (posttest) of the mathematics methods course. The preservice elementary teachers in the third year of the study (N= 39) completed the Fennema-Sherman Scales at the beginning (pretest) and end (posttest) of the elementary mathematics course. Table 2 provides the means and standard deviations for the Fennema Sherman Scales of mathematics anxiety, confidence, perception of teacher, mathematics as a male domain, and attitude toward success in mathematics for all of the preservice elementary teachers in the study. Note, a higher score (to a maximum of 60), is positive, for example, in the case of the scale measuring mathematics anxiety, a higher score indicates a lower anxiety level. For the scale of the perception of mathematics as a male domain, the higher the score, the less mathematics is perceived as a male domain.

Table 2

Mean and Standard Deviation Scores for all Scales and all Subjects

Group	Scale				
	Math Anxiety	Confidence in Learning Math	Perception of Teacher	Math as a Male Domain	Attitude Toward Success in Math
	X (S.D.)	X (S.D.)	X (S.D.)	X (S.D.)	X (S.D.)
YR 1 Post N=42	38.9(13.0)	42.3(11.9)	42.2(10.3)	56.6(3.8)	51.1(5.1)
YR 2a Pre N=16	39.1(11.9)	43.8(9.3)	40.5(8.7)	54.1(5.0)	48.8(6.5)
YR 2a Post N=16	45.2(7.3)	45.2(6.7)	44.3(5.4)	55.3(4.8)	47.6(5.3)
YR 2b Post N-15	40.9(11.0)	45.9(9.4)	44.6(6.9)	55.9(4.7)	51.5(5.0)
YR 3 Pre N=39	34.4(12.4)	40.1(11.6)	40.5(10.1)	56.2(4.0)	50.6(5.3)
YR 3 Post N=35	37.7(12.8)	42.6(11.6)	43.0(9.5)	56.1(4.1)	49.3(6.8)

Note. Maximum Score is 60, Minimum Score is 12

Research Question One

The first research question deals with whether or not the elementary mathematics methods course reduces the mathematics anxiety levels of the preservice teachers. To answer this question it was necessary to explore both the questionnaire results and interview data. The questionnaire data from the Fennema and Sherman Mathematics Anxiety Scale are reported first, followed by an analysis of the interview data regarding mathematics anxiety.

Questionnaire Data

Within this institutional recurrent cycle research design comparisons have been drawn through independent and paired t-test analyses of the pretest and posttest scores. The comparisons of pretests to posttests are to determine the effectiveness of program. Year One Posttests have been compared to the pretests administered in Years Two and Three. The Year Two Posttests have been compared separately and together with the Pretests in Years Two and Three. The Year Three Posttests have been compared to the pretests in Years Two and Three. A further grouping was the statistical comparison of both pretests and posttests of all the subjects who completed the Fennema-Sherman Scales during the second and third years of the study.

A summary of the means and standard deviations for mathematics anxiety for all three years of the study is presented in Table 3. Note, the higher the score (to a maximum of 60), the lower the mathematics anxiety.

Table 3

Mathematics Anxiety Pretest and Posttest Means (Standard Deviations) for All Subjects by Year in Study

Year						N
One	**M** 38.9(13.0)					42
Two a		39.1(11.9)	**M** 45.2(7.3)			16
b			**M** 40.9(11.0)			15
Three				34.4(12.4)	**M** 37.7(12.8)	39

Note. **M** = elementary mathematics methods course

To answer research question one, whether or not the elementary mathematics methods course reduces mathematics anxiety, using the questionnaire data, t-tests were conducted to compare the scores on the mathematics anxiety scales before and after completing the mathematics methods course. A probability level of .10 was chosen for this research project because of the exploratory nature of the research in investigating the effectiveness of an intervention(Gay, 1987). Also the use of other data sources will provide for further analysis of the data. A summary of the t-test analysis for all of the pretest and posttest results on the mathematics anxiety scale is presented in Table 4.

Table 4

t-Test Analysis for All Pretest and Posttest Scores for Mathematics Anxiety

Comparisons	Mean Difference	df	t	p
YR 1 post vs YR 2 prea	0.2	56	04	972
YR 1 post vs YR 3 pre	+4.5	79	1 62	083 *
YR 2 prea vs YR 2 posta	+6 1	15	1.85[†]	084 *
YR 2 prea vs YR 2 postb	+1.8	29	44	665
YR 2 prea vs YR 3 post	-1.4	49	37	712
YR 2,3 pre vs YR 2,3 post	+5.7	50	2.68[†]	010 *
YR 3 pre vs YR 2 posta	+10.8	53	4 01	0009
YR 3 pre vs YR 2 postb	+6.5	52	1.88	070 *
YR 3 pre vs YR 2 posta,b	+8.7	68	3 35	001 *
YR 3 pre vs YR 3 post	+3.3	34	1.39[†]	.174

Note. * p .10.

[†] indicates a paired sample t test, all others are independent t tests

For six of the ten statistical comparisons, significant differences were found in the predicted direction, the posttest scores were higher indicating lower anxiety levels. Also the pretest scores for all subjects (X-35 73, N 55) were lower than the posttest scores (X=39.72, N-108), indicating a reduction in mathematics anxiety after completing the elementary mathematics methods course. The higher the score the lower the mathematics anxiety levels. The course appears to have been successful in reducing the mathematics anxiety levels of the preservice teachers. There were significant differences found in year two between the pretest(a) and posttest(a) (p=.084). Significant differences were also found when the combined pretest scores from years two and three were compared to the combined posttest scores from these same years (p=.01). When the pretests in year 3 were compared to the posttests in year 1, significant differences were found (p=.083). Significant differences also occurred when year 3 pretests were compared to: year 2 posttest(a) (p<.001); year 2 posttest(b) (p=.07); and to year 2 posttests(a,b) (p=.001).

Therefore the scores on the Fennema-Sherman Mathematics Anxiety Scale seem to indicate that after completing the elementary mathematics methods course the mathematics anxiety levels of the preservice elementary teachers were lower. To assist in answering research question one further, an analysis of the interview data regarding mathematics anxiety is presented next.

Interview Data - Mathematics Anxiety

The interview data to answer research question one are reported chronologically from the first interviews through to the final interviews. The preservice elementary teachers who volunteered to participate in the interview section of the research were each interviewed three times during the span of the elementary mathematics methods course. These preservice elementary teachers were interviewed at the beginning, in the middle and near the end of the course. The beginning interview was structured to gather information about the preservice elementary teachers and their feelings towards mathematics. The second and third interviews were to see whether or not these feelings towards mathematics changed during the span of the methods course. An interview guide is found in Appendix (B).

To gain a sense of the preservice elementary teachers' feelings towards mathematics and to see whether or not they were mathematics anxious before starting the elementary mathematics methods course, a variety of questions were asked in the first interview. The preservice elementary teachers were asked to recall their most and least favourite subjects during their own school years. The purpose of this question was to see if mathematics stood out for them, negatively or positively, in their remembrances of schooling. The preservice teachers were also asked what they thought about having to take a course in teaching mathematics now. Continuing with the preservice teachers' memories of schooling, other questions explored their early experiences with mathematics. This was to determine if the preservice teachers were mathematics anxious, and if so, could they pinpoint how their mathematics anxiety arose.

Comments regarding the preservice teachers' most and least favourite subjects were gathered during the first interview. They stated that not only were they anxious about doing mathematics, but also said they did not like, and even hated, mathematics. When asked what their favourite subject was during their own school years the preservice teachers reported English(4 of 13), Social Studies (3 of 13), Art (2 of 13), Reading (2 of 13), Health (1 of 13), and French (1 of 13). There was not one subject that clearly stood out as a favourite for all of the preservice teachers. This situation was quite different when the preservice teachers were asked what subject they disliked the most or was their least favourite. Mathematics was identified by 85% (11 of 13) of the preservice elementary teachers as their least favourite subject during their own school years. Mathematics was not only their least favourite subject during their pre-university schooling, but continued to be disliked throughout their university careers. One preservice teacher (#2) reported that she was "pretty happy" when she did not have to take any mathematics after high school. Yet another preservice teacher (#5) said, "when I graduated from grade twelve, this is the attitude I had, there's going to be no more math for me. I had a rough time in high school with math". Therefore, for most of the preservice elementary teachers, mathematics was not a subject that they liked or enjoyed.

Not only was mathematics their least favourite subject during elementary and secondary schooling, but it continued to cause negative feelings for these preservice elementary teachers. Several of the preservice elementary teachers reported during the first interview feeling anxious when they realized that during their education degree they would have to take a course relating to mathematics. One preservice teacher (#6) reported that she was not looking forward to taking the methods course in mathematics, "because this one is math, I just think, here we go again". During the conversation she resigned herself to the "fact" that mathematics was not for her. "I've come to terms with it, math is just not one of my strong points". Another preservice teacher (#3) stated that when he saw the class schedule for education courses "I looked down and there it was, mathematics. I just cringed and thought I don't know what I'm going to do. I said it will be my lowest mark of everything but I have to take it". He said that he felt very uncomfortable about having to take a mathematics course even though it was a course in teaching mathematics. To him, it was a "mathematics" course. Mathematics for him had always involved negative experiences including low grades or failures.

Another preservice elementary teacher (#2) said, "I remember back in the summertime looking up courses that I'd have to take and remember saying 'Teaching Math!', and that was the one that stuck out the most. So that was the course of them all that I was a little scared of taking". And yet another one of the preservice teachers (#7) called mathematics her "Black Fear". Many of these preservice teachers had continually experienced failure with mathematics in school. One of the preservice teachers (#3) further commented that "my two years here would be a lot easier if I didn't have to take math", (referring to the two year education degree). Not only did these preservice teachers dislike mathematics, but they were happy when they did not have to take mathematics anymore. These teachers admitted to feeling anxious and frightened that they would have to take a course involving mathematics. These comments about mathematics indicate the preservice elementary teachers' negative and anxious state of mind towards mathematics at the beginning of the mathematics methods course.

Some of the preservice teachers clearly stated that they thought they knew where and how their mathematics anxiety arose. The following are illustrations of their views. One preservice teacher (#12) stated that her experiences in mathematics classes were not always positive and she clearly understood how her mathematics anxiety could have arisen. As she stated, "I took a couple of math classes that blew me away. That's when I decided, thank God I just won't be teaching math, because they just went over my head. . . . I thought, I'll never grasp this". Because she had been unsuccessful in her attempts to learn certain mathematical concepts, she decided that mathematics was no longer for her. She then tried to avoid any future contact with situations where she might have to do mathematics. One preservice teacher (#10) who said that she hated mathematics, failed a basic grade six skills test in mathematics. As she related her thoughts about writing the test, "I mean, it seems simple enough but it takes a lot of soul searching to try to find the answers". For her mathematics had always been a guessing game where, through trial and error, you "found" the answer. Elementary school mathematics was not a positive experience for another preservice elementary teacher (#11) as she recalls:

> In grade three we used to do - oh they're horrible - we used to do those ones where you had number facts and you see how many you can do in so many minutes. . . . and I had those. It made me right anxious and nervous and everything.

She thought that her mathematics anxiety arose from timed "math minutes" in elementary school.

Another of the preservice teachers (#6), for whom mathematics and science were always her lowest marks, assigns her teacher's attitude towards her or actually towards her lack of ability in mathematics as contributing to her mathematics anxiety. As she says:

> I had a great math teacher and he just thought I could do math and I was fine in it. Then came the next grade and we came into the section in geometry and it just wasn't coming to me very well. I asked one of my teachers and he said, "If you

> can't do geometry then you're not a logical thinker, you can't deduct". There were me and about four or five others in the class, and we all did just horrible in geometry. I just thought, that was it, you can't do geometry, you can't do math. . . I lived and learned, once again.

Unfortunately for her, what she learned was to be anxious about mathematics.

Mathematics evokes strong memories for these preservice teachers while memories of other school subjects were blurred but generally well thought of. When the preservice elementary teachers interviewed were asked to recall why certain subjects were their favourites, none of them could retrieve a specific memory. There was just a general feeling for them that their experiences had been positive. Yet for mathematics the remembrances were clear, distinct, and negative. These preservice elementary teachers also indicated where they thought their own anxiety toward mathematics began, during their school years, especially during elementary school years. As one preservice teacher (#5) recalled, this experience with elementary mathematics:

> I remember this because she [the teacher] had me up at the board. I was the only one, and she was making sure I understood this question and she told me that I couldn't sit down until I figured it out and she started to get really impatient with me, and she got so upset with me that I ended up crying, so then she finally let me sit down. I remember it so well because I was so embarrassed in front of all my friends, so she finally let me sit down, and

I did have to stay after school too, to get this question right.

This was certainly a very negative and anxiety generating experience for her. She attributes her anxiety towards mathematics as having its beginning with this incident. Another preservice teacher (#8) recalled an experience where mathematics was used as a punishment because the class was misbehaving:

> I remember grade four, grade three, math was used as a punishment a lot of the time. We'd be going nuts, working on our Art projects or something and the teacher's trying to calm us down, you know how kids are, yelling and screaming and being free explorers, and BOOM! The teacher had a bell . . . RING, RING, and then you had to sit with your hands on your desk and look at the teacher. "Heads down, now get out your math books", and we had to do math until we were quiet.

This preservice teacher equates the doing of mathematics with punishment. Mathematics was something you were made to do when you were bad. He stated that he was surprised that not more people were anxious towards mathematics. As he said, "I remember some kids hated math because of that [referring to math as punishment]. Two girls I know, good friends of mine, hate math even to this day. . . . Obviously it had quite an impact on them". Yet another preservice teacher (#4) remembers her elementary school years and in particular her grade four teacher:

> She used to have us doing drills, up at the board, of times-tables, and that's the only time I remember being absolutely petrified and going home and crying at night. Because I had to do well, I wasn't sure what number I'd get from 1 to 9 in

> my times-tables and she was going to give the whole set. What you were going to do is get up to the board, she'd pick you and another person, and write them down as fast as you could and then the answers and see who got them done the fastest. But I remember the night before my Mom and Dad sitting down and just going through them because I wanted them to drill me with these times-tables to make sure that I knew them.

Here is a preservice teacher who remembers being "absolutely petrified" and crying during a mathematics lesson. This experience is sharply remembered and is pinpointed as the reason why she began to feel mathematics anxiety.

In summary, as these preservice elementary teachers started the methods course, they were anxious about mathematics and were not looking forward to having to take a course "in mathematics". For the majority of the preservice elementary teachers their experiences with mathematics had been negative ones. Mathematics was disliked as a subject and consequently many of them had avoided situations that involved mathematics. Most of the preservice elementary teachers were able to explain how they thought their own mathematics anxiety had arisen. Some of the major explanations given for mathematics anxiety were (i) unsuccessful attempts to learn mathematical concepts and subsequent failures, (ii) timed mathematical experiences, (iii) mathematics used as a punishment for misbehaviour, and (iv) the way that mathematics had been taught, e.g., through repetitive drills.

As the course progressed, the preservice elementary teachers began to feel less anxious about mathematics in general and about the mathematics methods course. The second and third interviews illustrate how these feelings toward mathematics were changing. The preservice elementary teachers' feelings and anxiety toward mathematics seemed to improve rapidly. All of the preservice elementary teachers reported feeling less anxious towards mathematics as the course progressed. The very fact that mathematics anxiety was talked about was helpful in reducing anxiety. As one person (#6) reported, "you think you're the only person who experiences math anxiety, so it's really comforting to know that you are not alone and it's okay". For many of the preservice elementary teachers it was the first time that they realized they were not alone in experiencing mathematics anxiety. The very acknowledgement that their mathematics anxiety was real was helpful in beginning to reduce their anxiety.

The structure of the mathematics methods course was helpful in reducing mathematics anxiety. The course was structured to allow the preservice elementary teachers to learn mathematical concepts with manipulative and concrete materials. The course was very much "hands-on', with an experiential nature. One preservice teacher (#2) said that after taking the methods course she now felt a lot more comfortable with mathematics. If teachers taught mathematics the way this methods course had shown then she thought, "that kids aren't going to be afraid to do math and have math anxiety as much as maybe we [preservice teachers] would have had coming through [school]. The very nature of the methods course was responsible for providing her with positive learning experiences in mathematics and thus reduced her mathematics anxiety.

Many of the preservice teachers (#7,8 9, 10) reported feeling "more comfortable", a "lot better", and "more confident" about doing mathematics and "less anxious" about mathematics. As one preservice teacher (#11) stated, "I like the math class, I like going to math class, and I used to hate it when I was in school'. For her the positive learning experiences provided in the mathematics methods course helped her to improve her feelings towards mathematics and to reduce her own mathematics anxiety. It is very difficult to separate the comments regarding mathematics anxiety and confidence in learning mathematics. Fennema and Sherman (1976) agree with this finding of a relationship between confidence in learning mathematics and mathematics anxiety. In fact, their scales of confidence in learning mathematics and mathematics anxiety have a correlation of .89 (Fennema & Sherman, 1976). Improved confidence in learning mathematics and lowered mathematics anxiety seem to be intertwined for these preservice elementary teachers. As one preservice teacher (#7) stated:

> I feel more confident at the elementary level. . . . That was my major thing in September, I had to have the confidence in myself or I wouldn't be a teacher, and I'm serious about that. Every area in math, I knew it was going to be the biggest challenge.

This was the same preservice elementary teacher who at the beginning of the methods course called mathematics her "Black Fear". She no longer felt as negatively towards mathematics and stated that she was less anxious about having to do mathematics. Another preservice teacher (#9) said that what she desired of the methods course was that, "I wanted to come away feeling a little bit better about Math, a little bit more confident, and I did. Like even teaching that math lesson that we did, I felt pretty good about it". This same preservice teacher said that she did not want to take the mathematics methods course in the first place, because it involved mathematics, but she surprised herself. There was a connection for these preservice elementary teachers between feeling more confident in their ability to perform mathematics and feeling less anxious towards mathematics.

Several of the preservice teachers (#2, 3, 4, 5, 9) reported that they had a new awareness of mathematics at the end of the elementary mathematics methods course. As one of the preservice teachers (#2) said, she felt more confident about mathematics because she now realized mathematics could be fun, and it wasn't just repetition and rules. Before she understood mathematics to be "you go in, teacher stands up at the board, do drills, drills, drills, you know". Many of the preservice teachers as noted above found the experience of having fun while doing mathematics to be a new one. The new awareness of mathematics for them was that learning mathematics could be an enjoyable and an anxious free situation.

As one preservice teacher (#2) stated near the end of the methods course:

> I feel more comfortable with Math now, then I did at the start. . . . I think if you start out with them [children] at a young age, in grade one, using concrete materials and group activities, that kids aren't going to be afraid to do math and have math anxiety as much as maybe we did.

Some of the preservice teachers came to realize that what a teacher thinks about a subject could affect how that subject gets treated in the curriculum. That is, a teacher who was anxious about mathematics could avoid teaching that subject. As one preservice teacher (#5) stated, "I can understand, like, a lot of time math is the last subject on the teacher's list, as it was I think on mine, and it shouldn't be". She was trying to express the idea that just because a teacher does not enjoy a subject, it should not be neglected in the school curriculum. She no longer felt as negatively towards mathematics and felt that for her mathematics now had an equal chance in the day to day teaching of her classroom. The preservice elementary teachers were able to articulate exactly what components of the mathematics methods course successfully contributed to the reduction of their mathematics anxiety. The data regarding the structure of the methods course will be reported in detail in response to the third research question which asks what are the components of the mathematics methods course that successfully reduce anxiety.

It appears that the elementary mathematics methods course was successful in reducing the preservice elementary teachers' mathematics anxiety. The preservice elementary teachers started the mathematics methods course feeling anxious towards mathematics. Both the scores on the Fennema-Sherman Mathematics Anxiety Scale and the interview results indicated that the elementary mathematics methods course was successful in reducing the preservice elementary teachers' mathematics anxiety. The posttest scores were higher on the mathematics anxiety scale indicating a lower mathematics anxiety and during the interviews the preservice elementary teachers clearly reported feeling less anxious about mathematics.

To further examine mathematics anxiety and attitudes towards mathematics an exploration of the data involving the second research question is reported next.

Research Question Two

The second research question asks, "are the attitudes toward mathematics of the preservice elementary teachers changed after completing the elementary mathematics methods course"? Four dimensions of an attitude towards mathematics are explored through the second research question. The first dimension concerns the preservice elementary teachers' confidence in learning mathematics. Confidence in one's ability and or performance is crucial to what one is willing to attempt. A second dimension related to the attitude one has toward mathematics is the perception of a teacher toward one as a learner of mathematics. The attitudes of significant others are important for learning. Therefore this dimension relates to how one perceives the perception of teachers toward one as a learner of mathematics. The third dimension that is explored in this research is the perception of mathematics as a male domain. When mathematics is perceived to be in the masculine domain, girls may be less willing to pursue studies in this area. Since preservice elementary teachers are primarily female, the perception that mathematics belongs in the male domain becomes important to study. The fourth and final dimension that will be explored under research question two, is the attitude toward success in mathematics. This dimension describes and measures the degree to which one anticipates positive or negative consequences, as a result of success in mathematics.

Each dimenson is analyzed through a reporting of both the questionnaire results and interview data. The first dimension to be reported is confidence in learning mathematics.

Confidence in Learning Mathematics

Confidence in one's ability to learn and perform is important if one wishes to be successful. As was evident in the reporting of research question one, the preservice elementary teachers refer to their confidence or lack of confidence in performing mathematical tasks. The dimension of one's "confidence in learning mathematics" is explored further here in answering research question two. The questionnaire data on confidence in learning mathematics are presented first, following by the reporting of the interview data. Table 5 provides a summary of the means and standard deviations for all subjects on the confidence in learning mathematics scale. Note that the higher the score (to a maximum of 60) the higher the confidence level.

Table 5

Confidence in Learning Mathematics Pretest and Posttest Means (Standard Deviations) for All Subjects by Year in Study

Year						N
One	**M** 42.3(11.9)					42
Two a		43.8(9.3)	**M** 45.2(6.7)			16
b			**M** 45.9(9.4)			15
Three				40.1(11.6)	**M** 42.6(11.6)	39

Note. **M** = elementary mathematics methods course

To answer the first part of research question two, whether or not the levels of confidence in learning mathematics change after completing the elementary mathematics methods course, the questionnaire data were analyzed. The same comparisons of paired and independent t-tests analyses were utilized as in research question one. That is, Year One posttests were compared to the pretests administered in Years Two and Three. The Year Two posttests were compared separately and together with the pretests in Years Two and Three. The Year Three posttests were compared to the pretests in years Two and Three. A further grouping was the statistical comparison of all pretests and posttests on the confidence in learning mathematics scales completed during the second and third years of the study. Table 6 presents a summary of the t-test analysis for all of the pretest and posttest results on the confidence in learning mathematics scale.

For three of the ten comparisons, significant differences were found in the predicted direction. Also the pretest scores for all subjects (X=41.14, N=55) were lower than the posttest scores (X=43.33, N=108), indicating an improvement in the level of confidence in learning mathematics after completing the elementary mathematics methods course. Eight of the ten comparisons did show improvement in the level of confidence in learning mathematics, but the improvements were not large enough to be statistically significant. There were significant differences found when the combined pretest scores from years two and three, were compared to the combined posttests scores from these same years (p=.068). Significant differences were also found when the pretest scores from year three were compared to the postest scores in year two(b) (p=.09). The final significant differences occurred when the pretest scores in year three were compared to all of the postest scores in year two (p=.029).

Table 6

t-Test Analysis for all Pretest and Posttest Scores for Confidence in Learning Mathematics

Comparisons	Mean Difference	df	t	p
YR 1 post vs YR 2a pre	-1.5	56	.46	.651
YR 1 post vs YR 3 pre	+2.2	79	.86	.391
YR 2a pre vs YR 2a post	+1.4	15	.50 †	.626
YR 2a pre vs YR 2b post	+2.1	29	.61	.544
YR 2a pre vs YR 3 post	-1.2	49	.36	.721
YR 2,3 pre vs YR 2,3 post	+3.6	50	1.87 †	.068 *
YR 3 pre vs YR 2a post	+5.1	53	1.65	.105
YR 3 pre vs YR 2b post	+5.8	52	1.73	.090 *
YR 3 pre vs YR 2a,b post	+5.4	68	2.23	.029 *
YR 3 pre vs YR 3 post	+2.5	34	1.39 †	.174

Note. $^*p<.10$

† indicates a paired sample t-test, all others are independent t-tests

The posttest scores on the whole were higher than the pretest scores suggesting that there was slight improvement in confidence in learning mathematics after completing the elementary mathematics course. The significant differences were found when the sections were combined, possibly indicating that the small sample size may have hindered finding significant differences. To assist in answering this part of research question two further, an analysis of the interview data regarding confidence in learning mathematics is presented next.

Interview Data - Confidence in Learning Mathematics

The interview data to answer this section of research question two are reported in chronological order from the first interviews through to the final interviews. The preservice elementary teachers were each interviewed three times during the span of the elementary mathematics methods course. Initially the preservice elementary teachers were generally not confident in their own ability to learn and perform mathematical tasks successfully. As was reported in the mathematics anxiety section, many of these preservice elementary teachers had had negative experiences with mathematics. Consequently their confidence in their ability in regards to mathematics was low. Many of the preservice elementary teachers reported feeling very anxious and not confident before having to do assignments or tests that would demonstrate what their ability was in mathematics.

One preservice elementary teacher (#10) was not confident in her ability to learn mathematics successfully. As she states, "maybe it is just because it's math. Cause it's sort of written in stone in my brain that I haven't done well in math so far". Another preservice teacher (#12) stated she was not very confident in her ability to perform well on mathematical tasks. She reported that the thoughts that always go through her head are, "Oh, I don't know anything, I'll forget everything, or if I just look it up maybe I'll remember it. I'm very uptight and I get sick a lot before I do exams [mathematics]". She was worried about the possibility of having to teach a grade six mathematics class, because of her lack of confidence in her own ability to do the mathematics required. "I was worried about that before, you know, I didn't know about being able to teach grade six. I wasn't sure what level that word problems were." Another preservice teacher (#11) was also always doubting herself before mathematics tests, and only before mathematics tests, because she felt in the other subjects she could always form some kind of answer. In regards to mathematical tests and assignments, she said, "I always felt like I didn't know if I was prepared enough for them".

The preservice elementary teachers at the beginning of the course were unsure about their ability to do mathematics and were unsure about having to teach mathematics because they did not know where the students in each grade would be. As one preservice elementary teacher (#2) explained she was nervous about having to teach mathematics because she "was not really sure what kind of work you take in each level". She herself did not like mathematics and said "I was pretty happy I didn't have to take it", once she left high school. She was "scared about taking the methods course, because I thought that we were going to be doing math". If the preservice elementary teachers are not confident in their own ability to do mathematics, then they are generally not confident in their ability to be able to teach mathematics especially at the upper elementary grade levels (5 and 6). As one preservice elementary teacher (#3) explained, he was nervous about having to teach the upper grades because of his lack of confidence in his ability to do the mathematics. "If it comes to having to teach math, well I can enroll in math classes myself. I'll be learning the same time they're learning because I'll have to stay two steps above them". He knew or felt that his own ability to successfully perform mathematics was poor, and that he would have to take remedial math classes himself if he had to teach in the upper elementary grades. He was not very successful on his first attempts at the mathematics content mastery assignment during the class. He became very "frustrated because everybody else is finishing up before you", when he had to do the assignments.

Another one of the preservice elementary teachers (#5) did not like mathematics because she got frustrated trying to learn it in school. "I just got fed up with not being able to do it". The attitude she had upon leaving high school was "no more math for me". She stated that she hated mathematics "mainly because I didn't feel competent in it like my other subjects". She did not have confidence in her ability to learn or to do mathematics. When describing an assignment she had to complete at the beginning of the course she said, "the only things that I really had trouble with were those word problems. I did feel what I do when I first started the word problems, I felt I was going to have trouble, so I just flipped to the next page". She knew right away she was going to have trouble, or she did not have confidence in her ability to solve word problems. What she wanted from the methods course was, "I do want to know how to do math. I'm hoping that it will give me a lot of confidence to be able to go out there and teach it and not to feel insecure about it. If the teacher feels insecure, the students are going to do that too".

Another preservice elementary teacher (#6) wanted to have a positive attitude toward mathematics, because she really did not like mathematics.

Mathematics had always been her lowest subject for marks. What she wanted from the methods course was, "hopefully I'll have a positive attitude too, so that when I go in to teach, I don't want the students thinking, if she's so intimidated by it . . . I guess it's all a point of confidence". This same theme about how the teacher feels was mentioned by another preservice teacher (#7). "I need someone who's so confident that they can teach that I'm going to learn. I'm fine until I pick up that little threat, and I'm just like, she can't do it either, she can't even explain". She thought if she felt that way other people might also, and she was not confident in her own ability to learn and do mathematics, much less to teach it. She was hoping that the mathematics methods course would actually help her to learn how to do mathematics. She thought she had a lot to offer as an elementary teacher, "but it's the math that's really killing me. If I didn't have to teach math I would have an easier time".

As shown above from the earliest interviews, the preservice elementary teachers started the elementary mathematics methods course with low confidence in their own ability to perform mathematical tasks. As the course progressed, they gained confidence in their abilities to learn, successfully perform, and to teach mathematics. One preservice teacher (#10) said,

> my attitudes toward math have changed somewhat, not a lot. Well, they have I guess, they changed. I'm a little bit more comfortable with it [math] but that doesn't mean that I'm really confident about it. Well, I wanted to come away feeling a little bit better about math, a little bit more confident, and I did.

Another preservice teacher (#9) stated, "I feel more confident and I think I can do it [math] and I can teach it [math]". And another preservice teacher (#8) said, "I always thought math was important so my attitudes toward math haven't changed. My attitudes toward how it should be taught, definitely changed. I guess I feel a lot better about teaching grade six next year, teaching them their math, because of what I've learned here." Yet another preservice elementary teacher (#7) stated,

> That was my major thing in September, I had to have the confidence in myself or I wouldn't be a teacher, and I'm serious about that. Every area in math, I knew it was going to be the biggest challenge. I feel confident that when I go to teach I'll be able to find a way because I want to. And that overrides and supercedes any kind of fear I had. I feel more confident about math at the elementary level.

When asked if their attitudes toward mathematics have changed since the elementary mathematics methods course, most of the preservice teachers thought that their attitudes had changed. As one preservice teacher (#5) states,

> I think so, I know when we did our questionnaires I'm not sure if many of my answers changed, but I think I just realized now the importance of really teaching children about math. I feel more comfortable about math. I think some of the problems with me was that I never really felt secure in doing the math.

Another preservice elementary teacher (#6) felt that her attitudes toward mathematics had changed after completing the course since

> Math teaching isn't as bad as we make it out to be and I think it's really, really important, and I'm glad to see math, starting from primary on, we're almost promoting a healthy attitude towards math because it's nothing to be scared of.

Successfully completing some of the mathematics content assignments helped one preservice elementary teacher (#2), "feel more confident after writing the content mastery". Her attitudes toward mathematics had changed. "Math can be fun. I feel more comfortable with math now, than I did at the start". One of the preservice teachers (#3) stated, "sure I feel competent in math, once I get the course here, the methods course, but I'd feel more confident if I took a few extra courses, and the more confident you feel, the better your sense of competence".

Therefore after completing the elementary mathematics methods course the preservice elementary teachers show a slight improvement in their confidence in learning mathematics. The preservice elementary teachers also refer to their increased confidence in being able to sucessfully perform mathematics, and confidence in being able to teach mathematics The scores on the Fennema-Sherman Confidence in Learning Mathematics scale did show an improvement after completing the methods course indicating a higher level of confidence, and the majority of the preservice elementary teachers reported feeling more confident and comfortable in their ability to learn, perform and teach mathematics.

Perception of the Teac'ie . Toward One as a Learner of Mathematics

The second dimension of attitude toward mathematics that is explored under research question two, is the perception of the teacher toward one as a learner of mathematics. Again, from the interview data reported in answering research question one, regarding mathematics anxiety, the perception of the teacher towards one as a learner is important in how successfully one learns and performs a subject. All of the preservice elementary teachers who identified themselves as being mathematics anxious could remember with clarity negative experiences in mathematics classes during their own schooling. These experiences were reported in the answer to research question one.

The questionnaire data regarding the perception of the teacher toward one as a learner of mathematics scale are reported first, followed by an analysis of the interview data regarding this attitude. Table 7 presents a summary of the means and standard deviations for the perception of teacher toward one as a learner of mathematics scale for all three years of the study. Note the higher the score (to a maximum of 60) the more positive the perception of the teacher toward one as learner of mathematics.

Table 7

Perception of Teacher Towards One as a Learner of Mathematics Pretest and Posttest Means (Standard Deviations) for All Subjects by Year in Study

Year							N
One	**M**	42.2(10.3)					42
Two a		40.5(8.7)	**M**	44.3(5.4)			16
b			**M**	44.6(6.9)			15
Three				40.5(10.1)	**M**	43.0(9.5)	39

Note. **M** = elementary mathematics methods course

To discover whether or not the levels of the perception of teacher toward one as a learner of mathematics change after completing the elementary mathematics methods course, t-tests were conducted on the mean scores of this scale before and after the methods course. A summary of the t-test analysis for all of the pretest and posttest mean scores are presented in Table 8.

Table 8

t Test Analysis for all Pretest and Posttest Scores for Perception of Teacher Toward One as a Learner of Mathematics Scale

Comparisons	Mean Difference	df	t	p
YR 1 post vs YR 2a pre	+1.7	56	.59	.557
YR 1 post vs YR 3 pre	+1.7	79	.44	.441
YR 2a pre vs YR 2a post	+3.8	15	1.55 †	.142
YR 2a pre vs YR 2b post	+4.1	29	18	.150
YR 2a pre vs YR 3 post	+2.5	49	.90	.373
YR 2,3 pre vs YR 2,3 post	+4.3	50	2.72 †	.009 *
YR 3 pre vs YR 2a post	+3.8	53	1.	.155
YR 3 pre vs YR 2b post	+4.1	52	1.49	.143
YR 3 pre vs YR 2a,b post	+4.0	68	1.96	.054 *
YR 3 pre vs YR 3 post	+2.5	34	1.52 †	.138

Note. *$p < .10$

† indicates a paired sample t-test, all others are independent t-tests

In only two of the ten comparisons were statistically significant differences in the predicted direction found. But all ten of the comparisons did show mean differences in the predicted direction, (i.e) for all comparisons, the posttest scores were higher. The mean for all pretest scores was ($X=40.47$, $N=55$), which was lower than the mean for all posttest scores ($X=43.12$, $N=108$), indicating an improvement in the perception of the teacher towards one as a learner of mathematics after completing the elementary mathematics methods course. The significant differences were found when the samples were combined indicating that maybe the small sample size influenced the finding of significant differences. When all of the pretest scores in years two and three were compared to all postest scores in years two and three significant differences were found ($p=.009$). Another significant difference was found in the comparison between the pretest scores in year three and all the postest scores in year two ($p=.054$).

There may have been some confusion for the preservice elementary teachers over which teacher (i.e., elementary, secondary, university, globally) they were to refer to in answering these questions. The fact that there was improvement in all of the posttest scores over the pretest scores may indicate that the posttests were scored in response to the teacher of the methods course. That is, since the preservice teachers have reduced their math anxiety and improved their confidence in learning mathematics, they may perceive that the teacher of the methods course sees them as successful learners of mathematics. To further answer this portion of the second research question concerning the perception of the teacher toward one as a learner of mathematics it is necessary to explore the interview data.

Interview Data - Perception of Teacher Toward One as a Learner of Math

The preservice elementary teachers past remembrances with mathematics teachers and current observations of mathematics teachers will be reported here. The preservice elementary teachers were provided with opportunities to observe elementary classrooms during the span of the methods course. This provided a further source of data regarding teacher's perceptions of students as learners.

In answering research question one, regarding mathematics anxiety, several of the preservice teachers recalled experiences that they felt had initiated their mathematics anxiety. As one preservice teacher (#6) reported earlier, she felt that her teacher's attitude toward her lack of ability in mathematics led to her mathematics anxiety. Therefore since the teacher had a negative perception of her as a learner of mathematics, she could not learn in that mathematics class. Another preservice teacher (#8) recalled experiences where his teacher used mathematics as a punishment for the class misbehaving. Therefore the perception he felt that the teacher had was that mathematics was something to be disliked. If you did like mathematics that was contrary to the message that the teacher was sending. And he even stated that he was surprised that not more students hated mathematics. Other preservice teachers (#4, 5) recalled being embarassed and crying during mathematics lessons because of the actions of their teacher. These were not very positive experiences and consequently they thought that their teachers had negative perceptions of them as learners of mathematics.

Another preservice teacher (#7) recalled being "whopped on the back by her teacher for not doing her math". Unfortunately she then "decided that I really didn't like math and if I didn't want to do it, all I had to do was get put in the corner during math lesson. So I did". She avoided so much of elementary mathematics that she had extremely poor basic mathematics skills and thought that all her teachers perceived her as a poor mathematics learner. These experiences are sharply remembered by this preservice teacher, and consequently she did not believe that her teachers thought of her as a successful learner of mathematics.

The preservice elementary teachers had the opportunity to observe mathematics being taught across several elementary grades. These observations illuminate how some teachers perceive not only mathematics but also how they perceive their students as learners of mathematics. It also highlights for the preservice teacher the impact that teachers have on the attitudes, perceptions and anxieties of their students. These observations further bring memories back to the preservice teachers of when they were in school. One preservice elementary teacher (#2) told about observing a grade six class,

> She [the teacher] didn't spend a lot of time on Math. She would rearrange her schedule and she had to cut out one of the classes and put in Language Arts, so she cut out Math. I really don't think she liked Math herself. She taught them maybe five minutes, and then they'd do it and it always seemed like it was such a rush for them to do it, like let's see how fast we can get it done.

In a different school in a grade four classroom another preservice elementary teacher (#9) observed about the teacher,

> I think the only thing she liked was Language Arts. It seemed everything they did all the time was writing, reading, and stuff like that because there was no science, no math, no social studies. There

was gym, and the rest was Language Arts.

In yet another school, this time in a grade five classroom, another preservice teacher (#5) observed the teacher pushing aside mathematics to do another topic. The teacher acknowledged "we should be doing math, but I don't think it will hurt us if we push it aside for a couple of days and just not touch it". The preservice teacher (#5) felt that for this other teacher mathematics "just isn't one of her favourite things". The message that was being sent by these teachers was that mathematics was boring, or disliked and it would be more fun to do other things. If a student in one of these classes liked or enjoyed mathematics, that attitude would be contrary to the one being sent by the teacher. The students in elementary school generally desire to emulate the teacher, and therefore may change their attitudes to match those of the teacher. This same preservice teacher felt that her problems with mathematics were related to the fact that "I didn't feel that I had a teacher that would come over to my side if I wasn't doing it right. The teachers wouldn't worry, they'd say, 'hurry up, you should be on your next question by now' ". She never felt that her teachers saw her as a successful learner of mathematics because she was always slower than the rest of the class to finish any mathematics work. To her, teachers only perceived learners of mathematics as those who could finish their work quickly.

Another preservice teacher (#10) observed in a grade six classroom that the teacher "thought that mathematics was memorization and drill, straight forward and basic. I'm a stickler and there are some things that I expect to be carried out". As this preservice teacher further reported about her observations, "she's such a stickler about getting every number made correctly and everything's got to be neat and tidy - even if the answer is right and it's not done neatly enough she'll erase it and make them do it over again". Earlier, preservice teachers reported in the section on mathematics anxiety, that this strict reliance on rules and drills may have caused anxiety in them with regards to mathematics.

The preservice teachers did not feel that their early teachers had perceived them as successful learners of mathematics. Many of the preservice teachers felt that in the elementary classrooms they observed, there were teachers who were sending negative messages about mathematics to their students. These negative messages were similar to ones that they had received during their own schooling, and which they felt initiated their mathematics anxiety. The preservice teachers felt that after completing the methods course they had less mathematics anxiety and more confidence in their ability to do mathematics. This improved confidence and reduced mathematics anxiety might allow the preservice teachers to think that a teacher (the professor teaching the methods course) might now perceive them as successful learners of mathematics.

Perception of Mathematics as Male Domain

The third part of research question two concerns the perception of mathematics as male domain. Table 9 presents a summary of the means and standard deviations for the mathematics as male domain scale for all subjects in the study. Note the higher the score (to a maxium of 60) the less mathematics is perceived as a male domain.

Table 9

Mathematics as a Male Domain Pretest and Posttest Means (Standard Deviations) for all Subjects by Year in Study

Year						N
One	**M** 56.6(3.8)					42
Two a		54.1(5.0)	**M** 55.3(4.8)			16
b			**M** 55.9(4.7)			15
Three				56.2(4.0)	**M** 56.1(4.1)	39

Note. **M** = elementary mathematics methods course

To answer the question of whether or not the perception of mathematics as a male domain changes after completing the elementary mathematics methods course using the questionnaire data, paired and independent t-test analyses were performed on the pretest and posttest mean scores. Table 10 presents the summary of this t-test analysis.

Only one of the ten comparisons shows a significant difference in the predicted direction in the perception of mathematics as male domain, year one posttests compared to year two pretests ($p=.052$). All of the scores are so close that the average mean difference is only 1.04. The scores are all very high and indicate that the preservice elementary teachers do not perceive mathematics as a male domain. The mean for all of the pretest scores was 55.58 ($N=55$) while the mean for all of the posttest scores was slightly higher at 56.13 (N=108). The scores were so high to start with (maximum score is 60) that it would be almost impossible to find a significant improvement.

Table 10

t-Test Analysis for all Pretest and Posttest Scores for Mathematics as a Male Domain Scale

Comparisons	Mean Difference	df	t	p
YR 1 post vs YR 2a pre	+2.5	56	1.98	.052 *
YR 1 post vs YR 3 pre	+0.4	79	.42	.673
YR 2a pre vs YR 2a post	+1.2	15	.75 †	.462
YR 2a pre vs YR 2b post	+1.8	29	.99	.328
YR 2a pre vs YR 3 post	+2.0	49	1.51	.137
YR 2,3 pre vs YR 2,3 post	+0.6	50	.79 †	.434
YR 3 pre vs YR 2a post	-0.9	53	.74	.466
YR 3 pre vs YR 2b post	-0.3	52	.24	.808
YR 3 pre vs YR 2a,b post	-0.6	68	.61	.547
YR 3 pre vs YR 3 post	-0.1	34	.06 †	.954

Note. * $p < .10$

† indicates a paired sample t-test, all others are independent tests

The interview data provides some insight into the perception of mathematics as a male domain but moreso provides information about gender roles and elementary school teachers. The preservice elementary teachers seem to agree that everyone should be able do mathematics and everyone should feel welcome to become elementary school teachers but that is not the message society gives.

Interview Data - Mathematics as a Male Domain

The interview data will not be reported in a chronologically fashion because the preservice elementary teachers' attitude towards mathematics as a male domain did not really change. Some comments were made about elementary teaching in general that may prove to be illuminating. The preservice elementary teachers were not surprised that elementary teachers are primarily female and that therefore the elementary education class had a majority of female students. As the comments below show, the general attitude seemed to be that, "that is just the way it is, everyone knows that females are more nurturing and males are smarter and more task-oriented".

One preservice elementary teacher (#2) said during a discussion of the course and elementary teachers, "I guess I have always assumed that girls respond to small children - I don't know really. I guess you think of guys as not wanting to play little games, play with blocks, and everyone has this macho image type of thing". In this same theme another preservice teacher (#4) felt that teaching elementary school was not a man's role, "those are the grades where they need to be nurtured, they're helpless, and all this type of stuff. A man's role is teaching Biology, or teaching Math". Therefore this preservice elementary teacher felt that a man's role was to teach mathematics or science while a female's role was to teach elementary school children. Another preservice teacher (#11) thought that elementary teachers were primarily female because,

> I think that the Elementary teacher was always seen as a mother-type role and younger children are thought of as, you know, a female should deal with them because they have the characteristics - emotionally - to adapt to children that way.

And yet another preservice teacher (#3) felt that "females make better elementary teachers because they're motherlike". Even though the preservice elementary teachers did not rate mathematics as a masculine pursuit on their questionnaires, very definite roles for males and females were stated during the interviews.

Another preservice elementary teacher (#10) felt that for any female teacher to be successful in teaching secondary school, she must assume traditional masculine qualities, such as being tough, because the students were older and more difficult to handle than elementary students. She also felt that males tend to specialize in university (i.e., choose majors) while females are more likely to take generalist degrees with no majors. As she states,

> there are always more male high school teachers, because they specialize, they find it easier to focus on one thing. I find that males have more of an authoritative figure. You can't be - I find that females at the secondary level have to have a certain way about them that they're not going to take - like, I'm not going to take shit so

don't try to pull it with me.

Another preservice teacher (#9) was not surprised that elementary teachers were mostly female because she never had a male teacher all through elementary school and yet in high school, especially grade eleven and twelve, most of her teachers were male. The message that this experience had sent to her was that "males are smarter". The only preservice elementary teacher (#1) who was interviewed that had a mathematics and science background gave as her reason for choosing elementary education,

> I think it's good to have an elementary teacher who has a good background in math, is comfortable in math and is female. I think a lot ot teachers unconsciously do things, don't treat girls as well, especially in the areas of math and science.

Therefore these preservice elementary teachers feel that elementary teachers are female, and male teachers are generally teaching secondary school, especially mathematics and science courses.

Even though the preservice elementary teachers did not rate mathematics as a male domain on the questionnaires, when asked to describe someone who was considered to be good at mathematics, the preservice elementary teachers came back with what has been traditionally labelled masculine qualities. One preservice teacher (#4) said of someone in a career that involved a lot of mathematics, "I think of people who are analytical, they pick up on details that aren't apparent - they don't focus on emotional issues or things like that, they really concentrate on structure". Another preservice teacher (#9) felt that anyone in a career that deals with a lot of mathematics would be "very intelligent and smart and I'd probably think of a he". And yet another preservice teacher (#5) agrees with these sentiments about someone in a career that has a lot of mathematics in it, "I think of someone who is really great with working with numbers and I would tend to think male". Another preservice elementary teacher (#4) reported that she chose elementary teaching as a career because she wanted to do "something people-oriented and not number oriented". Therefore when asked to describe someone who is good at mathematics, the preservice elementary teachers think of males or of qualities traditionally attributed to males.

There appeared to be some gender differences noted in the ways that girls and boys respond in the classrooms that the preservice elementary teachers observed. One preservice teacher (#2) reported that during her observation of a grade six class during the teaching of mathematics,

> the girls didn't put their hands up once, not once. She [the teacher] would ask them though, what she'd do is she'd answer a couple of the boys - all the boys had their hands up practically, then she'd ask a couple of the girls, and most of the time they had the right answer, they just didn't put their hands up. And we had Health class, because I noticed Health came next, and the girls couldn't wait to get their point across, hands were up.

Why did the girls not volunteer answers in mathematics, when they knew the answer? Yet in Health class, they could not wait to volunteer. What message is being conveyed here? This same preservice teacher noted about this grade six class, "the boys were treated really well even when they were bad. Whenever little errands had to be done, she [the teacher] always picked them to go". More questions could be asked here. Were the girls ever picked for errands regardless of whether they were good or bad? How much attention did the males receive in other areas?

Several of the preservice elementary teachers made reference to the fact that the boys in the classrooms they observed were given more attention and their concerns were addressed more often than the girls. As one of the preservice teachers (#6) observed in a grade one class,

> you could tell the boys were getting a lot more of the discipline. You know, "you sit down, you be quiet", and the boys were a lot more verbal too. Like, if they had an answer, they'd just say it right away. The girls just sat back and weren't as open to give their responses as quickly as the boys were. . . . It just reinforces what they already believe, that guys are more outgoing, guys are more aggressive. Girls are more laid back, they put up their hands and speak when spoken to.

Other female preservice teachers expressed their concern that during the methods course a male preservice teacher monopolized much of the discussion and they did not feel that they had a chance to speak their minds. This male preservice teacher (#8) said during an interview,

> it's funny, I speak out a lot, that's obvious, probably too much. I often wonder if that makes a difference, makes people think, oh, that guy again, because guys are seen as boisterous or something like that. But it's not something I'm worried about.

This preservice teacher did wonder at first if he was bothering anyone speaking out so much, but he was not about to change, and yes it was bothering some of the other preservice teachers that he was dominating the conversation.

Some of the preservice elementary teachers made further reference to the fact that elementary teaching was a feminine pursuit. Although this deviates from the notion of mathematics as a masculine pursuit, this information relates to the notion of gender and career choice. Some of the preservice elementary teachers questioned the reason why males would choose elementary education as a career. One preservice teacher (#6) felt that any male in a profession surrounded by females (e.g., nursing, elementary teaching) was without a doubt effeminate. As she says, elementary teaching is for females because

> people always associate younger children with mothers - child rearing is a motherly thing. I think a lot of the people would expect that they wouldn't be hired as a primary, one, two, or three teacher if they were male. I think a lot of people might automatically assume - something like - child molester. Do you know what I mean? Like, what does he want to do with a bunch of young kids?

Another preservice elementary teacher (#7) stated that

> I was looking to see if there was anyone in Elementary that were [sic] male. Just because of that, you know, you must be homosexual if you are male and you teach elementary. And the males that are here I have to

> question, you know. Male teachers that are in the elementary system now are either heading for or trying to get into administration, or they're gym teachers.

Both of these preservice elementary teachers felt that the perception of elementary teaching as a feminine pursuit would remain in society because of the predominance of women in elementary teaching. As one of these preservice teachers (#7) stated, "you can't teach equal role models if you haven't got equal role models in the business".

In summary, even though the preservice elementary teachers did not rate mathematics as a male domain on the Fennema-Sherman Scale, when describing people who were good in mathematics, they listed traditionally perceived masculine qualities or stated that the person would be male. The preservice elementary teachers felt that more females became elementary school teachers because females are more nurturing and mothering while males were more suited to secondary school teaching. Very definite gender roles were assigned to males and females. Mathematics may not be in the male domain for these preservice elementary teachers, but elementary teaching was strictly in the female domain.

Attitude Toward Success in Mathematics

The fourth and final dimension that is explored under research question two, is attitude toward success in mathematics. This dimension is a measure of how much individuals desire to be successful in mathematics. A summary of the means and standard deviations for this scale is reported in Table 11. The maximum possible score is 60. The higher the score the more positive the attitude.

Table 11

Attitude Toward Success in Mathematics Pretest and PosttestMeans (Standard Deviations) for all Subjects by Year in Study

Year					N
One	**M** 51.5(5.1)				42
Two a		48.8(6.5)	**M** 47.6(5.3)		16
b			**M** 51.5(5.0)		15
Three				50.6(5.3) **M** 49.3(6.8)	39

Note. **M** = elementary mathematics methods course

To answer the question whether or not the attitude toward success in mathematics changes after completing the elementary mathematics methods course, paired and independent t-tests were conducted on the pretest and postest scores. Table 12 presents a summary of the t-test analysis for the attitude toward success in mathematics scale.

Table 12

t-Test Analysis for all Pretest and Posttest Scores for Attitude Toward Success in Mathematics Scale

Comparisons	Mean Difference	df	t	p
YR 1 post vs YR 2a pre	+2.3	56	1.45	.152
YR 1 post vs YR 3 pre	+0.5	79	.44	.663
YR 2a pre vs YR 2a post	-1.2	15	.54 †	.599
YR 2a pre vs YR 2b post	+2.7	29	1.34	.192
YR 2a pre vs YR 3 post	+0.5	49	.26	.793
YR 2,3 pre vs YR 2,3 post	-0.6	50	.55 †	.582
YR 3 pre vs YR 2a post	-1.8	53	1.88	.065
YR 3 pre vs YR 2b post	+0.9	52	.59	.555
YR 3 pre vs YR 2a,b post	-1.1	68	.83	.409
YR 3 pre vs YR 3 post	-1.3	34	.94 †	.35

Note. † indicates a paired sample t-test, all others are independent t-tests

There were no significant differences found in any of the comparisons. The mean for all of the pretest scores was 50.05 (N=55) while the mean for all of the posttest scores was 50.06 (N=108). The average mean difference for all of the comparisons was 1.29. The scores were so high to begin with as pretest scores, that there is the possibility of a ceiling effect precluding the finding of any statistical improvement.

Interview Data - Attitude toward Success in Mathematics

From the interview data that has already been reported, it is obvious that the preservice elementary teachers would like to be successful in mathematics. But the nature of success to these preservice elementary teachers may be qualitatively different than the measure of success as intended by the Fennema-Sherman scale. The preservice elementary teachers want to be successful enough in mathematics to feel confident about teaching it at the elementary level. These individuals do not desire to become mathematicians, they just want to be able to do enough mathematics to enable them to teach mathematics successfully at the elementary school level.

When asked to describe someone who was successful in mathematics, none of the preservice teachers described themselves. As was just reported in the last dimension of an attitude toward mathematics, the preservice elementary teachers described individuals with qualities that have been traditionally attributed to males. In describing someone who was successful in mathematics the preservice teachers generally described someone who was an accountant (#3,#4,#5,#6,#9) or an engineer (#2,#4). As one preservice teacher (#9) stated, "I would think of an accountant. I would probably say he was very intelligent, and smart, and I'd probably think of a he". Another preservice teacher (#5) said, "I think business, I think of someone who is really great with working with numbers. I would tend to think male". Another preservice teacher (#2) in describing someone who was successful in mathematics said,

> A real keener, someone smart, dedicated to their work. Someone who isn't just breezing by in University, just handing stuff in whenever, late, or doing things late. I get the image that everything will be well-organized and prepared - no I don't want to say they don't socialize, I don't want to say that. They're really dedicated towards it. Someone who didn't always deal with a lot of people, and they don't really want a job associated a lot with people.

Yet another preservice teacher (#4) in describing someone who was successful in mathematics, "I think of people who are analytical, they pick up on details that aren't apparent - they don't focus on emotional issues or things like that, they really concentrate on structure". This same preservice elementary teacher had started a business degree before changing to psychology as a major because, "I decided Accounting was too dry. I only liked the courses that were people oriented, and not the things that were number oriented".

These preservice elementary teachers in describing people who are successful in mathematics were describing individuals in careers that they felt were "dry" and "boring". Another preservice elementary teacher (#13) in discussing careers involving mathematics stated, "I wasn't interested. I found math dry". Yet another preservice teacher (#1) in describing mathematics, "area and perimeter is kind of dry stuff, not much excitement in the area of a triangle". Still another preservice teacher (#11) stated, "Math. I though it was boring. Everyone thinks that Math is boring so they approach it with a bored attitude. I always thought Math was just a subject that wasn't related. I always thought when am I going to use this because I'm not going into Math".

All of the preservice elementary teachers do want to know how "to do mathematics", yet they could only think of people who are successful in mathematics with stereotypical qualities. One preservice teacher was not worried about not being successful in mathematics since "I can remember my Mom saying to me, we were talking about it this one morning, Don't worry about your math, I was never any good either, and it made me feel better at the time". This preservice teacher stated that she did want to know how to do math, but only enough so that she could teach it at the elementary school level. Why would anyone want to be successful in an area that is typically described as dry, boring, and solitary?

There is a clear division here between being successful in mathematics, and successfully teaching elementary school mathematics. The preservice elementary teachers did not change the level of their desire to be successful in mathematics after completing the mathematics methods course. One possible reason may be that to be successful in mathematics would mean changing careers in their estimation, to one that is not associated with people and is probably dry and boring.

Third Research Question

The third research question concerns the identification of components of an elementary mathematics methods course that were successful in reducing the mathematics anxiety levels of preservice elementary teachers. This research question can only be answered if the mathematics anxiety levels of the preservice teachers were in fact reduced after completing the elementary mathematics methods course. It was discovered in answering the first research question that the levels of mathematics anxiety of the preservice teachers were reduced after completing the elementary mathematics methods course. The third research question becomes: "What are the components of this elementary mathematics methods course that successfully reduced the preservice elementary teachers' mathematics anxiety"?

In order to answer this question the interview data from the professor, the interview data from the preservice elementary teachers, and the observation data from all classes of the elementary mathematics methods course during the second year of the study were reviewed. The further assumption is that the preservice elementary teachers will be able to articulate what parts of the course were helpful to them in reducing their mathematics anxiety levels. The observational data from the methods course is used to triangulate the data received from the professor and the preservice elementary teachers. Triangulation is an attempt to relate different types of data through the checking of inferences drawn from one set of data sources with other data sources (Hammersley & Atkinson, 1983).

This section begins with an explanation of the features of the methods course that were structured by the professor to reduce mathematics anxiety. This information was gathered through an interview with the professor who taught the course, and observational data gathered by the researcher during the elementary mathematics methods course. Next, the data from the preservice elementary teachers and the observational data gathered by the researcher are reported. The preservice elementary teachers were able to identify specific components of the mathematics methods course that aided in the reduction of their mathematics anxiety.

Interview Data from the Professor and Observational Data of the Course

One crucial assumption made by the professor in constructing this elementary mathematics methods course was that preservice elementary teachers were anxious about mathematics. As she stated, "I think that they come into class quite anxious about [mathematics]. It is a course they have to take, they have no option but to take it. . . . in many cases they talk about their math not being a pleasant experience, and so they are anxious". She furthered assumed or hypothesizes that the elementary mathematics methods course was a place where an attempt could be made to reduce this mathematics anxiety.

There were six main components of the elementary mathematics methods course observed by the researcher that seemed to be structured so as to reduce the mathematics anxiety of the preservice elementary teachers. These six components were: (i) the acknowledgement of mathematics anxiety as real, (ii) the utilization of small group work, (iii) the use of concrete materials as mathematics manipulatives, (iv) the use of videotapes, (v) the use of content mastery tests, and (vi) the modelling of appropriate behaviour.

Acknowledgement of Mathematics Anxiety as Real

The professor stated during an interview with the researcher that there was a need to openly recognize and discuss mathematics anxiety as something real in the methods course. For many of the preservice elementary teachers it may be the first time that they realize they are not alone with their feelings of anxiety toward mathematics. The professor believed that it was important to first legitimize this anxiety before it could be reduced. Throughout the methods course there were discussions about mathematics anxiety and some of the things that may contribute to its development between the professor and preservice teachers. These discussions began in the very first class of the methods course and continued through to its conclusion. During the first class of the methods course the professor addressed the issue that mathematics anxiety was real and that many of the preservice elementary teachers possessed mathematics anxiety. She stated that after completing the methods course hopefully their mathematics anxiety levels would be lower.

Throughout the mathematics methods course the professor spoke to the class about the need to provide a non-threatening environment for learning mathematics. This environment was important not only in the methods course, but also in their future classrooms. One manner in which to attempt to provide such an environment was to be continually concerned about students' feelings towards activities and learning. The professor constantly consulted the preservice elementary teachers about their feelings as they participated in activities and assignments during the course As she circulated through the small groups she would ask such questions as, "How do you feel solving this problem? Why do you feel that way? What would make you feel less stressful?" By allowing the preservice elementary teachers to express their anxiety, and to get them to think aloud while they solved problems, she hoped to not only address their mathematics anxiety but to also gain insight into their thought processes while solving mathematical problems. As the professor stated, "talking through problems and what you are thinking is very important to allow you to be involved in the thought process". By being involved in the thought process, the professor felt that negative thoughts such as, "I can't do this", and "I was never any good at math", could be interrupted and then dealt with. She believed that these negative thoughts interfered with learning and only reinforced any mathematics anxiety that was present. By correcting any erroneous perceptions, she hoped to reduce their mathematics anxiety.

The professor, in the ongoing discussions with the class about mathematics anxiety, also discussed some of the things that may create anxiety. For example she stated during one class, "teachers must remember that what is easy for one person is not for another. Therefore, do not say this is an easy problem, because the person that cannot solve it, feels terrible and more anxious". She also asked the preservice elementary teachers to share what made them anxious about mathematics while they were in school. The preservice elementary teachers then discussed how situations such as these could be avoided. These experiences were reported in the analysis of data for the first research question. The preservice teachers related stories such as being sent to the blackboard without any idea of how to solve the problem, too much emphasis on speed in solving problems, and being made to do mathematics when the class was misbehaving, as contributing to their mathematics anxiety.

Utilization of Small Group Work

A second feature of the mathematics methods course that was structured to reduce mathematics anxiety was the use of small group work for many of the activities of the course. The professor believed that small groups enable everyone to have a chance to voice their opinions and to work in a non-threatening environment. As explained in Chapter III, research supports the idea that such a non-threatening environment is necessary to allow the preservice elementary teachers the opportunity to take risks in solving problems without risking being embarrassed or feeling anxious in front of the entire class. Ideally small groups provide a less pressured and more relaxed atmosphere for solving mathematical problems. There was a chance in almost every class for the preservice elementary teachers to work in small groups whether they were working with the concrete materials, discussing reading assignments, in problem-solving sessions, or peer teaching.

As the professor explained during an interview, another advantage of working in small groups is that sometimes individuals only need a first step to get them going to solve a problem. Rather than sitting alone and struggling to find a way, or giving up, the individual actually begins to solve more problems while working in a small group. Another important feature of working in small groups is that by sharing information from problem solving sessions, it allows the preservice teachers to see many methods for solving problems.

Use of Concrete Materials as Manipulatives for Mathematics

A third feature of the methods course that was designed to reduce mathematics anxiety as stated by the professor, was the use of concrete materials to learn mathematical concepts. The major portion of the elementary mathematics methods course was based on hands on experiences with the concrete materials. The materials that were utilized in this course were geoboards, attribute blocks, pattern blocks, base ten blocks (or place value blocks), cuisenaire rods, and unifix cubes. The use of these materials assisted the preservice elementary teachers in moving from the concrete through to the abstract in mathematical concepts. The preservice elementary teachers were instructed in the use of the concrete materials in the same manner that students would be instructed in their use in an elementary classroom. The preservice teachers used pattern blocks to add and subtract fractions and to learn relationships in geometry; geoboards to study perimeter and area; unifix cubes for adding and subtracting whole numbers; base ten blocks for learning place value, and for multiplying and dividing whole numbers and decimals; and cuisenaire rods for learning ratio and percent to give a few examples.

The preservice elementary teachers were always in small groups while working with the concrete materials to enable everyone to manipulate the materials, and to gain insight into how other people approached problems with the materials. The preservice elementary teachers would begin a lesson with a brief free exploration of the materials that were the focus for that class, and then proceed to answer questions that were posed by the professor and arose from their free explorations.

Videotapes

The use of videotapes to see actual elementary classrooms working with the concrete materials was a fourth feature of this elementary mathematics methods course. The purpose of incorporating the videotapes into the course was, as the professor stated,

> I think the major advantage is that the students get to see exactly how children respond to the materials. While I provide lots of opportunities for them to use the manipulative, I think it takes it one step beyond that and they're able to see how children respond to them.... It helps them to see that it's not just a student playing with the materials, but the kind of questions the teachers asks is instrumental in having them formulate some of their ideas.

There were four different videotapes that were used during the span of the course. The videotapes employed concerned the learning of concepts about fractions using pattern blocks; using pattern blocks to introduce geometry; the use of base ten blocks to learn multiplying and dividing; and the use of cuisenaire rods to learn about percent and ratio. Each videotape attempted to show a variety of grade levels using the materials. While watching the videotapes, all of the preservice elementary teachers would have the same materials as being demonstrated in the lesson in front of them. The tape would be stopped and the preservice elementary teachers would attempt the same problems as the children. Then the tape would be restarted and the preservice elementary teachers would see how the children answered the same questions posed by the teacher in the video. The tape would be stopped and started several times to enable the preservice elementary teachers to interact with the materials and to see an elementary class interacting as well. The professor hoped that by viewing teachers in action with a class on the videotapes, and continuing to learn with the concrete materials, the preservice elementary teachers would gain confidence in learning mathematics. The preservice elementary teachers would also see appropriate teacher behaviour for the teaching of mathematics.

Content Mastery Tests

Another feature of the elementary mathematics methods course that was designed to reduce mathematics anxiety was the use of content mastery tests. As the professor explains,

> I think it's important for the teachers to feel that they have a sound understanding of some of the concepts in elementary mathematics. I do this particular part of the course to make them feel more confident in the long term. I give them the option of writing it as many times as they want to make 90%.

There were three content mastery tests throughout the course. The first one assessed calculator problems, word problems, area, perimeter and volume. The second one dealt with fractions, decimals, percent, and place value. The final content mastery test was on geometry. By exploring current elementary mathematical textbooks that were available in the education resource center in library, or from the professor, the preservice elementary teachers would review elementary mathematical concepts outside of class time. Within the mathematics methods course the activities that were planned with the concrete materials were in sequence with the timing of the content mastery tests. Therefore, the preservice elementary teachers reviewed in class word problems, area, perimeter, and volume utilizing concrete materials before the first content mastery test. The next topics covered through exploration of the concrete materials were fractions, decimals, percent and so on. The preservice elementary teachers had opportunities both in and out of class to prepare and seek remediation on topics to be assessed through the content mastery tests.

Modelling

The final feature of the elementary mathematics methods course that was designed to reduce mathematics anxiety was modelling. There was modelling by the professor herself, by the teacher in the videotape, and by the preservice elementary teachers themselves. This feature was interwoven with many of the other components of the methods course. For example, modelling was evident in the activities with the concrete materials, in the videotapes, in the use of small groups and in the behaviour of the professor herself throughout the methods course.

As the professor stated she was always conscious of how she appeared to the students and she tried to model appropriate teacher behaviour. For instance, regarding gender roles, she stated that when she gave examples concerning teachers,

> I'm always referring to both male or female. And when I give examples I try to be conscious of that. . . . For example Farmer Brown was a character in one of the problems and she was building a fence. They saw women in other roles then they might typically have thought.

She also stated during the methods course that, "I am modelling strategies for use in your own classroom. For example one way to reduce mathematics anxiety is by only asking for volunteers to solve problems in front of the class". The suggestion was not to just send students up to the board without their prior agreement.

Modelling of problem solving strategies could be shown by watching how other students solved problems. Modelling was also consciously shown by having the groups share their information on how they solved problems. By being able to see how other people do things is an important learning tool. The videotapes were utilized so that the preservice elementary teachers could watch another teacher model appropriate teaching behaviour as well.

The preservice elementary teachers also had the opportunity to observe elementary classrooms within the span of the methods course. Approximately halfway through the methods course, the preservice elementary teachers went to different elementary schools and observed an elementary class for one week. There was only one preservice elementary teacher per classroom, so a wide variety of classrooms and grade levels were observed. When the preservice elementary teachers came back to the methods course they discussed what they observed in those elementary classes and in particular what they observed during mathematics lessons. The preservice elementary teachers discussed teacher behaviour and student behaviour and gained further insight into behaviour or activities that may contribute to, or reduce, mathematics anxiety.

In order to see what the preservice elementary teachers identified as being helpful in reducing their mathematics anxiety, it is necessary to explore their interview data and continue with a reporting of the observational data from the methods course.

Interview Data of Preservice Teachers and Observational Data of the Course

The preservice elementary teachers that were interviewed were asked, "Was the course helpful in reducing your mathematics anxiety?", and "What part of the course helped to reduce your mathematics anxiety?". The preservice elementary teachers could clearly identify those parts of the mathematics methods course that were helpful in reducing their mathematics anxiety. Overall the preservice elementary teachers identified the same features of the course that were structured by the professor in an attempt to reduce mathematics anxiety.

The observational data gathered by the researcher served as a complementary data source for the interview data. This data source provided many additional comments from preservice elementary teachers regarding what they felt was helpful in reducing their mathematics anxiety. Only those preservice elementary teachers who were interviewed are identified by number for their comments. Any unidentified quote comes from preservice elementary teachers during classroom sessions of the mathematics methods course.

Acknowledgement of Mathematics Anxiety as Real

The preservice elementary teachers felt that it was important for them to realize that they were not alone with their feelings and anxieties towards mathematics. As one preservice elementary teacher stated (#6), "you think you're the only person who experiences math anxiety, so it's really comforting to know you are not alone and it's okay". Another preservice elementary teacher stated during the methods course, "I grew up in the math of the dark ages. Do all the odd questions from 1 to 13. How awful. No wonder I early developed a fear of math". There seems to be a sense of relief for the preservice elementary teachers when they are able to talk about their mathematics anxiety and see that they are not alone. Another preservice teacher stated, "it feels like you are not stupid because you can't do it. There are lots of other people who feel the same anxiety". Being made to feel "stupid" because they could not do the mathematics problems in school seemed to be a common theme for many of the preservice elementary teachers. Yet another preservice teacher stated, "my teachers were apprehensive about teaching math and made me feel stupid", or from another preservice teacher, "my teacher always acted so smart and made me feel stupid". The fact that the preservice elementary teachers were able to state that they had mathematics anxiety was the first step towards reducing it. The anxiety must be clearly recognized before it can be eliminated.

The preservice elementary teachers also identified other situations that contributed to their anxiety and discussed how to avoid the perpetuation of these situations in their future classrooms. For many of the preservice teachers surprise quizzes contributed to their mathematics anxiety because they were not prepared for the test. For other preservice teachers it was the concentration on speed as important in mathematics that contributed to their anxiety because they could not go as fast as the teacher wanted. Some of the female preservice teachers felt that most of elementary mathematics was not relevant to them because the examples were all related to boys. As one preservice elementary teacher stated, "Jane only watched, while Dick and Bob solved the area of the baseball diamond". Another preservice elementary teacher stated that her guidance counsellor "encouraged me to take something non-mathematical, because math was not for girls". The sharing of these stories during the mathematics methods class gave further understanding of mathematics anxiety as something real, and enabled the preservice elementary teachers to begin the first steps towards reducing their anxiety.

Utilization of Small Group Work

The opportunity of working in small groups was seen by a majority (70%) of the preservice elementary teachers interviewed as being useful in allowing them to reduce their mathematics anxiety and also gain confidence in their ability to learn mathematics. One preservice elementary teacher (#2) stated that working in small groups helped her because, "it helps you to learn and you learn from everybody". Another preservice teacher (#11) found through working in small groups that math could be creative. The atmosphere in the methods course was very relaxed when the preservice elementary teachers were working in small groups as observed by the researcher. The preservice elementary teachers were very much at ease and many stated that it was the first time they realized that math could be "fun". As one preservice teacher (#8) stated in discussing the strong points of the course that were helpful in reducing mathematics anxiety, "the big one was working in groups, learning to interact in groups. I learned a lot about how to approach concrete materials, give them to children, use them with children. I got a lot out of the cour' e as far as materials and working in groups". As one preservice elementary teacher stated while working in a small group, "it is refreshing to see someone else solve a problem using different methods". Another preservice stated that by having, "repeated opportunities to work together, everyone gets a chance to participate and solve a problem".

For some of the preservice elementary teachers working in small groups enabled them to solve a problem successfully for the first time. As one preservice teacher stated, "it feels good to solve it and know you were involved". By being able to solve problems successfully the preservice elementary teachers were able to reduce their mathematics anxiety. There was a strong link between being able to do mathematics and reducing mathematics anxiety.

Use of Concrete Materials as Manipulatives for Mathematics

All of the preservice elementary teachers who were interviewed stated that using concrete materials to learn mathematics helped to reduce their mathematics anxiety. One of the preservice elementary teachers (#2) stated that she had never experienced concrete materials in mathematics throughout her schooling so this part of the course opened up a whole new perspective of mathematics for her. As she stated,

> when I look back at Math in elementary, all I can think of is the teacher sitting up there and drilling and drilling and doing the work. Like, I've never been in a class where there has been concrete materials. And I find it's good to know that there's other ways you can teach math besides up there drilling. . . .Concrete materials are one of the greatest things.

One of the reasons she was pleased was that drilling had not worked for her in learning mathematics, and the use of concrete materials could help students learn mathematics without becoming anxious about mathematics. As she stated near the end of the methods course,

> I feel more comfortable with Math now, than I did at the start. . . .I think if you start out with them [children] at a young age, in grade one, using concrete materials and group activities, that kids aren't going to be afraid to do math and have math anxiety as much as maybe we would have had coming through, and now too, I don't think you see as much separation between girls and boys.

Another preservice elementary teacher (#4) stated that, "to actually do, to actually perform the activity means so much more experience", than just being told about activities. Doing the activities enabled her to understand concepts rather than just trying to memorize them. The concrete materials enabled her in some cases to understand mathematical concepts for the first time. Another preservice elementary teacher (#3) also said that after experiencing concrete materials to learn mathematics, mathematics had a new meaning for him. It was no longer just rote instruction and memorization.

During the observation of the methods course many of the other preservice elementary teachers also commented on the strength of using concrete materials to reduce their mathematics anxiety. As one preservice elementary teacher stated, "it would have been so much easier to learn fractions using these blocks than the blackboard". Another preservice elementary teacher said, "I was so involved with the materials, I never noticed I was doing math". Yet another preservice teachers said, "if I had been exposed to these materials I would have had more enjoyment with math". Continuing with the idea that using the concrete materials promotes understanding of mathematics, one perservice elementary teacher stated, "when I was in school I just memorized the rules and followed them. I could add, subtract, multiply, and divide in isolation, but I could not apply it in other problems". By being able to understand mathematical concepts, the preservice elementary teachers were able to reduce their mathematics anxiety. They no longer had to rely on memorization of rules or worry about forgetting the rule.

As one preservice elementary teacher (#7) clearly stated it was not only working with the materials that was important but the manner in which they were presented as well,

> the class workshops were really good, positive feedback, really good practising what we're supposed to be

> teaching was really evident in this class more so than in a lot of classes. You know, teach this way when you're out, here are your methods, and then be treated in a different way in that actual classroom that you're learning those wonderfully holistic type ways. But, I think [the professor] really practiced what she was doing with us.

The preservice elementary teachers continued to explore and learn with the concrete materials through exposure to other teachers teaching with the concrete materials, by videotapes.

Videotapes

The intent of using the videotapes was to model appropriate teaching behaviour and to continuing working with the concrete materials. As stated earlier, the preservice elementary teachers worked with the same concrete materials as were being observed through the videotapes. The videotapes that were shown with children actually using the concrete materials were extremely helpful for the preservice elementary teachers to see a mathematics class in action. The majority (80%) of the preservice elementary teachers interviewed felt that these videotapes were effective in reducing their mathematics anxiety. In response to a question that asked what reduced your mathematics anxiety, one preservice elementary teacher (#6) stated, "what was really helpful were the videos, the woman who did the pattern blocks, she was amazing, she was really good".

The preservice elementary teachers enjoyed the experience of working with the materials at the same time as the children in the videotapes. One preservice teacher stated while watching one of the videos, "I feel cheated in my own schooling that I was not taught this way, with concrete materials. It makes so much sense and it is fun and enjoyable". The videotapes helped the preservice elementary teachers with their own learning of mathematical concepts and reduced their mathematics anxiety. The use of the videotapes also helped them to feel more confident about having to teach mathematics.

Content Mastery Tests

There appears to be mixed feelings about the content mastery tests that were employed during the methods course to reduce mathematics anxiety. A majority (60%) of the preservice elementary teachers interviewed felt that the content mastery tests were useful in enabling them to feel less anxious about mathematics and their ability to do mathematics, but the remainder (40%) wanted even more mathematics content. While the content mastery tests were useful, more were needed, or another means of learning mathematical content was required. All of the preservice elementary teachers agreed that knowledge about mathematics content was necessary to reduce mathematics anxiety, but not everyone felt that the content mastery tests were the best way to go about it. Many of the preservice elementary teachers did not feel that there was enough content to make them feel secure in teaching mathematics, especially mathematics at the upper elementary levels. As one of the preservice elementary teachers (#4) stated, about the content mastery tests, "I just think they're great. It gives me a good feeling that I know what is going on. . . .I like doing them but not everyone does, it just gives me a feeling that I have a better grasp".

Another preservice elementary teacher (#5) stated that she needed the content mastery tests in order to refresh her memory about certain mathematical concepts but she still wished that the course had "taught her to know how to do Math really". The preservice elementary teachers all stated during the interviews, that in order to reduce their mathematics anxiety they would have to improve their mathematics skills. But some of the preservice elementary teachers did not know if the content mastery tests were sufficient to improve their mathematics skills.

The content mastery tests also contributed to mathematics anxiety in many of the preservice elementary teachers. Even though the preservice elementary teachers were told that they could have as much time as needed and could rewrite the test as many times as necessary in order to achieve mastery (90%) without penalty, they still saw it as a "mathematics test". Before the first content mastery test most of the preservice elementary teachers were in the classroom early "cramming" for the "test". One preservice elementary teacher complained of feeling sick and clammy because she knew she was going to write a mathematics test, even though she was aware it was only grade six material. Another preservice elementary teacher said, "I feel like I'm back in school again. I hate word problems". The whole tone of this class was much different than from the previous two weeks, the preservice elementary teachers were very serious and there was no joking or laughter. By the second and third content mastery tests, the preservice elementary teachers were not as anxious as the first time, but there were still some preservice elementary teachers who were anxious about writing a "mathematics test".

The professor did acknowledge that the intent of the content mastery tests was to reduce mathematics anxiety in the long term by allowing the preservice elementary teachers to gain confidence in their ability to do mathematics. But in the short term, the tests actually contributed to the mathematics anxiety of some of the preservice elementary teachers. Many of the preservice elementary teachers desired even more mathematics content than was available in the elementary mathematics methods course and it was not clear that the content mastery tests were the right approach for providing content knowledge.

Modelling

The final feature of the mathematics methods course that was identified by the preservice elementary teachers as being helpful in reducing their mathematics anxiety was the modelling of appropriate behaviour by the professor herself, by the teachers in the videotapes, and by the teachers in the classrooms they observed. All of the preservice elementary teachers interviewed referred to the professor's modelling of appropriate teaching strategies and really "practising in class what she was promoting". The professor tried to provide a non-threatening atmosphere for the preservice elementary teachers to learn in and she was successful. The preservice elementary teachers also refer to the modelling observed in the videotapes as helping them to feel less anxious about having to go out and teach mathematics.

When the preservice elementary teachers were in elementary classrooms for a week, they had further opportunities to observe teachers and students and to learn appropriate behaviours for the teaching of

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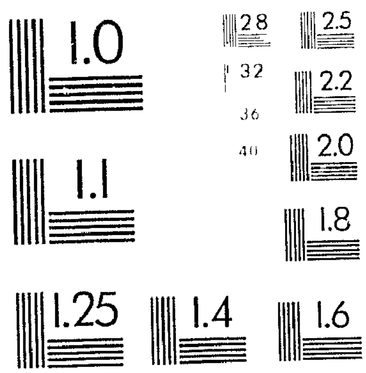

mathematics. One of the preservice elementary teachers (#11) was excited when, during her week of observation in a grade three classroom, she saw the teacher working with concrete materials during the mathematics lesson "When she first brought out these things, I thought, WOW. I've seen those and it was neat. She was actually using them and the mats and everything just exactly what [the professor] was teaching in class". Another preservice teacher (#9) had not realized the importance of using concrete materials in the learning of mathematics until she observed a grade one class learning substraction. "even when they were doing two minus one and things like that, they couldn't get the answer, because they didn't have the materials in front of them. I just realized they need concrete materials".

The preservice elementary teachers realized the importance of the teacher behaviour and the message being sent through modelling after being out in the schools for a week. One preservice elementary teacher stated, "concrete materials were being used just like the class was showing us. It was great and easy to see how everything we had been taught made sense These positive experiences for learning mathematics assisted the preservice elementary teachers in learning appropriate teacher behaviour that would not promote mathematics anxiety. Other preservice elementary teachers saw negative behaviour on the part of the teacher that they felt promoted mathematics anxiety in the classes that they observed. One preservice teacher reported, "my teacher [grade four] avoided mathematics all week Every time it was time for mathematics he showed a film or went on a field trip. It was always, Oh! No time for math!". Another preservice elementary teacher felt that the students in the class she observed were anxious about mathematics because their teacher did the times-tables so fast they just couldn't get it'.

All of these experiences impressed upon the preservice elementary teachers the importance of the messages being sent by teachers' behaviour in the classroom. They were aware that they would have an impact upon their own students and appreciated how much the professor in the course modelled behaviour that enabled them to reduce their mathematics anxiety. She was always available for help or discussion, no time limits on content mastery tests were set, group work and the sharing of ideas was promoted, and students were not made to feel embarrassed in class or out. The professor also modelled the very teaching strategies that she hoped the preservice elementary teachers would use to promote a non-threatening environment for learning mathematics in their future classrooms.

Summary

To summarize, it is evident from the interview data of the professor, the interview data of the preservice elementary teachers, and from the observational data of the methods course that it was possible to identify the components of the elementary mathematics methods course that were effective in reducing the mathematics anxiety levels of the preservice teachers. The preservice elementary teachers during interviews were asked what parts of the course were helpful in reducing their mathematics anxiety. Their responses to this question identified similar components to those stated by the professor and observed by the researcher as being designed to reduce their mathematics anxiety.

The professor had stated that the initial step towards the reduction of mathematics anxiety was the acknowledgement that such anxiety was real and present. The preservice elementary teachers also stated that this component was necessary in reducing their mathematics anxiety. It is impossible to reduce any anxiety until you are aware what it is, and you acknowledge that you possess such an anxiety.

Working in small groups further assisted the preservice elementary teachers in reducing their mathematics anxiety by enabling them to work in a cooperative rather than a competitive atmosphere. The use of small groups also provided opportunities for the preservice teachers to successfully solve problems and increase their confidence in their ability to do mathematics. By increasing their confidence in their ability to do mathematics, they were able to reduce their mathematics anxiety

The use of concrete materials as manipulatives for solving mathematical problems helped the preservice elementary teachers to improve their own mathematics skills and allowed them to experience mathematics in a fun and enjoyable manner. The emphasis on understanding rather than on rote memorization that comes with using concrete materials aided in the reduction of mathematics anxiety. By not having to rely on memorizing rules, the preservice teachers were able to concentrate on learning the concept. By learning mathematical concepts, they were able to increase their confidence in their ability to do mathematics, and reduce their mathematics anxiety.

Learning mathematical concepts through the use of concrete materials was continued through the use of the videotapes. The professor's original purpose in using the videotapes was to provide opportunities for the preservice elementary teachers to see how children in an elementary classroom respond to the concrete materials. For the preservice teachers the experience of working in tandem with the videotapes further assisted the preservice elementary teachers in improving their mathematical skills. By increasing their mathematical skills the preservice teachers were able to increase their confidence in learning mathematics and reduce their mathematics anxiety. The use of the videotapes also provided a means for the preservice elementary teachers to view appropriate teacher behaviour for the teaching of mathematics.

The preservice elementary teachers by being aware of the impact of teacher behaviour on learning, credit the modelling of appropriate behaviour by the professor as assisting in the reduction of their mathematics anxiety. The preservice elementary teachers also give credit to the modelling of the teachers on the videotapes, and to some of the teachers that they were able to observe during the week out in the schools.

One component that was intended by the professor to reduce mathematics anxiety, content mastery tests, actually created mathematics anxiety in some of the preservice elementary teachers. This anxiety was observed by the researcher and stated by the preservice teachers. The content mastery tests were intended to provide a means whereby the preservice elementary teachers could learn mathematical content and discuss where they needed remediation. Many of the preservice elementary teachers expressed the need to learn mathematical content as a necessary component in the reduction of their mathematics anxiety. The preservice elementary teachers need to feel confident in their knowledge of and ability to do mathematics. The content mastery tests do not appear to be that successful in achieving this goal.

The components then of the elementary mathematics methods course that successfully aid in the reduction of mathematics anxiety are: the acknowledgement of mathematics anxiety as real; working in small groups, using concrete materials as mathematics manipulatives; learning through modelling, live and vicarious (through videotapes); and some remediation of mathematical skills.

Chapter V
DISCUSSION

The purpose of this study was twofold. The first purpose was to further an understanding of mathematics anxiety by placing it within a psychological model The second purpose was to determine if and how an intervention for mathematics anxiety implemented within an elementary mathematics methods course, could reduce levels of mathematics anxiety among preservice elementary teachers. Social cognitive theory (Bandura, 1986), provided an explanation for mathematics anxiety that was consistent with earlier research findings regarding the development of mathematics anxiety, and was also consistent with the findings of this research. The intervention for mathematics anxiety found within the elementary mathematics methods course could be seen as being grounded in social cognitive theory. Findings indicated that the mathematics anxiety levels of the preservice elementary teachers were significantly reduced after completion of the mathematics methods course. The preservice elementary teachers were able to specify which components of the mathematics methods course successfully helped them to reduce their mathematics anxiety.

This chapter is divided into three parts. First, a psychological explanation of mathematics anxiety is presented, followed by a discussion of the effects of the intervention with regards to the reduction of mathematics anxiety, the changes in attitude toward mathematics, and the features of the elementary mathematics methods course that were successful in reducing mathematics anxiety. Finally the implications from this research and for future research are discussed.

Psychological Explanation of Mathematics Anxiety

Mathematics anxiety is a negative emotional and cognitive reaction to mathematics which interferes with a person's ability to do mathematical tasks. The development and perpetuation of mathematics anxiety may be explained through an understanding of social cognitive theory. As Bandura (1986) suggests, people evaluate situations cognitively and then respond. Individuals are not automatically shaped by what happens around or to them, but rather, their response depends upon how the situation is interpreted by them. It is this interaction of cognition, behaviour and environment that shapes human behaviour.

Other psychological theories, such as psychodynamic and behavioural theories are incomplete for describing or understanding mathematics anxiety. Psychodynamic theories attribute anxiety to subconscious conflicts over the expressing of forbidden impulses. Anxiety is supposedly then rooted in this prohibited impulse. But an internal motivator cannot explain the variation in the strength and frequency of any given behavior in different situations, at different times, toward different persons (Bandura, 1977;1986; Sarason, 1985) Behavioristic or conditioning theories believe in a simple cause and effect situation. Neutral events become fear generating through an association with painful experiences. These theories externalize the cause of the anxiety. But the variation in human behaviour in similar situations indicates that some cognitive interpretation of events influences and maintains certain behaviours (Warren & Zgourides, 1991). External stimuli then influence behaviour through their predictive functions and not because they are automatically tied to responses by occurring together (Bandura, 1977; 1986; Michels, Frances, & Shear, 1985).

A social cognitive perspective hypothesizes that it is the perceived inefficacy to cope with potentially averse events that makes them fearsome (Bandura, 1986). It is this feeling of inefficacy that permits anxiety to develop and remain. As Bandura (1988) explains, "it is not the sheer frequency of frightful cognitions but rather the perceived self-inefficacy to control their escalation or perseverance that is a major source of anxiety arousal" (p. 89). A painful experience has two components that can lead to the rise of anxiety, external discomfort and thought-produced distress (Bandura, 1986). Barlow (1988) concurs that anxiety is generated through both cognition and affective feelings. It is this thought component that further assists in an understanding of how mathematics anxiety can arise. Highly anxious individuals tend to internalize events and self-depreciate over stressful situations which takes their focus off the task at hand and results in misinterpreting or neglecting information. Anxiety arousal may result in a narrowing of attention (Barlow, 1988). It has been extensively shown that negative thoughts can arouse anxiety and debilitate performance (Bandura, 1986; Barlow, 1988; Beck & Emery, 1985; Warren & Zgourides, 1991). People who believe that they cannot perform a certain task dwell upon their coping deficiencies, magnify the severity of possible threats, and worry about situations that may never happen. As a result, a high level of cognitively generated distress is experienced that negatively effects performance and arouses anxiety (Mogg, Mathews & Weinman, 1987).

Mathematics anxiety appears to develop through such negative cognitive distress. After a negative experience with mathematics, some people may develop mathematics anxiety by continuing to anticipate that they will do poorly,they focus on such negative thoughts as, "I can't do this", "I am stupid", "Why am I bothering, I never get these right". The amount of attention that is given to these negative thoughts diverts the amount of attention that can be focused on the problem at hand. By dwelling on these negative thoughts or on their perceived inefficacy to solve the problem, individuals will not be able to focus on the problem, will not be able to solve the problem, and will generate more anxiety by proving to themselves that these negative thoughts must be correct (Beck & Emery, 1985). There is only a finite amount of attention that can be allocated to a task. The amount of attention focused in one area limits the amount that can be focused on another (Barlow, 1988). If anxious individuals dwell on internal thoughts such as, "I am stupid", or "I'll never get this", there is not much attention left to be focused on the problem at hand (Bandura, 1986; Barlow, 1988).

There have been two main components of mathematics anxiety identified: emotionality and worry (Dew, Galassi & Galassi, 1984; Hendel & Davis, 1978; Morris, Kelloway & Smith, 1978; Morris, Davis & Hutchings, 1981; Wigfield & Meece, 1988). The emotionality component refers to the physiological and negative affective arousal such as fear, nervousness, and external discomfort. The worry component involves the cognitive concern about performance. These two components of mathematics anxiety can be seen to be consistent with the components of anxiety in general. The emotionality component of mathematics anxiety is similar to the external discomfort experienced by anyone in a situation that promotes anxiety. Some of the forms that the external discomfort can take are sweaty palms, rapid breathing, rapid heartbeat, or fidgeting. The worry component or cognitive component of mathematics anxiety has been shown to lead to debilitating performance in mathematics and mathematics anxiety (Hunsley, 1987, Wigfield & Meece, 1988). Bandura (1986, 1988) indicates that external discomfort and thought produced distress (or in other words, emotionality and worry) lead to the rise of anxiety. Anxiety arousal develops because the idea of having to perform (i.e., solve a mathematics problem), causes a negative cognitive response such as fear of failure. This fear of failure causes the individual to dwell upon negative self-evaluative statements such as, "I am stupid". This narrowing of attention distracts the individual from the problem at hand and interferes with her/his performance (Barlow, 1988). The individual's self-efficacy or belief as to whether or not she/he can successfully perform, leads to anxiety arousal and maintenance (Bandura, 1986). For mathematics anxious individuals, apprehension about doing mathematics again only adds to their anxiety. This apprehension interferes with performance and may cause extensive worry over an upcoming task. Their performance on the upcoming task may be disrupted because of lack of concentration due to too much attention focused upon this worry component.

The experiences that were recounted by the preservice elementary teachers as contributing to their mathematics anxiety are consistent with such a social cognitive explanation of anxiety arousal through perceived inefficacy. As the preservice elementary teachers reported, they "knew" that they were going to do poorly in any class that involved mathematics. As various preservice elementary teachers stated:

> Because this one is math, I just think, here we go again; (#6)
>
> I just cringed and thought I don't know what I'm going to do, it will be my lowest mark of everything; (#3)
>
> I've come to terms with it, math is not for me; (#11)

> It's sort of written in stone in my brain that I haven't done well in math so far; (#10)
>
> I did feel what I do when I first started the word problems, I felt I was going to have trouble, so I flipped to the next page; (#5)
>
> I just got fed up with not being able to do it; (#7)
>
> Oh, I don't know anything, I'll forget everything. (#12)

These individuals had no belief in their abilities to do mathematics. It was a strong belief for them that they just could not do mathematics successfully. The feelings being expressed seem to be that, I know I can't do mathematics so why bother, why continue to put myself in situations where I feel inadequate and subsequently anxious? All of these preservice elementary teachers stated that they possessed mathematics anxiety.

When asked to relate how their mathematics anxiety arose, the preservice teachers recalled experiences in which they had been made to feel anxious, upset, and fearful about doing mathematics. One preservice teacher recalled being sent up to the blackboard to solve a problem which she could not do, and ending up crying in front of all her peers. The consequence of this experience was that she interpreted this situation to mean that she did not have the ability to solve mathematical problems, and everytime she had to solve a mathematics problem, she remembered this situation and got upset again. Her perceived self-inefficacy and anxiety became debilitating and interfered with her ability to learn mathematics. Consequently she missed several key concepts of elementary mathematics and a cycle of inadequate mathematics learning and mathematics anxiety began. As reported earlier, many of the preservice elementary teachers recalled experiences where they ended up crying and embarrassed in mathematics classes due to their inability to solve problems and consequently developed mathematics anxiety.

These experiences are consistent with a social cognitive explanation of anxiety development through feelings of inefficacy. As Bandura (1986, 1988) explains, the two components of a painful experience that can lead to the development of anxiety are external discomfort and thought produced distress. These components are consistent with the components of emotionality and worry of mathematics anxiety. The external discomfort or emotionality refers to the nervousness, sweating, rapid breathing observed in mathematics anxious individuals. The thought produced distress or worry component refers to the negative cognitions about performance. These preservice elementary teachers who were mathematics anxious had interpreted their situations cognitively, and as one preservice teacher stated they "lived and learned" to fear mathematics. Individuals who judge themselves as lacking coping capabilities, warranted or not, exaggerate potential harm in situations. "When a few mishaps are misread as signs of basic coping inefficacy, all kinds of situations become fraught with danger. People's thoughts about their self-efficacy influence how well they perform and thus the outcomes they are likely to experience" (Bandura, 1986, p. 220). As Bandura (1986) explains,

> Fear arousal and defensive behavior are largely coeffects, rather than causally linked. Aversive experiences, of either a personal or vicarious sort, can instill belief in one's inefficacy to control painful outcomes that gives rise to both fear arousal and defensive conduct. . . Until effective coping skills are

developed, threats will produce much arousal. (p. 188)

When individuals are mathematically anxious their defensive behaviour is to avoid situations where they may be required to do mathematics. This avoidance of mathematics only leads to further mathematics anxiety when these individuals are expected to perform mathematical tasks. Therefore a cycle exists of inadequate mathematics learning, mathematics anxiety, further loss of mathematics learning, more mathematics anxiety and so on. By avoiding mathematical situations, mathematics anxious individuals never get a chance to see if they can perform mathematics successfully, and thereby reduce their mathematics anxiety.

Mathematics anxiety may also be explained through the concept of vicarious learning of social cognitive theory (Bandura, 1986). Some mathematics anxiety may arise through the observation of the behaviour of others. Individuals themselves do not have to experience negative consequences to doing mathematics to develop mathematics anxiety. Observing another person reacting negatively to a situation involving mathematics may be enough to cause anxiety to develop. The strength of such vicarious learning is greater when the model is in a position of trust and power (Bandura, 1986), such as in the position of an elementary school teacher. Same sex models are stronger mediators of learned behaviour than opposite sex role models (Bandura, 1986), therefore female elementary school teachers become strong role models for their female elementary students. As the preservice elementary teachers observed and reported, in some elementary classrooms the teacher was subtly, and not so subtly, relaying the message that mathematics was something to be disliked and possibly feared. Since vicarious learning is increased when models in positions of authority are observed over time, the elementary school teacher becomes a very strong role model for children. Therefore an elementary teacher who is anxious towards mathematics may display anxious behaviour that is consequently learned by the children and promotes the development of mathematics anxiety in them.

As indicated earlier, the preservice elementary teachers observed elementary classrooms for one week during the mathematics methods course. These preservice elementary teachers observed classrooms in which (i) the teacher pushed aside mathematics for other subjects; (ii) rewarded students for good behaviour by excluding mathematics; (iii) rushed through mathematics lessons in an attempt to get them out of the way as quickly as possible; (iv) punished students for bad behaviour by making them do mathematics until they were quiet; and (v) embarrassed students in front of their peers for their inability to do mathematics. None of these behaviours send positive messages about mathematics. In fact, all of these behaviours are sending very negative messages about mathematics. The importance of modeled behaviour is explained by Bandura (1986), " the people with whom one regularly associates with, either through preference or imposition, delimit the behavioral patterns that will be repeatedly observed and, hence, learned most thoroughly" (p. 55). Since elementary school children have no control over the selection of their teachers, the observation of negative behaviour towards mathematics may cause mathematics anxiety to be learned by such children over time.

In summary, the development of mathematics anxiety is consistent with the development of anxiety as explained by social cognitive theory. Mathematics anxiety develops through the cognitive interpretation of aversive experiences and/or through observational learning. The cognitive interpretation of aversive experiences leads to a perceived lack of self-efficacy in the ability to learn and or perform mathematical tasks successfully. Mathematics anxious individuals debilitate their efforts by self-doubting and other self-defeating ideations. This self-inefficacy promotes a cycle of inadequate math learning and anxiety because individuals do not allow themselves to be placed in situations where they might be required to "do" mathematics. The observation of negative behaviour towards mathematics by models in positions of trust and authority, such as elementary school teachers, may also promote the development of mathematics anxiety. It is the cognitive interpretations of such behaviour and the environment in which it occurs that cause mathematics anxiety to develop and remain.

Effects on the Intervention on Mathematics Anxiety and Attitude Toward Mathematics

Three questions were answered through the data analysis. The first question asked if the preservice elementary teachers' mathematics anxiety levels were changed after completing the mathematics methods course. The second question asked if attitudes toward mathematics were changed after completion of the elementary mathematics methods course. The final question was concerned with the identification of components of an elementary mathematics methods course that could successfully aid in the reduction of mathematics anxiety.

The three research questions were related. The first and second questions are connected since there appeared to be a relationship between mathematics anxiety and one dimension of an attitude toward mathematics. For this research the dimensions of an attitude toward mathematics that were studied were confidence in learning mathematics, the perception of the teacher toward one as a learner of mathematics, the perception of mathematics as a male domain, and feelings toward being successful in mathematics. Only one dimension, that of confidence in learning mathematics appeared to change after completion of the mathematics methods course. There appeared to be for the preservice elementary teachers, a relationship between lower mathematics anxiety, and improved confidence in learning mathematics. The first and third questions are connected since the components that successfully reduce mathematics anxiety could not be identified, unless the mathematics anxiety levels were actually lowered, which was the case. The three questions intersect because the components of the mathematics methods course that reduced mathematics anxiety were those components that improved confidence in learning mathematics. The results from all data sources, questionnaires, interviews, and observations consistently indicated that the preservice elementary teachers did reduce their mathematics anxiety levels after completing the elementary mathematics methods course. The preservice elementary teachers were also able to identify those components of the methods course that they felt helped them to reduce their mathematics anxiety.

The preservice elementary teachers indicated through the Fennema-Sherman Mathematics Anxiety Scales and through the interviews that they were anxious about mathematics at the start of the elementary mathematics methods course. Not only were the preservice teachers anxious about mathematics but they generally had a negative attitude towards their ability to learn mathematics. This was evident through the Fennema-Sherman Confidence in Learning Mathematics Scales, the interviews, and the course observations. The preservice elementary teachers had low confidence levels in their abilities to learn mathematics. Therefore many of the preservice elementary teachers were thankful, happy, glad, and excited when they thought that they did not have to take mathematics anymore after high school. They had avoided situations where they might be required to do mathematics and consequently never changed or had a chance to change their self-efficacy about their ability to successfully perform mathematics. When faced with the requirement of taking an elementary mathematics methods course, the preservice elementary teachers were anxious because they thought they would be required to do mathematics and they did not have confidence in their ability to do so. All of the preservice elementary teachers interviewed mentioned their lack of confidence in learning mathematics and their desire to gain more confidence in their ability to be successful at mathematics.

As social cognitive theory explains (Bandura, 1986, 1988), improved self-efficacy is necessary for the reduction of anxiety to take place. The fact that an improved confidence in learning mathematics was required before the preservice elementary teachers could reduce their mathematics anxiety, further supports the placement of mathematics anxiety within a social cognitive perspective. Fennema and Sherman (1976) reported a correlation of .89 between their Mathematics Anxiety Scale and Confidence in Learning Mathematics Scale further indicating a connection between confidence in learning mathematics and mathematics anxiety.

Several studies support the role of self-efficacy as a mediator between attitudes and achievement in mathematics (Campbell & Hackett, 1986; Hackett & Betz, 1989; Hackett, Betz, O'Halloran, & Romac, 1990; Norwich, 1986; Randhawa, Beamer, & Lundberg, 1993; Siegel, Galassi, & Ware, 1985). Hackett and Betz (1989) in their investigation of 262 undergraduate students, found that mathematics performance was positively correlated with mathematics self-efficacy. They further found that mathematics anxiety and confidence in learning mathematics were also significantly correlated to mathematics self-efficacy. The findings of this research study concur with those of Hackett and Betz, in that individuals with higher levels of mathematics self-efficacy tend to report lower levels of mathematics anxiety and higher levels of confidence in learning mathematics. In a meta-analysis of studies concerning mathematics anxiety, Hembree (1990) found higher mathematics anxiety consistently related to lower mathematics performance. Furthermore, Hembree found a strong inverse relationship between mathematics anxiety and self-confidence in mathematics. This finding is in agreement with the results of this research study that of a relationship between self-efficacy in mathematics and mathematics anxiety.

Randhawa, Beamer and Lundberg (1993) investigated 225 students enrolled in a Grade 12 academic mathematics course and found that mathematics self-efficacy was a mediator variable between mathematics attitude and mathematics achievement. They concluded that confidence in doing a task and the confidence in one's ability in a certain area are critical factors for motivation. It is possible that perceptions of inefficacy in mathematics could lead learners to reduce their engagement in mathematics. It was also found that girls have significantly lower perceptions of mathematics self-efficacy than boys (Randhawa, et al., 1993). These perceptions of inefficacy in mathematics could lead to mathematics anxiety and mathematics avoidance and could put girls at a greater risk than boys. The placement of mathematics anxiety within the social cognitive framework, particularly in the case of self-efficacy, has strong support from other research.

The preservice elementary teachers in this study regularly mentioned that a feeling of confidence in their ability to do mathematics was a major contributing factor in the reduction of their mathematics anxiety. This need to feel confident in order to reduce anxiety is consistent with the social cognitive theory of improving self-efficacy as a necessary component of anxiety reduction. The preservice teachers all stated during interviews that the mathematics methods course was successful in allowing them to feel more confident, comfortable, a lot better, and less anxious about mathematics. As various preservice elementary teachers stated:

> I had to have the confidence in myself or I wouldn't be a teacher; (#7)
>
> I wanted to come away feeling a little bit better about math, a little bit more confident, and I did; (#9)
>
> I feel more confident and I think I can do it [math]; (#2)
>
> The more confident you feel, the better your sense of competence. (#3)

Individuals must believe that they are capable of successfully performing the task at hand if they are to reduce their anxiety. A positive self-efficacy towards mathematics is necessary if one is to successfully perform mathematical tasks and lower mathematics anxiety. Confidence in learning mathematics appears to be closely related to mathematics anxiety.

The intervention for mathematics anxiety within the elementary mathematics methods course was successful in improving the preservice elementary teachers' levels of confidence towards learning mathematics and in reducing their mathematics anxiety levels. Significantly reduced levels of mathematics anxiety were found in the results from the Mathematics Anxiety Scale, and lower mathematics anxiety levels were also reported by the preservice elementary teachers in their final interviews. While the preservice elementary teachers clearly indicated during interviews that they were more confident in their ability to learn mathematics at the end of the methods course, only 3 of the 10 pretest/posttest comparisons of the questionnaire scale showed significant levels of improvement. But 8 of the 10 comparisons did show improvement in the predicted direction. One possible explanation for the variance between these two data sources, may be that while the preservice elementary teachers were confident in their ability to learn mathematics, they may not have been confident in their ability to teach mathematics, especially at the upper elementary grades.

While the scale was designed to measure confidence in learning mathematics, there may have been some confusion for the preservice elementary teachers. It may have been difficult for the preservice teachers to separate themselves as learners and teachers of mathematics. The preservice elementary teachers clearly stated during the interviews that they did feel more confident in their ability to learn mathematics, but almost half of them wished that even more mathematics content had been taught in order to make them feel truly confident in their ability to teach mathematics at the higher grades. As the course neared completion, the preservice teachers were more preoccupied about having to teach mathematics than they were about learning mathematics.

The other dimensions of an attitude towards mathematics that were studied were the perception of the teacher toward one as a learner of mathematics, the perception of mathematics as a male domain, and attitude toward success in mathematics. Since the study was concerned with preservice elementary teachers, the dimension of how teachers' perceptions towards one as a learner affects learning is an important one. Further if mathematics anxiety does belong within a social cognitive perspective, then the awareness of vicarious learning and what one thinks about how others perceive him/her are important mediators of behaviour. The dimension of mathematics as a male domain and attitude toward success in mathematics are related. If one is female and perceives that mathematics is a masculine pursuit, then to be successful in mathematics is to be in conflict with one's gender identity. Since preservice elementary teachers are primarily female, and possess higher levels of mathematics anxiety than comparable groups, the perception of mathematics as a male domain may have affected their attitude toward mathematics. Questions about mathematics and gender are important in any study that involves mathematics anxious individuals who are primarily female.

The results from the dimension of the perception of the teacher toward one as a learner of mathematics were not conclusive. While the scores on the Fennema-Sherman Perception of Teacher Toward One as a Learner of Mathematics Scale did show improvement, only two of the ten comparisons were statistically significant. But all ten of the comparisons were in the predicted direction, that is, the mean scores after completing the elementary mathematics methods course were all higher than the mean scores before taking the course. There may have been some confusion for the preservice elementary teachers in context in answering this scale. Since these individuals have had so many teachers over the years, were the answers on the pretests made generally, that is were the preservice elementary teachers scoring their overall perception of all of their mathematics teachers combined; and/or were the answers on the posttests scored with just thoughts of the professor who taught the mathematics methods course in mind? It is difficult to know of whom the preservice elementary teachers were thinking when they answered the questions for this scale.

From the interview data in the area of teachers' perceptions, it was clear that the preservice elementary teachers' perception of their teachers toward them as learners of mathematics were varied over their schooling. But generally their remembrances of mathematics teachers were negative ones indicating that the preservice teachers thought that past teachers had not regarded them positively as learners of mathematics. In fact many of their negative experiences with mathematics were influenced by the behaviour of their teachers. The preservice elementary teachers stated in their final interviews that they now saw themselves as positive learners of mathematics, and also felt that the professor who taught the methods course perceived them as positive learners of mathematics.

These findings highlight the importance of the teacher's attitude, perceptions, expectations, and own mathematics anxiety in the learning of mathematics. As was discussed earlier, same sex role models are usually more effective for behaviour to be learned than opposite sex role models (Bandura, 1986). Since most elementary teachers are female, elementary girls may develop more mathematics anxiety than boys because of the actions of mathematics anxious teachers. If teachers do not like mathematics and make it obvious from their behaviour, then students will also learn not to like mathematics and possibly develop anxiety towards it. If the messages that are being sent are that mathematics is something you are made to do when you are bad; or as a reward for being good there will not be any mathematics; or if mathematics is consistently pushed aside in the curriculum for other subjects, then possibly the students in those situations may interpret the behaviour to mean that mathematics is bad, or is something that should be feared and consequently mathematics anxiety may develop. Vicarious learning through modeled behaviour can occur and be lasting. This is further support for the placement of mathematics anxiety within a social cognitive perspective and supports the idea of reducing preservice elementary teachers' own mathematics anxiety before they begin to teach as a preventative measure against the future development of mathematics anxiety.

Teachers' expectations and perceptions of students are complex and seem certain to affect performance (Avery & Walker, 1993). Girls appear to be more concerned about the teacher's perception of them as learners than boys (Leroux, 1988; Newman & Schwager, 1993). Girls are more concerned than boys about appearing "dumb" in mathematics class. This is of importance because "girls' lower expectancy for success and greater anxiety in mathematics class in relation to boys' might lead to girls not actively seeking needed assistance" (Newman & Schwager, 1993, p. 12). If girls fail to seek help in mathematics class because of how the teacher might perceive them, this could lead to lower mathematics skills, more mathematics anxiety, and avoidance of mathematics or mathematics-related courses. Of the preservice elementary teachers interviewed, most of them thought that their past teachers had not perceived them as competent learners of mathematics, possibly because the teachers saw mathematics as a masculine pursuit and did not expect girls to be good at mathematics.

Another dimension of an attitude towards mathematics was the perception that mathematics belongs in the male domain. The section above on teachers' expectations and perceptions indicates that gender and performance in mathematics are tied. The preservice elementary teachers clearly indicated through the questionnaire data that they did not perceive mathematics to be in the male domain. Yet the results from the interview data indicated different findings. The preservice teachers may think they believe that anyone and everyone is capable of being successful in mathematics, yet when asked to describe someone who was good at mathematics, the preservice elementary teachers invariably described someone who was male.

One finding that did arise from this area of the research concerned the preservice elementary teachers thoughts on elementary school teaching and gender. The preservice elementary teachers did not believe or think that society believes that males should be elementary teachers. The perception seems to be that elementary teaching is for females because they are more nurturing and motherlike and those are the qualities of teachers required at the elementary school level. Males belong more at the secondary level of teaching because they find it easier to specialize or their egos require them to be Biology or Mathematics teachers rather than "just" elementary school teachers. These findings indicate strong stereotypical beliefs of male and female roles and career choices. Despite some societal change in adult gender roles in recent years, stereotypical beliefs and behaviours among children have remained relatively constant (Lobel, Bempechat, Gewirtz, Shoken-Topaz, & Bushe, 1993; McAninch, Manolis, Milich, & Harris, 1993; Serbin, Powlishta, & Gulko, 1993). Serbin et al (1993), found a significant correlation between children's knowledge of gender stereotypes for occupations and their own preferences for "sex-appropriate" adult occupations. Even though the preservice elementary teachers seem to indicate that they believe that mathematics is not a masculine pursuit, they do possess strong and clear ideas about male and female roles and career choices. McAninch, Manolis, Milich and Harris (1993) found that concepts such as masculine and feminine appropriate behaviour were extremely resistant to change. The preservice elementary teachers investigated during this research had clear stereotypical beliefs about careers that also appeared to be resistant to change considering all the efforts over the past decade to promote equality. This finding indicates that more research is necessary in the area of gender and career choice, and that "sex-role stereotypes" should be included as a topic in all teacher education programs. Teachers are a strong influence on students and need to become aware of their own perceptions in the area of career choice.

The final dimension of an attitude towards mathematics that was explored in this research was the attitude toward success in mathematics. The Fennema-Sherman Attitude toward Success in Mathematics Scale attempted to measure how much individuals desire to be successful in mathematics. There were no significant differences found in any of the comparisons of the data arising from the questionnaire scale. At the beginning of the mathematics methods course the mean scores were all very high, indicating that the preservice elementary teachers wished to be successful in mathematics. Half of the comparisons showed a slight lowering after completing the elementary mathematics methods course while the other half showed a slight rise. Information that arose from the interview data indicated that this scale may have been an inappropriate measure for the population of this research, since their desired level of success in mathematics (to teach elementary school), may be much different than the level of success the scale was designed to measure. The preservice elementary teachers indicated during their interviews that they only wanted to be successful enough in mathematics to be able to teach it at the elementary level. They did not desire to pursue careers in mathematics, and they did not wish to take further courses in mathematics except to assist them in learning basic mathematical skills. They wanted to be confident in their ability to teach mathematics and the only measure of success that was necessary for them, was to be able to do mathematics at that same level.

The third research question was designed to identify the components of the elementary mathematics methods course that aided in the reduction of mathematics anxiety. This question was predicated on mathematics anxiety being reduced, and on the ability of the preservice elementary teachers to articulate what was helpful to them. The preservice elementary teachers did clearly identify the components of the elementary mathematics methods course that were successful in reducing their mathematics anxiety levels. The components of the mathematics methods course that were successful in reducing mathematics anxiety were those components that enabled the preservice elementary teachers to feel more confident in their ability to do mathematics and actually showed them how to successfully learn and do mathematical tasks. One component that appeared to be assisting in the reduction of mathematics anxiety was the recognition and validation of the preservice elementary teachers' own mathematics anxiety. By recognizing that they were not alone with their mathematics anxiety, the preservice elementary teachers slowly began tc realize that they were not "stupid", and that they could learn how to do mathematics successfully.

The use of small groups helped the preservice elementary teachers to successfully perform mathematical tasks. For many of the preservice teachers it was the first time they could actually relax in a situation involving the solving of mathematical problems, and they learned how to successfully perform mathematical tasks. One possible reason the use of small groups may have been successful is that by virtue of having more females than males in the class, there were also more females than males in the small groups. Studies have shown that by having girls outnumber boys in small groups solving mathematical problems, the girls get a greater chance to speak out and solve the problems for themselves (Holden, 1993). Boys tend to dominate talk in the classroom (Redpath, 1989; Sadker & Sadker, 1985; Swann & Graddol, 1988). Therefore by allowing small groups where the females outnumber the males, the females are more likely to get a chance to actively participate in the problem solving process (Holden, 1993). The use of the small groups to solve problems may have been effective then through the very makeup of the group. As one female preservice teacher said, "it feels good to solve it and know you were involved".

The importance of being able to do mathematics is highlighted for these preservice elementary teachers as necessary in reducing their mathematics anxiety levels. This finding is further support for the placement of mathematics anxiety with a social cognitive perspective. The reduction of anxiety through successful performance is a cornerstone of social cognitive theory (Bandura, 1986, 1988). Hembree (1990) also found that interventions that resulted in significant mathematics anxiety reduction, were accompanied by significant increases in mathematics performance. Further support for improved performance being necessary for anxiety reduction arises from Siegel, Galassi and Ware's (1985) findings that interventions designed to increase mathematical performance also increased efficacy expectations and reduced anxiety toward mathematics.

But preservice elementary teachers must also be provided with the instructional strategies necessary in order to teach mathematics without promoting anxiety. Therefore the use of concrete materials for the learning of mathematics was an important component of the elementary mathematics methods course. The preservice elementary teachers need to experience using these materials in an experiential setting. The use of concrete materials provide ways to learn mathematics content and instructional strategies for mathematics. The need to be successful in performing mathematical tasks requires remediation of mathematics skills for some of the preservice elementary teachers. There must be components then that focus on the remediation of mathematics skills and teach mathematics content. The use of content mastery tests provided a means through which the preservice elementary teachers could improve and test their mathematics skills. But, almost half of the preservice elementary teachers wished that even more mathematics content had been taught during the methods course. Therefore, another method for remediation would appear to be needed. The preservice elementary teachers must believe that they can successfully perform mathematics in order to reduce their mathematics anxiety.

Vicarious learning through the modeled behaviour of not only the professor in the class, but also the behaviour of the teacher in the videotapes, and the behaviour of some of the teachers in the observed classrooms all contributed towards the reduction of mathematics anxiety. By being able to see individuals learning and doing mathematics without feelings of stress and anxiety helped the preservice elementary teachers to gain a new perception of mathematics. They also were able to learn and do mathematics themselves without feelings of anxiety. These preservice elementary teachers hope to be successful teachers, and that includes teaching mathematics. Learning through modelled behaviour how to teach mathematics without promoting anxiety in their future students and in themselves, is necessary in order to reduce their mathematics anxiety.

All of these components are consistent with an intervention for anxiety grounded in social cognitive theory. Improved self-efficacy in mathematics is necessary to reduce mathematics anxiety. Confidence in learning mathematics and improved performance at mathematical tasks are necessary in order to reduce mathematics anxiety. The increase in self-efficacy, improved performance, and vicarious learning all assist in the reduction of anxiety (Bandura, 1986, 1988).

Implications

This research, indicates that increasing self-efficacy expectations are important to the reduction of mathematics anxiety. An explanation for mathematics anxiety and the intervention for mathematics anxiety that was investigated, were both grounded in social cognitive theory. Teachers of mathematics should pay as much attention to students' self-evaluations of competence as to actual performance (Hackett & Betz, 1989). Educators must not only assess these self-evaluations, but also must be prepared to modify these self-efficacy expectations. The finding that girls have significantly lower perceptions of mathematics self-efficacy (Randhawa, Beamer & Lundberg, 1993) than boys indicates that support for females needs to be re-emphasized in the area of mathematics. Continued and strong steps need to be taken to encourage women to participate in technical and mathematical courses. Strong female role models are necessary so that early perceptions of "sex-appropriate" careers can be altered and all careers can be seen as appropriate for either sex. Even though there have been changes in gender roles and career choices in the past decade, women are still under-represented in mathematically related careers. Mathematics anxiety and subsequent mathematics avoidance may have contributed to the lack of participation of women in these areas. Further work needs to be done in the area of gender and schooling, and in particular, in the area of gender and mathematics.

An appropriate site of intervention for mathematics anxiety is within elementary mathematics methods courses for preservice elementary teachers. Teachers need to be free of mathematics anxiety themselves before their students can also be free of mathematics anxiety. One goal for reducing preservice elementary teachers' mathematics anxiety in the mathematics methods course was to also provide them with the skills necessary to teach mathematics in an environment that promotes exploration, explanation, and encourages risk taking behaviour. Through the use of small group work and the utilization of concrete materials as mathematical manipulatives, preservice teachers learn strategies to teach mathematics in such an environment. The National Council of Teachers of Mathematics (1989) states that students need to become confident in their own abilities. Elementary mathematics methods courses then also need to assist preservice teachers in improving their confidence in their abilities to learn mathematics.

Interventions for mathematics anxiety, especially those designed within elementary mathematics methods courses for preservice teachers, should include components that will modify the self-efficacy expectations of the preservice elementary teachers toward mathematics. As Bandura (1986) hypothesized, there are four influences on self-efficacy expectations. One influence is past performance accomplishments. A second way self-efficacy can be modified is through vicarious learning, for example role models of mathematical achievement, particularly female role models for girls. A third way to modify self-efficacy is through encouragement, support and information, or verbal persuasion. The fourth and final way to modify self-efficacy expectations, is by actual reduction of mathematics anxiety, through an intervention specifically designed to do so (Hackett & Betz, 1989). These four influences on self-efficacy interact complexly to modify self-efficacy expectations (Randhawa, Beamer, & Lundberg, 1993).

The components needed to address self-efficacy expecations then are mathematical performance, role models, verbal encouragement and support, and reduction of mathematics anxiety. The intervention under investigation included all of these components. The reduction of mathematics anxiety was a primary feature of the methods course and included ways to modify self-efficacy expectations. The professor was a positive female role model, and was conscious of modelling behaviour that would promote a risk taking environment. There was strong encouragement and support for all members of the course in acknowledging their mathematics anxiety, and dealing with it on a cognitive level. There was an effort to improve mathematical performance through the remediation of mathematical skills, and through the promoting of an understanding rather than a memorization of mathematical concepts. The use of small groups to promote a risk taking atmosphere, the use of concrete materials to learn and understand mathematical concepts, the use of videotapes for vicarious learning, the remediation of mathematical skills, the acknowledgement of mathematics anxiety as real and not as something to be ignored, and the modelling by the professor herself were all important features of the intervention to reduce mathematics anxiety and improve self-efficacy.

The use of small groups and concrete materials needs to be explored further. Because the concrete materials were usually explored in small groups, there may be a question of which feature was really acting to reduce the mathematics anxiety. Was it working in small groups, or was it learning mathematical concepts through the use of concrete materials? The preservice elementary teachers clearly identified during interviews both of these features, but it is not clear if one component can be utilized effectively without the other. Future research might address this issue.

The importance of role models opens the question of the professor herself. The preservice elementary teachers mentioned that the professor was important in assisting them to reduce their mathematics anxiety. Was it this individual in particular, or would anyone who modelled the same behaviour be successful? This question could be investigated in future research.

The preservice elementary teachers stated that they needed to learn mathematical concepts, and they realized that remediation of their current skills was necessary. But the content mastery tests seemed to promote mathematics anxiety in the short term which may have interfered with their learning of mathematics. The preservice elementary teachers need to perceive themselves as successful learners and doers of mathematics in order to reduce their mathematics anxiety. Another method of remediation might be more appropriate to improve mathematical skills, increase mathematics self-efficacy, and reduce mathematics anxiety.

Future elementary mathematics methods courses concerned with the reduction of mathematics anxiety should include then the following components:

1) Positive role models for preservice elementary teachers. These role models can be live, for example the professor of the course, and teachers in actual elementary classrooms, or symbolic, for example in videotapes. The importance of vicarious learning cannot be underestimated and positive role models are a necessary component in the reduction of mathematics anxiety.

2) The learning and remediation of mathematical concepts must be a major component. Preservice elementary teachers must see themselves as successful doers of mathematics. The importance of self-efficacy in the reduction of mathematics has been clearly indicated. One way to increase self-efficacy is through increased performance.

3) The use of concrete materials in small group settings is another component that allows preservice elementary teachers to not only improve their own mathematical skills, but also provides them with the strategies necessary to teach mathematics in an environment that does not promote anxiety. Preservice elementary teachers need to be given an opportunity to improve their mathematical skills, and increase their confidence in their ability to learn and do mathematics in order to reduce their mathematics anxiety.

Further research is necessary to support the placement of mathematics anxiety in a social cognitive perspective. Future interventions for mathematics anxiety need to be grounded in such a psychological perspective and investigated to determine which features are effective in reducing mathematics anxiety. Social cognitive theory provides a framework to understand the development and perpetuation of mathematics anxiety. The means through which mathematics anxiety may develop, i.e., self-efficacy expectations, vicarious learning, cognitive perceptions, and past performance, all indicate means through which mathematics anxiety may be reduced and eventually even prevented. Social cognitive strategies for the reduction of mathematics anxiety that were not explored in this research may provide direction for future research. Such strategies could be cognitive reframing, monitoring self-thoughts through the keeping of a mathematics journal, or greater one-on-one counselling.

Future investigations into mathematics anxiety may also wish to explore a different research design. Since the majority of significant differences were found when groups were combined in this study, the small sample size may have hindered the finding of significant differences. Even though 112 preservice elementary teachers were investigated over three years of an elementary mathematics methods course, the numbers that occurred when sections were split (into pretest and posttest sections), may have been too small. Possibly future research could involve different universities to increase the sample size. The use of different universities would also reduce possible instructor bias, since only one instructor taught all sections of the elementary mathematics methods course in this study. This study does indicate that an elementary mathematics methods course is an appropriate site for the intervention of mathematics anxiety.

Another change in future research design may be the modification of some items of the Fennema-Sherman Mathematics Attitude Scales. Because the individuals under investigation were preservice teachers in the process of learning how to teach mathematics, there may have been some confusion in the perception of the teacher toward one as a learner of mathematics scale. These individuals have had so many teachers of mathematics over the years that it became difficult to isolate which teacher they referred to in answering the questions for this scale. The attitude toward success in mathematics scale could be eliminated for preservice elementary teachers. The only level of success that these individuals desire is to be able to teach and do mathematics successfully at the elementary level. Another change may be in the perception of mathematics as male domain scale. While the preservice elementary teachers did not indicate that they perceived mathematics as a male domain on their answers to this scale, they clearly indicated gendered notions of career choices. A dimension that may need to be study is gender and career choice and a more appropriate scale needs to be found.

Mathematics anxiety is real and needs to be reduced and prevented. Through the reduction of preservice elementary teachers' own mathematics anxiety, and the learning of strategies to teach mathematics in a positive environment, mathematics anxiety may be prevented in future individuals. The reduction of mathematics anxiety should be a feature of elementary mathematics courses, and such courses should incorporate components to reduce mathematics anxiety that are consistent with social cognitive theory.

APPENDIX A

FENNEMA-SHERMAN MATHEMATICS ATTITUDE SCALES IN QUESTIONNAIRE

FENNEMA-SHERMAN MATHEMATICS ATTITUDE SCALES

Elizabeth Fennema - Julia A. Sherman

On the following pages is a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. Suppose the statement is:

Example: I like mathematics.

As you read the statement you will know whether you agree or disagree. Circle the letters as follows:

A	strongly agree
B	agree
C	undecided
D	disagree
E	strongly disagree

Do not spend much time with any statement, **but be sure to answer every statement.**

There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice.

THIS INVENTORY IS BEING USED FOR RESEARCH PURPOSES ONLY AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE.

1. It would be really great to win a prize in mathematics.	A B C D E
2. My teachers think advanced math is a waste of time for me.	A B C D E
3. I would expect a woman mathematician to be a masculine type of person.	A B C D E
4. I'll need a firm mastery of mathematics for my future work.	A B C D E
5. I think I could handle more difficult mathematics.	A B C D E
6. Math has been my worst subject.	A B C D E
7. Being first in a mathematics competition would make me pleased	A B C D E
8. My father thinks I could be good in math.	A B C D E
9. Mathematics will not be important to me in my life's work.	A B C D E
10. Being regarded as smart in mathematics would be a great thing.	A B C D E
11. Winning a prize in mathematics would make me feel unpleasantly conspicuous.	A B C D E
12. My math teachers have been interested in my progress in mathematics.	A B C D E
13. Girls can do just as well as boys in mathematics.	A B C D E
14. Females are as good as males in geometry.	A B C D E
15. Generally I have felt secure about attempting mathematics.	A B C D E
16. My mother thinks advanced math is a waste of time.	A B C D E
17. I'm no good in math.	A B C D E
18. I would trust a woman just as much as I would trust a man to figure out important calculations.	A B C D E
19. Mathematics is of no relevance to my life.	A B C D E
20. My mother hates to do math.	A B C D E
21. I see mathematics as a subject I will rarely use in my daily life as an adult.	A B C D E
22. If I got the highest grade in math I'd prefer no one knew.	A B C D E
23. Women certainly are logical enough to do well in mathematics	A B C D E

24. My mother has always been interested in my progress in mathematics. A B C D E

25. Math teachers have made me feel I have the ability to go on in mathematics. A B C D E

26. I have had a hard time getting teachers to talk seriously with me about mathematics. A B C D E

27. In terms of my adult life it is not important for me to do well in mathematics in high school. A B C D E

28. I have a lot of self-confidence when it comes to math. A B C D E

29. I expect to have little use for mathematics when I get out of school. A B C D E

30. It wouldn't bother me at all to take more math courses. A B C D E

31. My father thinks I need to know just a minimum amount of math. A B C D E

32. I would talk to my math teachers about a career which uses math. A B C D E

33. I get a sinking feeling when I think of trying hard math problems. A B C D E

34. Most subjects I can handle O.K., but I have a knack for flubbing up math. A B C D E

35. Mathematics makes me feel uneasy and confused. A B C D E

36. Mathematics is for men; arithmetic is for women. A B C D E

37. I have found it hard to win the respect of math teachers. A B C D E

38. Girls who enjoy studying math are a bit peculiar. A B C D E

39. I'll need mathematics for my future work. A B C D E

40. I don't think I could do advanced mathematics. A B C D E

41. I can get good grades in mathematics. A B C D E

42. My mother wouldn't encourage me to plan a career which involves math. A B C D E

43 I will use mathematics in many ways as an adult. A B C D E

44. It would make me happy to be recognized as an excellent student in mathematics. A B C D E

45. My father hates to do math. A B C D E

46. As long as I have passed, my mother hasn't cared how I have done in math. A B C D E

47. My mother thinks I could be good in math. A B C D E

48. Mathematics usually makes me feel uncomfortable and nervous. A B C D E

49. When a woman has to solve a math problem, it is feminine to ask a man for help. A B C D E

50. My father thinks advanced math is a waste of time for me. A B C D E

51. Taking mathematics is a waste of time. A B C D E

52. I haven't usually worried about being able to solve math problems. A B C D E

53. It's hard to believe a female could be a genius in mathematics. A B C D E

54. My father thinks I'll need mathematics for what I want to do after I graduate from high school. A B C D E

55. My mother thinks that mathematics is one of the most important subjects I have studied. A B C D E

56. My mind goes blank and I am unable to think clearly when working mathematics. A B C D E

57. My teachers have encouraged me to study more mathematics. A B C D E

58. My father thinks that mathematics is one of the most important subjects I have studied. A B C D E

59. My father wouldn't encourage me to plan a career which involves math. A B C D E

60. I don't like people to think I'm smart in math. A B C D E

61. I am sure that I can learn mathematics. A B C D E

62. My mother thinks I'm the kind of person who could do well in mathematics. A B C D E

63. Males are not naturally better than females in mathematics. A B C D E

64. My teachers would think I wasn't serious if I told them I was interested in a career in science and mathematics. A B C D E

65. I study mathematics because I know how useful it is. A B C D E

66. Studying mathematics is just as appropriate for women as for men. A B C D E

67. I almost never have gotten shook up during a math test. A B C D E

68. My mother thinks I need to know just a minimum amount of math. A B C D E

69. I would have more faith in the answer for a math problem solved by a man than a woman. A B C D E

70. My father has strongly encouraged me to do well in mathematics. A B C D E

71. If I had good grades in math, I would try to hide it. A B C D E

72. I usually have been at ease during math tests. A B C D E

73. My teachers think I'm the kind of person who could do well in mathematics. A B C D E

74. Getting a mathematics teacher to take me seriously has usually been a problem. A B C D E

75. My mother thinks I'll need mathematics for what I want to do after I graduate from high school. A B C D E

76. When it comes to anything serious I have felt ignored when talking to math teachers. A B C D E

77. I usually have been at ease in math classes. A B C D E

78. My math teachers would encourage me to take all the math I can. A B C D E

79. My father has shown no interest in whether or not I take more math courses. A B C D E

80. It would make people like me less if I were a really good math student. A B C D E

81. My mother has shown no interest in whether or not I take more math courses. A B C D E

82. I'm not the type to do well in math. A B C D E

83 I'd be proud to be the outstanding student in math. A B C D E

84. Math doesn't scare me at all. A B C D E

85. I am sure I could do advanced work in mathematics. A B C D E

86. Knowing mathematics will help me earn a living. A B C D E

87. A math test would scare me. A B C D E

88. Mathematics makes me feel uncomfortable, restless, irritable, and impatient. A B C D E

89. As long as I have passed, my father hasn't cared how I have done in math. A B C D E

90. My mother has strongly encouraged me to do well in mathematics. A B C D E

91. I'd be happy to get top grades in mathematics. A B C D E

92. My father thinks I'm the kind of person who could do well in mathematics. A B C D E

93. Mathematics is a worthwhile and necessary subject. A B C D E

94. My father has always been interested in my progress in mathematics. A B C D E

95. People would think I was some kind of a grind if I got A's in math. A B C D E

96. For some reason even though I study, math seems unusually hard for me. A B C D E

DEMOGRAPHIC DATA

SEX ______________________ **I.D. No.** ________

MAJOR AREA OF STUDY ______________________

HIGHEST LEVEL OF MATH STUDIES COMPLETED;

Grade 10 ________	**1st yr University** ________
Grade 11 ________	**2nd yr University** ________
Grade 12 or 13 ________	**3rd yr University** ________
	Higher ________

TOTAL NUMBER OF FULL YEAR UNIVERSITY MATH COURSES COMPLETED

____

APPENDIX B

SAMPLE INTERVIEW QUESTIONS FOR PRESERVICE ELEMENTARY TEACHERS

First Interview with Preservice Teachers

1. What is your name? How have you liked Acadia so far? [General guestions to set the conversational tone of the interview].

2. Do you have any brothers or sisters? Tell me a little about them, like for example what are they going to choose for a career

3. Does your mother/father work outside the home? Do they use any math in their work?

4. What does your family think about you becoming a teacher? Why elementary?

5. What do you think of the materials that Heather has presented so far? Which ones do you find interesting and think that you will like to use?

6. What subject did you like the best in elementary school? Why? What was it about that subject that you liked? Did that change when you got to high school?

7. Now how about the subject that you liked the least, did that change when you reached high school? university?

8. What was the last math course that you took? Why did you stop there?

9. Think back to elementary school, what do you recall about any really good experiences with a teacher who taught math? What made the experience a good one?

10. Now think back to high school, what good memories do you have in regards to math?

11. Let's try the opposite, in elementary school can you recall any experiences you would classify as bad ones? Tell me about them. How about in high school?

12. What grade level would you like to teach? What is it about the other grades that makes you not want to teach them?

13. Can you rank the things that you expect to like about teaching and tell me more about them?

14. What subject to you expect you'll like to teach the most? What is it about the other subjects that you don't think you'll like to teach them as well?

15. When Heather was using the geoboard to demonstrate area did you understand what she was doing? Do you remember how you were taught? How was it the same/different? Do you think this would help children understand area?

16. How did you feel about the content mastery?

17. Have any of the articles surprised you, or made you relate to them?

18. What did you discover in today's class about math?

APPENDIX C

PERCEPTION OF MOTHER TOWARD ONE AS A LEARNER OF MATHEMATICS PRETEST AND POSTTEST MEANS (STANDARD DEVIATIONS) FOR ALL SUBJECTS BY YEAR IN STUDY

<u>Perception of Mother Towards One as a Learner of Mathematics Pretest and Posttest Means (Standard Deviations) for all Subjects by Year in Study</u>

Year						N
One	**M** 45.6(8.1)					42
Two a		46.1(7.8)	**M** 47.4(6.3)			16
b			**M** 46.5(8.2)			15
Three				44.2(8.5)	**M** 45.0(8.2)	39

<u>Note</u>: **M** = elementary mathematics methods course

APPENDIX D

PERCEPTION OF FATHER TOWARD ONE AS A LEARNER OF MATHEMATICS PRETEST AND POSTTEST MEANS (STANDARD DEVIATIONS) FOR ALL SUBJECTS BY YEAR IN STUDY

Perception of Father Toward One as a Learner of Mathematics Pretest and Posttest Means (Standard Deviations) for All Subjects by Year in Study

Year						N
One	**M** 43.8(10.9)					42
Two a		45.44(6.1)	**M** 45.8(6.3)			16
b			**M** 47.0(8.3)			15
Three				43.4(8.3)	**M** 43.7(8.0)	39

Note: **M** = elementary mathematics methods course

APPENDIX E

PERCEPTION OF USEFULNESS OF MATHEMATICS PRETEST AND POSTTEST MEANS (STANDARD DEVIATIONS) FOR ALL SUBJECTS BY YEAR IN STUDY

Perception of Usefulness of Mathematics Pretest and Posttest Means (Standard Deviations) for All Subjects by Year in Study

Year						N
One	**M** 50.5(4.8)					42
Two a		50.6(4.0)	**M** 50.6(4.5)			16
b			**M** 50.0(5.9)			15
Three				50.5(5.0)	**M** 49.0(4.8)	39

Note: **M** = elementary mathematics methods course

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