MATH-TEST ANXIETY AND TEST PREPAREDNESS

by

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ABSTRACT

The purpose of this study was to investigate the relationship between math-test anxiety and test preparedness. Initial observation of the literature surrounding math anxiety led to the development of the primary hypothesis of the study: students' math-test anxiety, as measured by a math-test anxiety inventory, is related to their self-reported preparedness for a math test. This study also tested six secondary hypotheses relating to performance, first language, and gender.

An adapted version of the Test Anxiety Inventory provided the means to measure math-test anxiety. Knowledge (measured by test performance), math attitude (measured by a math attitude scale), math usefulness (measured by a math usefulness scale), and math self-efficacy (measured by a math self-efficacy scale) provided the framework for test preparedness. To survey high school students, a questionnaire was developed and circulated to eight districts across British Columbia. Three hundred and twenty-two questionnaires (67 percent) were returned.

Quantitative data were analyzed using Pearson correlation coefficients, multiple regression analysis, and the independent samples t-test in the SPSS 10.1 Windows software package. Confidence levels for statistically significant figures reported by the package were set at the $p < 0.05$ level.

The following results were found: there was strong evidence ($R = 0.531$, $Rsquare = 0.282$ and $p < 0.05$) that preparedness before a test is significantly correlated with math-test anxiety; Strong evidence was found ($R = 0.521$, $Rsquare = 0.271$ and $p < 0.05$) that a student's knowledge and self-efficacy are significantly correlated with

his or her last math course mark; moderate evidence was found ($r = -0.353$, *rsquare* = 0.125 and $p < 0.05$) that performance is significantly correlated with math-test anxiety; moderate evidence was found ($r = 0.409$, *rsquare* = .167 and $p < 0.05$) that a student's performance is significantly correlated with his or her last math course mark; evidence was found that performance ($t = -2.817$, $d = 0.526$ and $p < 0.05$) and math attitude ($t = -3.322$, $d = 0.490$ and $p < 0.05$) are significantly correlated with first language; There is evidence that math self-efficacy ($t = 3.686$, $d = 0.420$ and $p < 0.05$) is significantly correlated with gender; and, no evidence was found ($t = 1.117$ and $p = 0.269$) that first language is significantly correlated with math-test anxiety.

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Chapter I

INTRODUCTION

> An autobiographical note: *Have you ever sat in a math class and felt lost or totally overwhelmed? While sitting in fifth grade, I can still remember watching my teacher explain multiplication with decimals and feeling worried. I did not understand what was being taught and nothing written in front of me seemed connected or made sense. I experienced math anxiety. Over the last twenty or so years, I still at times experience math anxiety. But the difference is that I know I can beat it–so much so that it did not deter me from becoming a math teacher. It was not until I became a teacher, however, that I realized the extent to which math anxiety affects people. To some degree every day, I see it on the faces and in the actions of almost all my students. I want to help them build strategies to help themselves.*

Anxieties are fundamental human emotions that occur in direct response to a perceived threat and the incapacity to cope with that threat in a satisfactory way (Zeidner, 1998). Anxiety can be both good and bad. Some anxiety is beneficial because it can act as a motivator to spur individuals to take action (Hembree, 1990; Zeidner, 1998). Test anxiety, on the other hand, is usually not beneficial. It has been shown that test anxiety can interfere with the normal thought processes, inhibit the recall of information, and therefore, prevent success (Lee, 1999). Math anxiety is another anxiety that is usually not beneficial. With estimates as high as 68 percent of students having a problem with math anxiety, and with a 40 percent failure rate among freshmen in college calculus, it is easy to see why so few people seem to enjoy mathematics or pursue careers in math related fields (Hubber, 1990; Vander-Zyl & Lohr, 1994; Wieschenberg, 1994). Shawyer (1985) notes that in a society with an ever-increasing emphasis on science and technology, and with mathematics being the foundation of science and technology, math anxiety is a serious problem that has been out of hand for some time now.

This study was interested in the association between a student's level of math-test anxiety and his/her self-reported level of preparedness before a math test. The context of the study were teenage math students engaged in the BC high school curriculum across the province. The focus was on students in grades 9 through 12.

The Question

The following question is being examined: What association exists between the level of math-test anxiety that a student experiences and his/her self-reported level of preparedness before that test? This question leads to the following hypotheses:

1. That students' math-test anxiety, as measured by a math-test anxiety inventory, is related to their self-reported preparedness for a math test.

   Null Hypothesis: Students' self-reported preparedness for math tests is not correlated significantly $(p < 0.05)$ with their scores on the math-test anxiety inventory.

2. That students' performance on a math test is related to their math-test anxiety as measured by a math-test anxiety inventory.

   Null Hypothesis: Students' performance on math tests is not correlated significantly $(p < 0.05)$ with their scores on the math-test anxiety inventory.

3. That students' self-reported preparedness before a math test is related to their previous success in a math course as measured by the self-reported last course mark.

Null Hypothesis: Students' self-reported preparedness before a math test is not correlated significantly $(p < 0.05)$ with their success in their last math course.

4. That students' performance on a math test is related to their previous success in a math course as measured by the self-reported last course mark.

   Null Hypothesis: Students' performance on a math test is not correlated significantly $(p < 0.05)$ with their last math course mark.

5. That students' self-reported preparedness before a math test is related to whether or not their first language is English (NB: all math classes involved in the study were taught in English).

   Null Hypothesis: Students' self-reported preparedness is not correlated significantly $(p < 0.05)$ with whether or not their first language is English.

6. That students' math-test anxiety, as measured by the math-test anxiety inventory, is related to whether or not their first language is English.

   Null Hypothesis: Students' math-test anxiety, as measured by the math-test anxiety inventory, is not correlated significantly $(p < 0.05)$ with whether or not their first language is English.

7. That students' self-reported preparedness before a math test is related to gender.

   Null Hypothesis: Students' self-reported preparedness is not correlated significantly $(p < 0.05)$ with gender.

Assumptions

Based predominately on the review of the literature outlined below, the following assumptions were made:

1. The first assumption deals with how math anxiety is defined. Many studies are calling into question the nature of math anxiety, its exact definition, and its distinction from test anxiety (Alexander & Martray, 1989; Kazelskis, 1998; Kazelskis et al., 2000; Williams, 1994). Because of this, the present study focuses on the test anxiety factors of worry and emotionality and how they are related to preparedness before a mathematics-testing situation. Therefore, this study assumes that math anxiety manifests itself as a special or specific type of test anxiety.
2. The second assumption is composed of three parts, all of which pertain specifically to the concept of preparedness. Preparedness is complex and difficult to measure. For the purpose of this study, a student's preparedness before a test will be measured by the following three factors:
    a. his/her motivation for doing mathematics, which is split into the two sub-factors of general attitude towards mathematics and perceived usefulness of mathematics;
    b. his/her self-efficacy in mathematics (i.e., the belief that one has about his/her ability to accomplish the task at hand successfully);
    c. his/her knowledge of mathematics.

Brief Review of the Theory and Background

Studies to determine the difference between math anxiety and test anxiety have not been conclusive. Williams (1994) found results suggesting that math anxiety and test anxiety are markedly consistent methods for measuring the same construct. Alexander (1989) suggested that apprehension about taking math tests should be the most salient feature of a revised definition of math anxiety. Kazelskis et al. (2000) also did not find strong support for a clear distinction between the two; however, they still are not prepared to say that math anxiety and test anxiety are one and the same. They feel that math anxiety is clearly multidimensional and that test anxiety alone is inadequate to describe it properly. The number of different math anxiety scales that exist and that obviously measure different dimensions–including math-test anxiety–provide evidence of this. Future research into math anxiety must address this complexity; otherwise the conceptual uniqueness of math anxiety, and its distinction from test anxiety, cannot be further delineated and its measurement improved (Kazelskis, 1998; Kazelskis et al., 2000). It is because of this lack of distinction between math anxiety and test anxiety that this study assumes that math anxiety manifests itself as special type of test anxiety and will be referred to as math-test anxiety.

With respect to assumption numbered two, the factors of motivation (with its sub-factors of attitude and usefulness) and self-efficacy are interrelated in a circular fashion. In fact, it may be more advantageous to see this relationship as a helix with an upward flow indicative of gaining more positive motivation and greater self-efficacy, and a downward flow signifying more negative motivation and lower self-efficacy.

If one starts by looking at attitude, there is little doubt that attitude affects self-efficacy and is affected by perceived usefulness. According to Aiken (1970), attitude clearly affects achievement and vice versa. Students with positive math attitudes have greater success and achievement than those students with negative attitudes. Success breeds success as confidence rises in the belief of being able to attain positive outcomes and the sense of control over one's environment improves (Wieschenberg, 1994). This need to control one's environment is strongly linked to past experiences and it is critical to maintaining a positive self-efficacy in mathematics. Miller (1994) and Thorndike-Christ (1991) discuss how students with low self-efficacy quit sooner or do not try at all when working in mathematics, and students with high self-efficacy try harder and for longer periods of time.

However, in order for students to try harder and longer to become better prepared they must feel that what they are learning is meaningful to them. Simply put, if the material is meaningful, students will learn more effectively and this, in turn, improves attitude (Aiken, 1970; Miller & Mitchell, 1994). Steele (1998) states that math needs to be useful for students or they will not see the connections to the real world. If students do not see and understand these connections, then the opportunity for real learning is lost as they rely solely on memorization. Memorization, of course, serves students less and less effectively as they climb the academic ladder (Norwood, 1994; Steele, 1998). We see, therefore, that the perceived usefulness of math helps improve attitude and understanding. This then relates directly to better achievement and self-efficacy, which, in turn, relates back to perceived usefulness and positive attitude. All play important roles in preparation, or how hard and for how long a student will try to ensure his/her success in mathematics.

On the other hand, failure can breed failure. Both Aiken (1970) and Wieschenberg (1994) discuss the idea of learned helplessness when unwanted outcomes are followed by further unwanted outcomes. These failures can produce negative attitudes that eventually begin to feed upon themselves (Aiken,1970; Wieschenberg, 1994).

Finally, knowledge is critical to being well prepared for a math test. It is logical that without the knowledge of the material that is to be tested, a student's chances of scoring well on the evaluation decrease sharply. Conversely, if a student has the knowledge of the material to be tested, his/her chances of doing well increase.

Therefore, the factors of knowledge, self-efficacy, and motivation–with its two sub-factors of attitude and usefulness–provide a measure of the level of preparedness of a student before a math test. Also, the factors of self-efficacy and motivation may be seen as bound together in a helix of development. A student with positive motivation and high self-efficacy will wind around the helix in an upward direction with success stimulating more success, while a student with negative motivation and low self-efficacy can spiral down the helix with failure breeding more failure. In either direction, the factors feed upon themselves and are therefore self-fulfilling.

Need for the Study

Studies have found that math anxiety has a negative correlation with performance (Betz, 1978; Hembree, 1990; McCoy, 1992; Norwood, 1994). Negative conditioning, in the form of past poor performance, has a strong effect on future outcomes (Wieschenberg, 1994).

When math-test anxiety effectively inhibits learning and causes doubt, poor performance is inevitable and a negative attitude towards mathematics becomes a self-fulfilling prophecy (Miller & Mitchell, 1994; Vander-Zyl & Lohr, 1994;Wieschenberg, 1994). On the other hand, some studies have shown little to no relationship between math anxiety and performance (Abramovich, 1997; Cook, 1997). Norman (1998) states quite clearly that math anxiety does not always lead to lower performance. She found in her study that there are certain background factors that appear to promote math success with or without anxiety.

Research done strictly on test-anxiety, however, has shown clear evidence of performance deficits caused by the inability of individuals to retrieve task-related information. This is because the working memory of an individual has a finite space, and this space is being used up by the representation of test anxiety (Lee, 1999; Zeidner, 1998). This is especially true of complex tasks that require language comprehension and reasoning–two areas essential to success in learning and applying mathematics (Hembree, 1990; Lee, 1999; Zeidner, 1998).

For most students, there is little control over the environment and atmosphere in which they find themselves when it comes to taking a math class. For example: they have no control over what is to be taught, to what level it will be taught, and how quickly it will be taught. This uncertainty can readily translate itself into math anxiety, particularly when it comes to performance on math tests. Tobias (1978) sees the basis of math anxiety centered on how students deal with this uncertainty. How well do they accept failure? What happens to their concentration when they perform poorly? Are they willing to take risks to learn?

As mentioned above, Wieschenberg (1994) discusses this in terms of a mental state of conditioned helplessness in mathematics when poor performance is followed by poor performance. As educators, we need to find strategies to empower students to help themselves with math anxiety–especially in testing situations. If this study finds a strong negative correlation between preparedness and math-test anxiety, then, armed with this information, educators could inform, encourage, and support students in their efforts to prepare for evaluations knowing the benefits that being prepared can provide.

Definition of Terms

Math Anxiety: In the literature, there appears to be no clear and concise definition of math anxiety. Some definitions emphasize physical reactions; others center on feelings of apprehension, uneasiness or discomfort, and fear; while others focus on how a person worries about, and the negative affect reactions to, mathematics (Kazelskis et al., 2000). The definition used in this study is the following: Math anxiety involves the feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Norwood, 1994).

Test Anxiety: Like math anxiety, there appears to be no agreed upon definition of test-anxiety in the literature. Some researchers lean towards the definition that sees test-anxiety as a trait-anxiety, while others see it more or less as a state-anxiety. Trait anxiety is concerned with a person's more stable temperament to react with anxiety in a host of different situations. State anxiety, on the other hand, is concerned with a person's more temporary emotional state of anxiety brought about by the interaction of his/her trait anxiety and the specific situation at hand (Zeidner, 1998). There is, however, a widely accepted definition proposed by Spielberger that interprets test anxiety as a *situational-specific personality trait.* This means that "test anxiety refers to the individual's disposition to react with extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal when exposed to evaluative situations" (Zeidner, 1998, p.18). For the purpose of this study, test anxiety is defined as a *situational-specific personality trait.* This means that it is seen as a bi-dimensional construct with affective and cognitive components. Emotionality is the affective component; it refers to the physical reactions to testing situations such as nervousness, discomfort and fear. Worry is the cognitive component; it refers to worrying about testing situations and negative performance expectations (Williams, 1994).

Math–Test Anxiety: For the purpose of this study, math-test anxiety will encompass the two test anxiety components of emotionality and worry as they pertain specifically to mathematical evaluations; therefore, math-test anxiety can be seen as involving feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems specific to a testing situation.

Preparedness: The *Cambridge International Dictionary of English* defines the word *"prepare"* as *"verb–to make or get (something or someone) ready for something that will happen in the future"* (Cambridge-University-Press, 2000). This study is concerned with the extent that a student is "ready" for an evaluation, or his/her level of preparedness.

Data Collection and Procedures

Following the approval by the Ethics Review Committee, in September and October 2000, ten math teachers from eight school districts across BC were contacted through the PSA-BCAMT listserve and by telephone. They agreed to administer a questionnaire to at least one of their math classes in grades nine to twelve. In early January of 2001, packages were sent to each teacher containing the instructions for the administration of the survey, over 30 copies each of the consent form, the questionnaire, and the multiple choice Scantron sheets, as well as a self-addressed stamped envelope for the return of the survey. Regular post was used to send and receive the packages.

Teachers were asked to distribute the consent form to each student in a math class of their choice. Once all consent forms were returned, the questionnaire was administered during a class that immediately preceded a math test–either on the same day, or up to four days prior to the test, depending on class scheduling and weekend periods. The questionnaire was administered to all students in the class who had signed parental consent. Students not wishing to participate were given curriculum based math problems of appropriate level to work on for 15-20 minutes. Each student answering the questionnaire attached his/her consent form to the Scantron sheet he/she used. No name or identification of any kind appeared on the Scantron sheets. Consent forms and Scantron sheets were then collected and given to a second adult–e.g., a counselor, administrator, or department head. Teachers were then asked to mark the test and provide the second adult with a class list including each student's test score and current class mark–both in percent. The second adult transferred these scores to the respective Scantron sheets and then separated the Scantron sheets and consent forms. Both piles, one comprised of the consent forms and the other of unidentified Scantron sheets, were mailed back to me in the self-addressed stamped envelope.

In March of 2001, I used SPSS 10.1 for Windows software for statistical analysis of the data at the University College of the Cariboo, in Kamloops, British Columbia.

The Questionnaire

Data were collected through the use of a questionnaire. Items measuring math-test anxiety and preparedness were drawn from various recognized and published instruments, as well as seven items that I constructed. These seven items (questions numbered 56 to 63) follow the guidelines set out in the "Guide for Constructing Self-Efficacy Scales" by Albert Bandura (1995).

The questionnaire is composed of five parts: instructions and general questions; a math-test anxiety section; a math attitude section; a usefulness of math section; and a math self-efficacy section (see Appendix B). The general question section deals with basic questions such as gender, first language, last math course mark, etc. I wrote all the items in the general question section.

The math-test anxiety inventory is the Test Anxiety Inventory (TAI) by Spielberger (1980). It has been modified to read specifically for math test situations. The TAI was then reduced to 14 items from 20–seven of which measure worry and seven of which measure emotionality.

The math attitude scale is taken from the Revised Math Attitude Scale by Aikens (1963). No changes were made with the exception of the reduction in the number of items from 20 to 14–seven of which measure positive attitude relating to interest and enjoyment, and seven of which measure negative attitude relating to stress and worry.

The math usefulness scale is taken from the set of nine scales by Fennema and Sherman (1986) constructed to measure different attitudes towards learning mathematics. No changes were made with the exception of the reduction of the number of items from 12 to 10–five of which measure the perceived usefulness of math and five of which measure the perceived uselessness of math.

The self-efficacy scale is also taken from the set of nine by Fennema and Sherman (1986). However, only the first ten questions come from the Fennema and Sherman confidence scale. Again there were no changes made to this scale with the exception that the number of items was reduced from 12 to 10–five of which measure higher confidence and five of which measure lower confidence in mathematical ability. I wrote the remaining seven questions, keeping in mind the guidelines set out by Bandura (1995).

Finally, student knowledge was measured by taking into account the students' self-reported last math course marks, their current marks in their present course, and their marks on the test written directly after the questionnaire was administered.

Delimitations

Because there is no clear and concise definition of math anxiety and because there are numerous instruments that report on clearly different dimensions, I narrowed this study to math anxiety experienced before a math test. Therefore, the instrument used is a test anxiety scale modified to be specifically math test oriented.

Because the most convenient method of contacting math teachers across the province is through the PSA-BCAMT listserve, the author has narrowed the sample frame of students to those who have teachers on the listserve.

Limitations

The major limitation of this study is the sampling procedure. Because the PSA-BCAMT listserve does not have all British Columbia high school math teachers listed, the sample frame of possible students in the province, although large, is not complete.

A further limitation is that the teachers who have agreed to participate with their classes are volunteers and are therefore not randomly chosen.

An additional limitation is that it is unclear as to how many, if any, private schools have had the opportunity to participate. It is assumed that the vast majority of teachers on the listserve are from public schools. This may mean that students of much more affluent families may not be fairly represented.

A final limitation is the strength of discriminant validity present in the questionnaire. I believe the problem of the strength of discriminant validity comes into question between the constructs of math-test anxiety, math attitude, and math self-efficacy. The question that might be raised is how adequately do the measures of these constructs discriminate between each other? Clearly there will be some overlap in the different scales chosen; however, this is not to say that these constructs are identical or even largely the same. This will become evident by the review of the literature in Chapter II where these three constructs will be discussed in more detail. To gain a more statistical appreciation of the discriminant validity of the questionnaire, more complicated analyses are required that go beyond the scope of this study–see Williams (1994) for an example. Therefore, this final limitation manifests itself in the understanding that although the scales being used to measure math-test anxiety, math attitude, and math self-efficacy are reporting on distinct constructs, there are overlaps. The instruments, therefore, cannot avoid measuring some areas of similarity.

Chapter II

THE LITERATURE

Math Anxiety

Most individuals have a clear understanding of what math anxiety means to them. Because of this and because of the amount of research that has been conducted on the subject, it would seem reasonable to find in the literature a clear and concise definition. No such definition is forthcoming. In fact, in most cases, math anxiety is treated as one-dimensional by authors who use math anxiety scales that measure related, but clearly distinct, dimensions (Kazelskis, 1998). Kazelskis (1998) discusses six related but distinct dimensions of math anxiety:

1. worrying
2. negative effects
3. positive effects
4. numerical anxiety
5. math course anxiety
6. test anxiety

What is evident is that math anxiety is multi-dimensional, but what is not evident is the delineation or boundaries of these dimensions. As long as the boundaries of math anxiety remain unclear, a concise definition is impossible. Kazelskis (Kazelskis, 1998; Kazelskis et al., 2000) goes further to say that future research into math anxiety must address this complexity, otherwise the conceptual uniqueness of math anxiety, and its distinction from test anxiety, for example, cannot be further delineated and its measurement improved. Therefore, for the purpose of this paper, math anxiety is defined in the broadest sense as feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Norwood, 1994).

One of the most interesting aspects of math anxiety is the range of people it affects. Numerous studies show that math anxiety is present in both genders, in students from elementary school to the university level, in teachers, and across different race and ethnic groups (Campbell & Evans, 1997; Eckmier & Bunyan, 1995; Miller & Mitchell, 1994; Satake & Amato, 1995; Steele & Arth, 1998; Zettle & Houghton, 1998). What is unfortunate, however, is that there is little research directed at high school students–the years where the curriculum begins to depart into more theoretical or abstract mathematics. Students at this age, roughly fourteen to eighteen years old, are at the beginning of Piaget's formal operations stage, the fourth and last stage in his model on cognitive development. What this means is that students are being asked to stretch their abstract cognitive skills at a time when those skills are rudimentary at best (Miller & Mitchell, 1994; Weiten, 1995). That said, it is not that students are incapable of meeting the standards set by the curriculum during these years; it is that the mathematics curriculum in British Columbia is getting progressively harder and it is asking more of a process with which students have had little practice: abstract thinking (Ministry of Education, 1996). Hembree (1990) found in his research that math anxiety peaks in students who are in grades nine and ten.

The composition of math anxiety is as varied and complex as the people who suffer from it. Consequently, it is helpful to understand some of the reasons and behaviors behind the problem. The following are experiences that math anxious students can have to varying degrees and combinations.

Many math anxious students have a reluctance to ask questions for fear of being seen as stupid or being ridiculed by their peers. This can be exacerbated by teachers who consistently make it clear that some answers are obvious and that these questions should not be asked (Miller, 1994; Steele, 1998). Of course, what is obvious to one person is not always obvious to another. Some anxiety victims can clearly remember being embarrassed in front of their peers during a class when they did not understand or did not know some aspect of mathematics (Miller, 1994). This can be hard on a student's confidence because no one likes to be singled out for his/her mistakes. Buxton (1991) and Miller (1994) both state that teachers need to understand that some of their routine behavior in the classroom can elevate the degree to which some students experience math anxiety. Therefore, as Dubiel (1997) points out, teachers must understand the power they have as authority figures both in the school environment and as subject specialists. A teacher directly or indirectly indicating to students that they are poor at math can easily wipe out years of success in the subject. For a student, one word of encouragement from a teacher can go a long way; on the other hand, a word of discouragement from a teacher can seriously hurt a student's confidence. As Cuban (1993) says, "At the heart of schooling is the personal relationship between the teacher and student." This relationship can have a positive or a negative effect on a student's math anxiety.

Meij (1988) found that two factors limiting question asking by students during class are the perceived willingness of the teacher to answer questions and the teacher's competence with the material. Students are very perceptive: they can tell when a teacher is not approachable or open to questions. Miller (1994) discusses how math anxious students see no reason in asking questions if they are used to the instructor repeating the same explanation. If students did not understand the first time, they may not feel confident the material will be any easier to learn the second time. Students begin to defeat themselves. Without the information they need to understand the material, their progress is effectively impaired and their anxiety level rises (Miller, 1994). Most interestingly, a study by Brown (1992) found that well-prepared teachers have a positive effect on the math performance and the math anxiety level of their students.

A teacher's method of instruction can have either a positive or negative effect on a student's level of math anxiety. According to Norwood (1994), there are numerous studies that maintain that since learning in mathematics is a function of mathematics teaching, then math anxiety may also be a function of mathematics teaching. Greenwood (1984) and Steele (1998) believe that certain methodologies employed by teachers are the main cause of math anxiety. The process of explaining the problems, doing the problems, memorizing the algorithms, correcting the problems, and testing for the correct methods is the major culprit. This so-called explain-practice-memorize approach centers around the idea that math has a limited set of rules and problem types. All a student needs to do is recognize the particular type and then apply the known rule. Known as the instrumental approach to teaching mathematics, it begins to fail students in higher levels of mathematics because they cannot hope to memorize the growing number of fixed rules (Norwood, 1994). The instrumental approach has been the dominant method of instruction for years and is, curiously enough, the approach that math anxious teachers most easily slip into when faced with teaching a subject with which they are not confident (Folk, 1985). This does not mean, however, that teacher anxiety is transmitted to students; a study by Bush (1991) shows that is not the case. It is simply easier for a teacher to follow a structured outline, step by step, when teaching a subject about which he/she feels anxious.

Conversely, the relational approach attempts to explain mathematics as a system of relationships that are organized in ever-increasing levels of abstraction. Drawing on Skemp (1973,1978), Norwood (1994) explains that a student using the relational approach for a problem will relate it to a broad range of concepts and then devise a plan to solve it. The advantage here is that the emphasis is on understanding why a system of relationships works together. Instead of memorizing numerous and seemingly unrelated fragments, the student focuses on exactly how and why the pieces interrelate. Norwood's (1994) results, however, did not show any appreciable difference in the level of math anxiety between the two groups–instrumental or relational. This is interesting to note because Pesek & Kirshner (2000) show that the relational approach gives students a better understanding of mathematics. In fact, it has been shown that the instrumental approach is a hindrance to students' learning when they switch and begin to learn relationally. Hembree (1990) also did not find that class interventions of any kind–e.g., classroom instruction or provision of special equipment–had any real impact on a student's level of math anxiety. Norwood (1994) states that a possible reason for her results is that the students she chose to study were in a basic arithmetic course. She found that math anxious students responded better to the highly structured atmosphere of the instrumental approach. In this particular arithmetic course, the need to understand was not as necessary as the need to manipulate mathematics to get the right answer. This, unfortunately, mimics the high school atmosphere particularly when it comes to standardized provincial exams (Pesek & Kirshner, 2000).

Parents can also have an important and powerful effect on a student's level of anxiety. According to Poffenberger (1959), parents can affect their children's attitude and performance in the following three ways: parental expectations of their children's performance; parental encouragement; and parental attitude towards mathematics. All three can place negative pressure on students and intensify their anxieties. As Buxton (1991) points out, parents need to understand the excess pressure they place on their children when demanding a certain level of performance. Because questions in mathematics are often right or wrong, children can confuse their performance with feelings about themselves. "Wrong" can easily be replaced with "bad." By not attaining the marks a parent demands, students quickly see themselves as not worthy (Buxton, 1991).

The socioeconomic factor differentiates the top third of schools from the bottom third and it is a strong indicator of parental ability to assist their children academically in all subjects. This parental support helps students obtain good performance (Joshi, 1995; Pungello, 1996). This cycle of support and success becomes self-fulfilling. Conversely, those parents with little formal education may not be as supportive. This may be due to parental unawareness of the opportunities that education can afford their children; it also may be due to parental feelings of inadequacies during their own schooling (Pungello, 1996). If parents cannot offer their children positive support in the study of mathematics, they end up offering no, or worse only negative, support.

Of the three key areas (parental expectation, encouragement, and attitude), parental attitude towards mathematics, either good or bad, appears to have the strongest influence. The relationship between attitude and achievement in students is clearly and positively related to the attitudes of their parents (Aikens, 1976; Hall, 1999). Moreover, attitude is seen as one of the most important, if not the most important, factors in determining success in mathematics (Hembree, 1990). According to Buxton (1991), parents must also be cautious not to pass on their anxieties to their children. In an article by Parmet (1999) in *Family Life* magazine, Shelia Tobias is quoted as saying, "Parents owe it to their children not to show their own math anxiety. Children mimic, identify with, and take on the attributes of their parents. Parents must work on their own math fears" (p. 46). It is, therefore, counterproductive for parents to mention how difficult math was for them and still expect their teenagers to succeed. Further to this, a study by Cooper and Robinson (1991) also found that perceived support from parents had a positive relationship with math self-efficacy measures.

Many female students believe math is still more of a male domain. As they have gone through their mathematical learning, they have also experienced situations where they feel it is unpopular for them to be successful in mathematics (Buxton, 1991; Campbell & Evans, 1997; Dubiel, 1997; Miller & Mitchell, 1994; Tobias, 1978). Researchers have pointed to these two factors as the main reason why females experience math anxiety in higher numbers than males. In addition to this, Campbell and Evans (1997) also state that female high school students have lower self-concepts in mathematics than do their male counterparts. It is interesting to note, however, that more recent research indicates that it may be more socially acceptable for females to admit to having math anxiety – i.e., it is acceptable for females to admit to having weaknesses (Zettle & Houghton, 1998; Zettle & Raines, 2000). In other words, males may suffer from math anxiety just as frequently as females but may feel pressured not to admit it.

Miller (1994) discusses how many anxious math students feel there is only one right way to answer particular types of problems. If they do not know that method, they cannot hope to solve the problem. If a test is composed of a variety of seemingly separate types of problems, deciding where and when to use any particular method can be overwhelming. Students also worry about how a tiny error can lead to the loss of all marks in some evaluations such as multiple choice questions (Miller, 1994).

Time constraints, either on tests or in the need to complete the curriculum, are another factor that increases students' levels of math anxiety (Hebert & Furner, 1997; Lee, 1999). In my teaching experience, the most consistent complaint is that students feel they do not have enough time to understand the material. For many there is simply too much material to cover in far too little time. This constant pressure, which fuels the fear of falling hopelessly behind, wears them down and aggravates their level of math anxiety (Hebert & Furner, 1997; Lee, 1999).

Test Anxiety

Like math anxiety, there appears to be no agreed upon definition of test anxiety in the literature. Some researchers lean towards defining test anxiety as a trait anxiety while others lean towards a state anxiety (Zeidner, 1998). In general, trait anxiety refers to the relatively stable differences in anxiety proneness brought about by a testing situation. This is determined by the degree to which the situation is perceived as threatening, harmful, or challenging. State anxiety refers to the fluctuating anxiety states triggered by the autonomic nervous system in response to a testing situation (Spielberger & Vagg, 1995; Zeidner, 1998). There is, however, a widely accepted definition proposed by Spielberger that interprets test anxiety as a *situational-specific anxiety trait* with worry and emotionality as the main components (Spielberger & Vagg, 1995; Zeidner, 1998). Worry is primarily a cognitive component centered on the consequences of failure (Zeidner, 1998). It is, therefore, associated with performance decrements. Highly test-anxious students have their attention diverted from the task at hand by distracting worry cognitions: withdrawing inward and activating negative self-talk, negative thinking, and other task irrelevant thoughts (Zeidner, 1998). On the other hand, low test-anxious students do not have their attention diverted and are better able to remain on task (Spielberger & Vagg, 1995; Zeidner, 1998). This means that for the high test-anxious student, worry erodes the ability to process relevant information and the ability to remain focused. This is because the working memory of an individual has a finite space; if this space is being used up by the representation of worry cognitions, it effectively retards the learner's chances of reaching his/her full potential (Lee, 1999). This is especially true of complex tasks that require language comprehension and reasoning–two areas essential to success in learning and applying mathematics (Hembree, 1990; Lee, 1999; Zeidner, 1998).

Emotionality, on the other hand, is primarily an affective component consisting of feelings of tension, apprehension, nervousness, and the associated physiological reactions attributed to the activation of the autonomic nervous system (Spielberger & Vagg, 1995).

The intensity of emotionality is a function of past experiences, which influences the degree of perceived threat. The degree of perceived threat is dependent on the sense of one's ability to cope with the testing situation (Spielberger & Vagg, 1995; Zeidner, 1998). In Spielberger's opinion, the ability to cope with a testing situation depends on numerous factors such as the type of test questions, aptitude in the subject area, and feelings of preparedness. Emotionality is therefore not as directly linked to performance decrements as is worry; however, both worry and emotionality contribute to the problem of performance deficits. According to Spielberger and Vagg (1995), the two are linked in the following manner: Test anxious individuals are susceptible to high levels of emotionality, which cause them to withdraw inwards. This, in turn, elevates the worry component thus effectively reducing their capability to perform to their full potential (Spielberger & Vagg, 1995). The process becomes self-fulfilling as it feeds upon itself regardless of which component is triggered first–i.e., emotionality $\Rightarrow$ increased worry $\Rightarrow$ greater emotionality or worry $\Rightarrow$ increased emotionality $\Rightarrow$ greater worry. Students find themselves in a destructive loop that can clearly impact their performance.

Math-Test Anxiety

Studies to determine the difference between math anxiety and test anxiety have not been conclusive. Williams (1994) found results suggesting that math anxiety and test anxiety are markedly consistent methods for measuring the same construct. Alexander & Martray (1989) suggested that apprehension about taking math tests should be the most salient feature of a revised definition of math anxiety. Kazelskis et al. (2000) also did not find strong support for a clear distinction between the two; however, they still are not prepared to say that math anxiety and test anxiety are one and the same. They feel that math anxiety is clearly multidimensional and that test anxiety alone is inadequate to describe it properly. The number of different math anxiety scales that exist and that obviously measure different dimensions, including test anxiety, provide evidence of this. According to Kazelskis (1998), future research into math anxiety must address this complexity; otherwise the conceptual uniqueness of math anxiety, and its distinction from test anxiety, cannot be further delineated and its measurement improved (Kazelskis, 1998; Kazelskis et al., 2000). We can conclude from this that math anxiety and test anxiety, although very similar, are not one and the same.

It is because of the lack of a clear distinction between math anxiety and test anxiety that this study will assume that math anxiety manifests itself as special type of test anxiety which will be referred to as math-test anxiety. It will therefore deal specifically with the worry and emotionality components of test anxiety as they are affected by mathematics. This means that both components can be affected by the host of negative feelings, apprehensions, and past experiences discussed in the math anxiety and test anxiety sections above and not just by a testing situation. This seems logical only in light of the following parallel properties of math anxiety and test anxiety: both are related to general anxiety; the anxiety levels regarding student ability, gender, and ethnicity are similar for both; both affect performance in similar ways; and both respond to the same treatment modes (Hembree, 1990).

Preparedness

What is preparedness? It certainly is not the same thing for everyone. But it does have some common underlying characteristics. Knowledge, for example, is critical to being well prepared for any test. It is common sense that without the knowledge of the material to be tested, the chances of scoring well on the evaluation are slim at best. But, knowledge is in the cognitive domain and cannot stand alone. What factors from the affective domain are responsible for the acquisition and use of that knowledge during a math test situation? According to Ma (1999), belief in one's ability and a positive attitude are two major elements in the affective domain of learning mathematics. These emotions spur the motivation to learn; therefore, understanding the factors in both the cognitive and affective domains is the key to understanding the main characteristics of preparedness.

The literature agrees that the attitude of the student is paramount to learning and performing in mathematics (Hebert & Furner, 1997; Kazelskis, 1998; Miller & Mitchell, 1994; Tobias, 1993). Hembree (1990) goes further and suggests that attitude may be the most important factor for success in mathematics. Regardless of its exact contribution to learning mathematics, it remains evident in the literature that the better a student's attitude is towards wanting to learn mathematics, the better his/her chances are for success (Hebert & Furner, 1997; Kazelskis, 1998; Miller & Mitchell, 1994; Tobias, 1993). Nonetheless, attitude, too, does not stand alone. Meaningful learning is critical to student understanding. Both Miller (1994) and Steele (1998) state that students must see the connection between what they are learning and its usefulness for true understanding to take place. These two factors, attitude and usefulness, comprise the main motivational aspect of preparedness.

In addition, self-efficacy is another element of the affective domain to be considered. In a study by House (2000), support was found showing self-belief, or one's measure of self-efficacy, is also related to performance. All this lends strength to Ma's (1999) statement that belief and attitude, with the addition of perceived usefulness, are major players in the understanding of what affects mathematical performance. Therefore, the relationship between the elements of attitude, usefulness, and self-efficacy and how they affect preparedness warrant further discussion.

If one starts by looking at attitude, there is little doubt that it affects self-efficacy and is affected by perceived usefulness. According to Aiken (1970), attitude clearly affects achievement and vice versa. Students with positive math attitudes have greater success and achievement than those students with negative attitudes. Success breeds success as confidence rises in the belief of being able to attain positive outcomes and the sense of control over one's environment improves (Wieschenberg, 1994). This need to control one's environment is strongly linked to past experiences, and it is critical to maintaining a positive self-efficacy in mathematics. Miller (1994) and Thorndike-Christ (1991) discuss how students with low self-efficacy quit sooner or do not try at all when working in mathematics, and students with high self-efficacy try harder and for longer periods of time.

However, in order for students to try harder and longer they must feel what they are learning is meaningful to them. Simply put, if the material is made meaningful, students will learn more effectively, and this, in turn, improves attitude (Aiken, 1970; Miller, 1994). Steele (1998) states that math needs to be useful for students or they will not see the connections to the real world. If students do not see and understand these connections then the opportunity for real learning is lost as they will rely solely on memorization. Memorization, of course, serves students less and less effectively as they climb the academic ladder (Steele, 1998). Therefore, we see that recognizing the usefulness of math helps understanding and improves attitude. This then relates directly to better achievement and self-efficacy, which in turn, relates to perceived usefulness and positive attitude.

On the other hand, failure can breed failure. Both Aiken (1970) and Wieschenberg (1994) discuss the problem of learned helplessness when unwanted outcomes are followed by further unwanted outcomes. These failures can produce negative attitudes that can eventually begin to feed upon themselves. It is interesting to note that research into the use of schemas to define the human processing of information has shown that students with low-complexity self-schema, in certain domains, may not be able to take in feedback that contradicts schema expectations (Lips, 1995). In other words, it may be very difficult, if not impossible, to help some students with little to no motivation and low self-efficacy in mathematics.

The elements of motivation and self-efficacy are interrelated in a circular fashion. In fact, it is more advantageous to see this relationship as a helix with an upward flow indicative of gaining more positive motivation and greater self-efficacy and a downward flow signifying more negative motivation and lower self-efficacy.

The factors of knowledge, self-efficacy, and motivation (with its two sub-factors of attitude and usefulness) provide a solid measure of the level of preparedness of a student before a math test. It is convenient to use the analogy that the factors of self-efficacy and motivation are bound together in a helix of development. A student winds up the helix with positive motivation and high self-efficacy, and he/she spirals down with negative motivation and low self-efficacy. In either direction, the factors feed upon themselves and are therefore self-fulfilling.

Chapter III

RESEARCH METHODOLOGY

The objective of this study was to determine the association between the level of preparedness a student reports, as defined by his or her motivation, self-efficacy, and knowledge, and his or her corresponding level of math-test anxiety. The study examined the relationship between being prepared for a math test and the math-test anxiety experienced before that test. The source of data is students engaged in the British Columbia high school curriculum in grades nine to twelve during the 2000/2001 school year.

The dependent variable in this study is the level of math-test anxiety experienced by students. The main independent variable is the level of preparedness a student feels he/she has attained before a math test. The variables hypothesized to comprise preparedness are knowledge, self-efficacy, and motivation–with motivation divided into the two factors of attitude towards mathematics and perceived usefulness of mathematics.

The research technique used in this study is a survey method based on a questionnaire (see Appendix B) where the majority of questions were comprised of items from various published instruments and one small section based on a self-efficacy guide. The questionnaire consists of multiple choice questions in Likert form. Data were analyzed using the SPSS 10.1 for Windows software package.

This chapter will describe the population and sample, the construction of the questionnaire, the pilot survey, and the method of analysis.

Sample and Survey Procedures

The sample of this study consists of a selection of high school students in grades nine to twelve enrolled in the British Columbia public school system. Although the sampling was not random, the large number of participating school districts gives reason to believe that a broad range of students has been surveyed. To gather data from around the province and because random sampling of the total population of high school students in British Columbia was beyond the resources of this study, volunteer mathematics teachers were solicited by email. In September and October 2000, a general email message (see Appendix D) looking for teachers willing to administer a short questionnaire to one of their classes was sent to approximately 1000 provincial math teachers on the PSA-BCMAT listserve. Via email and telephone, and through the process of gaining support from various districts, ten math teachers from eight school districts across the province agreed to administer the questionnaire to at least one of their math classes. Permission from the various school districts was gained from the appropriate individuals from each high school and the respective school board offices. The volunteer teachers agreed to administer a questionnaire to at least one of their math classes in grades nine to twelve. In early January of 2001, packages were sent to each teacher containing the instructions for the administration of the survey, 32 copies each of the consent form, the questionnaire, and the multiple choice Scantron sheets, as well as a self-addressed stamped envelope for the return of the survey. Regular post was used to send and receive the packages.

Teachers were asked to distribute a consent form to each student in a math class of their choice (see Appendix A). Once all consent forms were returned, the questionnaire was administered during a class that immediately preceded a math test–either on that same day or up to four days prior to the unit test depending on class scheduling and weekend periods. The questionnaire was administered to all students in the class who had signed parental consent. Students not wishing to participate were given curriculum-based math problems of an appropriate level to work on for 15-20 minutes. I supplied the curriculum-based math problems to each volunteer teacher. Each student answering the questionnaire attached his/her consent form to the Scantron sheet he/she used. No name or identification of any kind appeared on the Scantron sheets. Consent forms and Scantron sheets were then collected and given to a second adult: a counselor, administrator, or department head. Teachers were then asked to mark the test and provide the second adult with a class list including each student's test score and current class mark, both in percent. The second adult transferred these scores to the respective Scantron sheets and then separated the Scantron sheets and consent forms. Both piles, the consent forms and the unidentified Scantron sheets, were mailed back to me in the self-addressed, stamped envelope. Exactly two thirds of the questionnaires sent were returned (see Table 1)[1]. According to Dr. Alder, Chair of the Department of Psychology at the University College of the Cariboo, this is a very good response for this type of study (Dr. G. Alder, personal communication, July 8, 2001).

[1] Because there were not 32 students in any of the classes surveyed, the return is actually higher than two thirds (or greater than 67 percent).

TABLE 1: SAMPLE SIZE OF RESPONDENTS

Name of School District	Questionnaires Sent	Questionnaires Returned
School District 1	32	20
School District 2	64	45
School District 3	57	20
School District 4	170	97
School District 5	32	58*
School District 6	32	23
School District 7	64	40
School District 8	32	19
Total:	**483**	**322**

* The volunteer teacher of this district had identical Scantron response forms that he gave, along with the questionnaire, to another math teacher in his school for the collection of further data.

Development of the Questionnaire

From the beginning, one of the parameters set for the questionnaire was for it to have a completion time of approximately 15 minutes by an average student. I felt that this time period would encourage teacher participation as it should not overly disrupt the normal classroom proceedings. I also felt that it should ensure a greater number of accurately completed questionnaires as it was not an excessive amount of time to ask students to focus on a task.

As discussed in the literature review, preparedness is a function of motivation, self-efficacy, and knowledge. This means that to address the question proposed by this research, an instrument that measured math-test anxiety, attitude, perceived usefulness, self-efficacy, and knowledge needed to be constructed. The final questionnaire (see Appendix B) is comprised of various recognized and published instruments as well as a small number of items I composed that follow the guidelines set out in the *Guide for Constructing Self-Efficacy Scales* by Albert Bandura (1995). Dr. F. Pajares of Emory University gave these guidelines to me.

The questionnaire is designed in five parts: instructions and general questions, a math-test anxiety section, a math attitude section, a perceived usefulness of math section, and a math self-efficacy section. The general question section deals with basic questions such as gender, first language, last math course mark, etc. I wrote all the items in the general question section.

To measure math-test anxiety, the Test Anxiety Inventory (TAI) by Spielberger (1980) was adapted. It was modified to read specifically for math test situations by simply inserting the word *math* in front of the word *test* or *exam* in each item. Dr. Spielberger (personal communication, September 5, 2000) gave permission to use and modify his TAI instrument and stated that the changes made provide a good measure of both worry and emotionality experienced by students in a math test situation. The TAI was then reduced to 14 items from 20, seven that measure worry and seven that measure emotionality.

To measure attitude towards mathematics, the math attitude scale was taken from the Revised Math Attitude Scale by Aikens (1963). No changes were made with the exception of the reduction in the number of items from 20 to 14. Seven of these items reflect positive attitudes and seven reflect negative attitudes. A student's score on the 14 items combined will range somewhere on this scale of positive to negative.

To measure the perceived usefulness of mathematics, the math usefulness scale was taken from the set of nine scales by Fennema and Sherman (1986) constructed to measure different attitudes towards learning mathematics. No changes were made with the exception of the reduction of the number of items from 12 to 10. Five of these items reflect the usefulness of mathematics and five reflect uselessness. A student's score on the 10 items combined will range somewhere on the scale of usefulness to uselessness.

To measure self-efficacy, the self-efficacy scale was taken from the set of nine scales by Fennema and Sherman (1986); however, only the first ten questions came from the Fennema and Sherman confidence scale. Again, there were no changes made to these questions with the exception that number of items was reduced from the original 12 to 10. Five of these items measure higher confidence and five measure lower confidence in mathematical ability. I composed the remaining seven questions following the guidelines set out by Bandura (1995) and keeping in mind an overall consistency with the Fennema/Sherman scale. My questions are more math-test oriented. Four of these questions were written to reflect positive confidence in math test situations, and three were written to reflect negative confidence in math test situations.

Finally, students' knowledge was measured by taking into account their self-reported last math course marks, their current marks in the present course, and their marks on the test written directly after the questionnaire was administered.

As noted above, the sub-scales were taken from various recognized and published instruments. The exception to this were the last seven questions that relate specifically to self-efficacy in testing situations. Using the guidelines set out by Bandura (1995), I constructed these last seven questions. The following procedures were used to validate and pilot the questionnaire and to receive ethical approval:

1. During the construction and revision of the questionnaire, the following judges reviewed, considered, and commented on all or part of the questionnaire for the purpose of establishing validity.

   - Dr. Charles Spielberger: the Chairman of the Department of Psychology at the University of South Florida and Director of the Centre for Research in Behavioral Medicine and Health Psychology, Tampa, Florida.
   - Dr. Richard Kazelskis: a professor in the Department of Educational Leadership & Research at the University of Southern Mississippi, Hattiesburg, Mississippi.
   - Dr. Frank Pajares: an associate professor in the Department of Educational Studies at Emory University, Atlanta, Georgia.
   - Mr. Allen Rasmussen: a high school mathematics teacher for 23 years and Head of the Department of Mathematics at Merritt Secondary School, Merritt, BC.

2. A smaller pilot study ($n = 5$) was conducted to test for ease of readability and to identify any possible areas of confusion or misinterpretation.

3. A larger pilot study $(n = 42)$ was conducted to test for timing.

4. The questionnaire was then submitted to the University of British Columbia's Ethics Review Board for approval. Once the approval was given (see Appendix C), the questionnaire was sent as part of a package to the volunteer teachers for administration to their students.

Pilot Study

An initial pilot study was undertaken with five students chosen by simple random sampling from a sample frame of 117–the number of students enrolled in my classes in the autumn of 2000. The students ranged in grades from ten to twelve. This study was conducted to determine how easy the questionnaire was to read and to identify any problematic items. Each student was informally interviewed immediately after he or she completed the questionnaire to identify any areas that needed improvement. I destroyed these completed questionnaires after the interviews were conducted.

A second pilot study was undertaken with a total of 42 students. These students were not randomly chosen but were selected in groups ranging from grades ten to twelve. This pilot study was undertaken to determine the length of time required for different aged students to complete the questionnaire. Keeping a fifteen-minute window in mind, it was my intention to change the questionnaire radically if it was found to take too much time. All students finished the questionnaire between nine minutes and forty-five seconds to fourteen minutes and fifty-five seconds. I immediately destroyed these completed questionnaires as well.

Method of Analysis

The present study collected quantitative data via a questionnaire comprised of multiple choice questions in Likert form. These data were analyzed using the SPSS 10.1 for Windows software package at the University College of the Cariboo in Kamloops, British Columbia.

The data were entered into SPSS 10.1 for Windows by hand. A total of 322 high school students, 163 males and 159 females, answered the questionnaire that was comprised of 63 items. Two further pieces of data, the score on the test that followed the administration of the questionnaire and a current class mark, were also collected on each student. This provided 322 cases with 65 items per case, or just under 21,000 pieces of information. Each student's questionnaire, test score, and class mark was entered and immediately rechecked before the next entry to minimize errors. The 63 questionnaire items ranged in possible responses from 'a' through 'e,' and these were assigned the values of 1 to 5 respectively. Questions numbered 6, 23, 24, 27, 28, 30, 31, 33, 42-46, 52-56, and 61-63 were then re-coded in reverse order to correct their polarity. This was done because these questions were negatively stated. The individual scales were then summed, and this produced ranges for math-test anxiety from 14-70, for math attitude from 14-70, for math usefulness from 10-50, and for math self-efficacy from 17-85. The lowest number of each scale indicates that little to no amount of the variable is present, and the highest number reflects a maximum amount of the variable. The test and current class marks were entered as a percent score.

For the purpose of analysis, the SPSS 10.1 for Windows package was used. After the raw data were tabulated, Pearson correlation coefficients, multiple regression coefficients and independent samples t-tests were calculated. Confidence levels for statistically significant figures reported by the package were set at the $p < 0.05$ level.

Reliability of the individual scales and the overall questionnaire was calculated using Cronbach's Alpha model provided by the SPSS program. The range of Alpha runs from 0 to 1. The reliabilities of the different scales are listed in Table 2. As shown, the reliability

TABLE 2: RELIABILITY OF THE SUB-SCALES AND OVERALL SCALE

	0–1
Math Test Anxiety (14 items)	0.9224
Math Attitude (14 items)	0.9380
Math Usefulness (10 Items)	0.9091
Math Self-Efficacy by Fennema/Sherman (10 items)	0.9404
Math Self-Efficacy designed by the author (7 items)	0.8069
Math Self-Efficacy combined (17 items)	0.9382
All Scales Combined (55 items)	0.9193

of each sub-scale is high. The exception is the Math Self-Efficacy sub-scale designed by me, which has the lowest Alpha value at 0.81. This alone is a relatively good measure of reliability; however, when this scale is combined with the Self-Efficacy sub-scale designed by Fennema/Sherman, the reliability of the overall Self-Efficacy Scale is a superb 0.94. Dr. F. Pajares (personal communication, May 1, 2001) agrees that I have strong reliability figures and therefore noted that I have a reliable measure of self-efficacy. These values indicate that the two sub-scales fit well together. The overall reliability is a very solid 0.92, another indication that each sub-scale meshes well in the overall questionnaire.

For face and content validity of the questionnaire, Dr. C. Spielberger was contacted about his Test-Anxiety Inventory and my adaptations. As noted above, he stated my changes would provide a good measure of math-test anxiety (Spielberger, personal communication, September 5, 2000). Dr. E. Fennema was contacted about her and Dr. I. Sherman's Math Usefulness and Math Self-Efficacy Scales. She noted that these scales should suit my needs (Fennema, personal communication, October 24, 2000). Dr. F. Pajares was contacted about Self-Efficacy Scales and their construction as noted above. Dr. R. Kazelskis was contacted about Math and Test Anxiety scales in general. He stated that for my research the changes I made to the Test Anxiety Inventory were appropriate (Kazelskis, personal communication, November 8, 2000). Moreover, Mr. A. Rasmussen, a BC high school mathematics teacher with 23 years experience, reviewed the entire questionnaire. He also affirmed that the items on the questionnaire were well suited to the objectives of the research–especially the addition of the questions that I constructed. With the exception of the seven questions that I constructed, strong content validity is present because these scales are instruments created by professionals who are experts in their field of research. Each test was constructed to measure what it is purporting to measure as established by these researchers, their research, and their results. No changes from the original were made to the wording of any question except for the items in the math-test anxiety scale. Again, as stated above, Dr. Spielberger stated that the changes made to his Test Anxiety Inventory were appropriate for my research (Spielberger, personal communication, September 5, 2000).

Missing Data

Missing data were assigned various values: nine, if it were data from question numbered three and should have been left blank; eight, if it were data from a question where two responses were mistakenly recorded; or minus one, if it were data from questions that were not answered or data not provided by the volunteer teachers, such as test or class mark. A missing or incorrectly recorded datum was dealt with by excluding it from the analysis.

Chapter Summary

The research technique used in this study was a survey method based on a questionnaire where the majority of questions were comprised of items from various published instruments and one small section based on a self-efficacy guide.

The sample of this study consists of a selection of high school students in grades nine to twelve enrolled in the British Columbia public school system.

Ten math teachers from eight school districts across the province agreed to administer the questionnaire to at least one of their math classes. Exactly two thirds of the questionnaires were returned.

Very good reliability figures were attained for each sub-scale, and the overall reliability of the questionnaire was 0.92. Good content validity is present for the recognized and published sub-scales, and good face validity is present for the small section that I wrote.

Pearson correlation coefficients, multiple regression coefficients, and independent samples t-tests were calculated for the data in this study. Confidence levels for statistically significant figures reported by the software package were set at the $p < 0.05$ level. A missing or incorrectly recorded datum was dealt with by excluding it from the analysis.

Chapter IV

ANALYSIS OF THE DATA

To gather data for the present study, volunteer teachers from across British Columbia administered a questionnaire to at least one of their math classes. The quantitative data were analyzed using the Pearson correlation coefficient, multiple linear regression, and independent samples t-tests on SPSS 10.1 for Windows. This chapter consists of the one main section discussing data analysis.

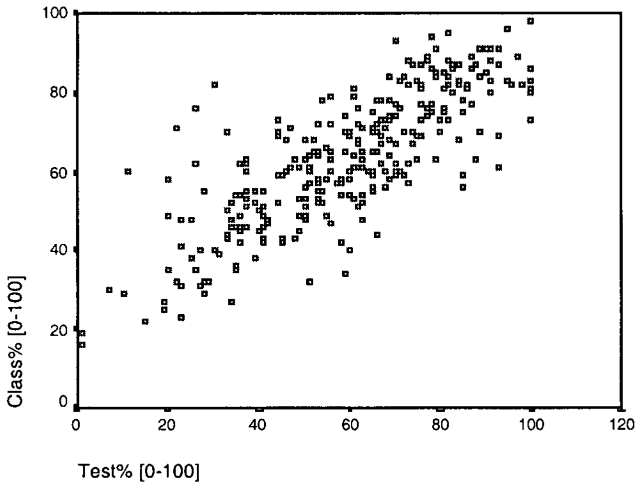
Data Analysis

I have a concern with the current class mark data in that 25 of the 322 cases are missing this information. This alone may not seem cause for concern; however, the missing data are not randomly distributed. Twenty-three of the 25 pieces of missing data are from one class which had the following test scores: eight, 100% scores; seven, 97% scores; four, 94% scores; three, 91% scores; and one, 82% scores. These marks are exceptionally high and specific to one group of the data. Missing these non-random and special cases does not fully represent the data. As shown in Table 3, the Pearson correlation coefficient between student test scores and class marks is the highest correlation among any two variables being considered at 0.79. Scatter plot 1 graphically shows this correlation and its linear relationship.

TABLE 3: PEARSON CORRELATION BETWEEN TEST SCORES AND CLASS AVERAGES

		Class Percent
Test Percent	Pearson Correlation	0.789
	Significance	0.001
	N	297

<u>SCATTER PLOT 1: CLASS PERCENT VERSUS TEST PERCENT</u>



This positive correlation shows that higher student test scores are clearly associated with higher class marks. Further to this, Pearson correlation coefficients were calculated between math-test anxiety and both test scores and class marks. As shown in Table 4, the correlation produced scores of -0.35 and -0.33 respectively, and they are statistically significant at the $alpha = 0.05$ level. This is, therefore, an indication that, of the data present, both test scores and class marks give similar results, and they relate to math-test anxiety in similar ways. In addition to this, because 23 of these 25 observations are from

<u>TABLE 4: CORRELATION OF MATH-TEST ANXIETY WITH TEST AND CLASS *PERCENTS*</u>

		Test Percent	Class Percent
Math-Test Anxiety	Pearson Correlation	-0.353	-0.327
	Significance	0.001	0.001
	N	310	285

one particular class, their absence changes the nature of the class percent sample. According to the positive correlation found above, this change would manifest itself in 23 higher class marks being added. This would only serve to strengthen the correlation between class and test percents if they were included. It is also logical that the knowledge of the material students are to be tested on is most relevant to their feelings on math-test anxiety at the time they are to be tested. In other words, test percent is the better indication of knowledge compared to class percent when considering math-test anxiety. In view of these considerations, class percent was removed from the analysis of the data because the test score alone provides a good measure of both.

Pearson correlation coefficients were calculated between each independent variable of interest (i.e., math attitude, perceived math usefulness, math self-efficacy, test score, last course mark, first language, and sex) and the dependent variable of math-test anxiety. Table 5 displays these coefficients along with their statistical significance and n.

TABLE 5: PEARSON CORRELATION COEFFICIENTS WITH MATH-TEST ANXIETY

	N	r	rsquare	Significance
Gender	293	0.096	0.009	0.051
First Language	293	-0.043	0.001	0.234
Last Course Mark	293	-0.278	0.077	0.001
Test Percent	293	-0.338	0.114	0.001
Math Attitude	293	-0.489	0.239	0.001
Math Usefulness	293	-0.173	0.030	0.001
Math Self-Efficacy	293	-0.445	0.198	0.001

A number of items of interest are immediately apparent. The first item is the correlation of -0.489 for math-test anxiety and math attitude and -0.445 for math-test anxiety and math self-efficacy. These are the highest correlation coefficients with math-test anxiety and are, thus far, showing the strongest relationships present in the data. The second item is the statistical significance ($p = 0.234$) of the correlation between math-test anxiety and first language. This figure is not statistically significant at the *alpha* = 0.05 level. This indicates that the low correlation coefficient of -0.043 could easily be present by chance. For this reason, the variable of first language will be removed from this analysis. This is unfortunate because the low correlation coefficient would indicate that for these data there is little association between the two variables of math-test anxiety and first language. However, since it is most likely that this has happened by chance, the question remains as to what levels of math-test anxiety do ESL students experience. The third item is the statistical significance ($p = 0.051$) of math-test anxiety and gender. Although this figure also does not meet the *alpha* = 0.05 standard, it is too close to this level not to consider it in the analysis of the data. Therefore, this variable will remain for further consideration.

To test the first hypothesis, the association between math-test anxiety and preparedness, a stepwise regression was undertaken with math-test anxiety as the dependent variable and sex, last course mark, test percent (knowledge), math attitude, math usefulness, and math self-efficacy as the independent variables. The stepwise regression entered math attitude and test percent and removed the rest of the variables for its model of best fit. As shown in Table 6, it produced a multiple $R = .512$, and an $Rsquare = .262$ for the data. When SPSS

TABLE 6: INITIAL REGRESSION (DEPENDENT VARIABLE: MATH-TEST ANXIETY)

Model	N	R	R Square
1. Math Attitude	293	0.489	0.239
2. Math Attitude and Test Percent	293	0.512	0.262

calculates a stepwise regression, the software provides a number of models equal to the number of variables it enters in the regression. The first model uses the independent variable with the strongest association with the dependent variable. The second model then adds the independent variable with the second strongest association and so forth.

In the analyses of these data, see Table 7, model one consists of the dependent variable math-test anxiety and the independent variable math attitude. Model two then adds the independent variable of test percent to the regression. When examining the excluded variables in model one and model two, we see that the statistical significance of math self-efficacy changes from slightly under the $alpha = 0.05$ standard at $p = 0.03$ to slightly over the standard at $p = 0.08$.

Given the significance figures alone, I am inclined to agree with the software that math self-efficacy could be removed; however, I am not prepared to remove math self-efficacy from the regression analysis. The literature clearly shows that math self-efficacy has a bearing on student learning and achievement. As discussed in the literature review in Chapter II, it is too important to discard. It is also worth noting that model one has both

TABLE 7: SOME EXCLUDED VARIABLES FOR THE INITIAL REGRESSION

Model	Excluded Variables	N	regression coefficient	t	Significance
1. Math Attitude	Test Percent	293	-0.174	-3.010	0.003
	Math Self-Efficacy	293	-0.125	-2.138	0.033
2. Math Attitude and Test Percent	Math Self-Efficacy	293	-0.103	-1.758	0.080

test percent and math self-efficacy as excluded values and both are statistically significant at the $alpha = 0.05$ level. Even though test percent has a p value that is lower than the p

value of math self-efficacy ($p = 0.003$ compared to $p = 0.03$), it is somewhat unclear, at this time, as to why the software chose to include one and not the other in the second model. Further to this, probably the most compelling reason not to exclude math self-efficacy from the analysis is that it has the second highest Pearson correlation coefficient with math-test anxiety at $r = -0.445$ (see Table 4). For these reasons, math self-efficacy was re-entered into a regression analysis along side test percent and math attitude.

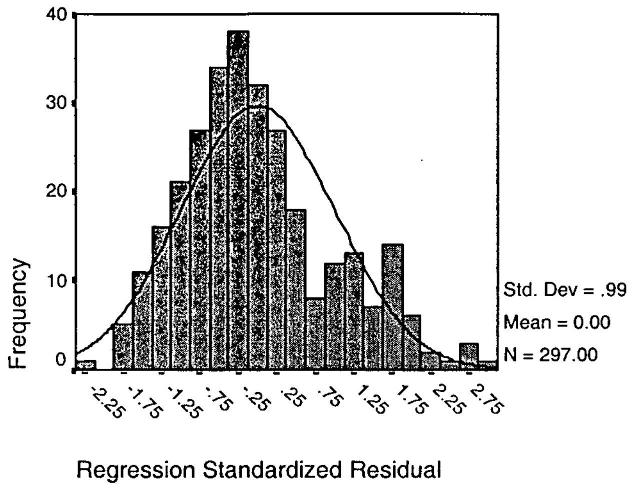
A second linear regression analysis was done with math-test anxiety as the dependent variable and math attitude, math self-efficacy, and test percent as the independent variables (see Table 8). It produced a multiple $R = 0.531$ and an $Rsquare = 0.282$ for the data.

TABLE 8: SECOND REGRESSION (DEPENDENT VARIABLE: MATH-TEST ANXIETY)

Model	N	R	R Square	F	Significance
1. Math Attitude	297	0.498	0.248	97.199	0.001
2. Math Attitude and Test Percent	297	0.522	0.272	55.053	0.001
3. Math Attitude, Test Percent and Self-Efficacy	297	0.531	0.282	38.268	0.001

According to Dr. C. Spielberger (personal communication, April 30, 2001), these are respectable values when dealing with human subjects[2]. It is also worth noting that the residuals are normally distributed in that they have one peak and two tails as shown in Histogram 1. This is encouraging because if the residuals were not normally distributed, then the analysis for the data would carry less strength.

[2] Because of Dr. Spielberger's comments, a coefficient value of 0.50 for both correlations and linear regressions was used as a guideline for attaining good results throughout the analysis of this data.



HISTOGRAM 1: FREQUENCY VERSUS REGRESSION STANDARDIZED RESIDUALS

In light of the results of this regression, the null hypothesis is rejected. There is strong evidence ($R = 0.531, RSquared = 0.282$ and $p < 0.05$) that preparedness before a test, as measured by a student's attitude, knowledge, and self-efficacy only, is significantly correlated with math-test anxiety. The linear equation that describes this regression is

$y' = 49.69 - 0.244(Attitude) - 0.069(Test\%) - 0.107(SelfEfficacy)$

As table 9 shows, it now becomes apparent why the stepwise regression analysis removed math self-efficacy. The p value for math self-efficacy in model three is $p = 0.056$, which is above the $alpha = 0.05$ level and is, therefore, no longer statistically

TABLE 9: SIGNIFICANT FIGURES FOR SECOND REGRESSION

Model		N	regression coefficient	t scores	part correlation	significance
1	Math Attitude	297	-0.498	-9.859	-0.498	0.001
2	Math Attitude	297	-0.428	-7.878	-0.392	0.001
	Test Percent	297	-0.172	-3.155	-0.157	0.002
3	Math Attitude	297	-0.318	-4.027	-0.199	0.001
	Test Percent	297	-0.156	-2.850	-0.141	0.005
	Math Self-Efficacy	297	-0.151	-1.921	-0.095	0.056

significant. The previous analysis did not show this result in this manner because math self-efficacy was excluded from the model. However, whether or not math self-efficacy should be kept in the analysis becomes somewhat of a moot point in light of its contribution to the model. This is because, as Table 8 shows, math self-efficacy has added only 0.009 to the multiple regression value of $R = 0.531$ in the third model. The overall addition to the Rsquare value, or the percent of the variance that this model accounts for, is almost negligible at 0.000081. Simply put, it is not a major component when looking at the association between preparedness and math-test anxiety. However, even in light of its small contribution to the model, I kept math self-efficacy in this analysis because of its importance in the literature, its stronger correlation coefficient of -0.445 with math-test anxiety, its statistical significance (only 0.006 from the $alpha = 0.05$ level), and because the regression model as a whole is statistically significant. Knowledge (as described by the test percent) fared a little better in that it was statistically significant, but it too did not add significantly to the multiple regression value. Knowledge added only 0.024 to the value of $R = 0.531$, and 0.000576 to the Rsquare value of 0.282. The results clearly show that the most important factor associated with math-test anxiety was math attitude because it has a multiple regression value of almost 0.50 on its own ($R = 0.498$). This gives math attitude an Rsquare value of 0.248. It is more advantageous, however, to look at the square of the part correlations of these variables given in Table 9. Math attitude had a squared part correlation $(-0.199)^2 = 0.040$, twice that of test percent which had the next highest squared part correlation $(-0.141)^2 = 0.020$. These part correlations indicate that math attitude had the largest unique contribution to the model and that this contribution was twice that of the next highest contributing variable. Therefore, the most significant factor in the association between test preparedness and math-test anxiety is math attitude.

With regards to the second hypothesis, the association between math-test anxiety and performance, a correlation coefficient was calculated as shown in Table 4. The Pearson correlation analysis produced a coefficient of -0.353 and is statistically significant at the $alpha = 0.05$ level. Therefore, the second null hypothesis was rejected and an association between the variables can be said to exist. However, it should be remembered that a correlation coefficient of -0.353 is only a moderate association as it falls short of the coefficient value of over 0.50 found in the previous analysis. Therefore, there is only moderate evidence ($r = -0.353$, $rsquare = 0.125$ and $p < 0.05$) that performance is significantly correlated with math-test anxiety.

To test for the third hypothesis, the association between preparedness for a math test and previous success in a math course, a third multiple regression analysis was done. The last course mark was used as an indicator of success and was entered in the calculation as the dependent variable. As Table 10 shows, the analysis produced a multiple $R = 0.518$ and an $RSquare = 0.258$ for the data.

TABLE 10: THIRD REGRESSION (DEPENDENT VARIABLE: LAST MATH COURSE MARK)

Model	N	R	R Square
1. Attitude, Test Percent, Usefulness and Self-Efficacy	302	0.518	0.268

However, not all the variables are statistically significant as shown in Table 11. Because math attitude and math usefulness both had probabilities that did not meet

TABLE 11: SIGNIFICANT FIGURES FOR THE THIRD REGRESSION

Model 1	N	regression coefficient	t score	significance
Test Percent	302	0.292	5.324	0.001
Math Attitude	302	0.095	1.143	0.254
Math Usefulness	302	0.043	-0.748	0.455
Math Self-Efficacy	302	0.263	3.348	0.001

the $alpha = 0.05$ criteria, they were removed from this analysis. A fourth regression analysis was then undertaken with only the two independent variables of test percent and math self-efficacy. As shown in Table 12, this analysis produced a model with a multiple $R = .521$ and an $RSquare = .271$ for the data. It also produced an $F = 56.716$ which is statistically significant.

TABLE 12: FOURTH REGRESSION (DEPENDENT VARIABLE: LAST MATH COURSE MARK)

Model 1	N	R	R Square	F	Significance
Test Percent and Self-Efficacy	308	0.521	0.271	56.716	0.001

As a result, the third null hypothesis was rejected. Therefore, there is strong evidence ($R = 0.521, Rsquare = 0.271$ and $p < 0.05$) that a student's knowledge (test percent) and self-efficacy are significantly correlated with his or her last math course mark.

This analysis also addressed the fourth hypothesis that dealt with the association between a student's last math course mark and his/her performance on a math test. The previous analysis indicated that there exists an association between the two variables. A Pearson correlation coefficient provides more information. Table 13 shows the coefficient value of 0.409 for the variables and that it is statistically significant at the $alpha = 0.05$ level. Again, the null hypothesis was rejected, and it can be said that a statistically

TABLE 13: PEARSON CORRELATION BETWEEN LAST COURSE MARK AND TEST PERCENT

		Test Percent
Last Math Course Mark	Pearson Correlation	0.409
	Significance	0.001
	N	321

significant association between the variables exists. However, similar to the correlation coefficient between math-test anxiety and performance, this coefficient is below the benchmark of 0.50 being used for the analysis of this data. Therefore, there is only moderate evidence ($r = 0.409$, $rsquare = 0.167$ and $p < 0.05$) that a student's performance is significantly correlated with his or her last math course mark.

To determine the relationship between the variables considered in the fifth hypothesis, those of first language and math test preparedness, an independent-samples t-test was conducted as shown in Table 14. In this association only test percent and math attitude have values that are statistically significant at the $alpha = 0.05$ level. Both math usefulness and math self-efficacy were not considered further because their probabilities

TABLE 14: INDEPENDENT SAMPLES T-TEST: FIRST LANGUAGE

		Equality of Means			
		N	t	d*	Significance
Test percent	Equal variance not assumed	278	-2.817	0.526	0.007
Math Attitude	Equal variance not assumed	275	-3.322	0.490	0.003
Math Usefulness	Equal variance not assumed	269	0.101	0.019	0.92
Math Self-Efficacy	Equal variance not assumed	277	-1.794	0.279	0.078

* For the effect size *d*, the weighted standard deviation was used.

do not meet the $alpha = 0.05$ criteria. Table 15 displays the means and standard deviations for the t-test analysis. It shows that the means for both test percent and math attitude are higher for students whose first language is not English. This is of interest because again we see math attitude playing an important role in mathematics.

TABLE 15: GROUP STATISTICS THE INDEPENDENT SAMPLES T-TEST: FIRST LANGUAGE

	First Language	N	Mean	Standard Deviation
Test percent	English	278	60.331	21.769
	Not English	44	72.114	26.364
Math Attitude	English	275	39.946	12.795
	Not English	44	46.114	11.203

As discussed earlier in Chapter II, research has demonstrated that attitude is associated with performance. Here the analysis revealed ESL students had better attitude and better performance compared to those students who have English as a first language. In further support of this, it is also interesting to note the standard deviations of the different samples. Although there is more variation in the mean of ESL students' test percents than in the Native-English speaking students, as shown in Table 15, the values of 26.4 and 21.8 respectively are not too different. The standard deviations of the math attitude scores were very similar at 11.2 for ESL students and 12.8 for English students. This indicates that each sample reacted in a similar manner around their respective measures of central tendency. These results lead to the rejection of the null hypothesis. Therefore, as shown in Table 15, there is evidence that performance ($t = -2.817$, $d = 0.526$ and $p < 0.05$) and math attitude ($t = -3.322$, $d = 0.490$ and $p < 0.05$) are significantly correlated with first language. This correlation has revealed that ESL students have better attitudes and performance.

The sixth hypothesis is concerned with the association between first language and math-test anxiety. In light of the importance of math attitude emerging from the data, it will be interesting to see if ESL students will also have lower anxiety than their Native-English speaking counterparts. This is in consideration of the fact that non-English students have better overall attitudes towards mathematics, that attitude is the main component of lower anxiety, and that lower anxiety is associated with better performance. To determine this, an independent-samples t-test was conducted. Tables 16 and 17 contain the values calculated for the t-test.

TABLE 16: STATISTICS FOR THE INDEPENDENT SAMPLES T-TEST: FIRST LANGUAGE

	First Language	N	Mean	Std. Deviation
Math-Test Anxiety	English	269	29.7138	9.9027
	Not English	41	28.0488	8.7263

TABLE 17: INDEPENDENT SAMPLES T-TEST: FIRST LANGUAGE

		t-test for Equality of Means	
		t score	Significance
Math-Test Anxiety	Equal variances assumed	1.018	0.310

The t-test value is not statistically significant as it failed the $alpha = 0.05$ criteria at $p = 0.310$. The sixth null hypothesis, therefore, cannot be rejected. The present values are likely present by chance. Therefore, there is no evidence ($t = 1.018$ and $p = 0.310$) that first language is significantly correlated with math-test anxiety.

The seventh and final hypothesis explored the relationship between test preparedness and gender. An independent samples t-test was done with gender and the variables of preparedness (as shown in Tables 18 and 19): attitude, usefulness, self-efficacy and knowledge. The variables of test percent, math attitude, and math usefulness are not

TABLE 18: GROUP STATISTICS FOR THE INDEPENDENT SAMPLES T-TEST: GENDER

	Sex	N	Mean	Std. Deviation
Test Percent	Male	163	60.39	24.40
	Female	159	63.53	20.92
Math Attitude	Male	162	41.5432	12.5040
	Female	157	40.0255	12.9950
Math Usefulness	Male	161	38.1863	8.3899
	Female	157	38.5669	7.5484
Math Self-Efficacy	Male	154	58.2078	12.9915
	Female	155	52.5419	14.0043

TABLE 19: INDEPENDENT SAMPLES T-TEST: GENDER

		Equality of Means		
		t score	d*	Significance
Test Percent	Equal variances assumed	-1.241	0.138	0.215
Math Attitude	Equal variances assumed	1.063	0.119	0.289
Math Usefulness	Equal variances assumed	-0.425	0.048	0.671
Math Self-Efficacy	Equal variances assumed	3.686	0.420	0.001

* For the effect size *d*, the weighted standard deviation was used.

significant at the $alpha = 0.05$ level. Only math self-efficacy is statistically significant. The variables of test percent, math attitude, and math usefulness were removed from further analysis. Table 20 contains only the means and standard deviations for the two groups of gender and math self-efficacy taken from Table 18. It shows that females have lower self-efficacy scores compared to males. The standard deviations are very similar at 13 for the male group and 14 for the female group. Similar to the results found in the t-test on first language, these figures are an indication that math self-efficacy and gender react in

TABLE 20: STATISTICS FOR THE INDEPENDENT SAMPLES T-TEST: GENDER

	Sex	N	Mean	Standard Deviation
Math Self-Efficacy	Male	154	58.208	12.991
	Female	155	52.542	14.004

similar ways around their measures of central tendency for males and females. These results lead to the rejection of the null hypothesis. Therefore, there is evidence that math self-efficacy ($t = 3.686$, $d = 0.420$ and $p < 0.05$) is significantly correlated with gender. This result indicates that high school females tend to have lower levels of math self-efficacy than do high school males.

Chapter Summary

Twenty-five of the 322 cases of the up-to-date class marks were missing from the data. Twenty-three of these 25 cases were from one class of students that scored exceptionally well on their tests. An analysis showed that test score alone provided a good measure of both test and class percent. Therefore, class percent was removed from the analysis of the data.

The correlation coefficients of -0.489 for math test anxiety and math attitude, and -0.445 for math-test anxiety and math self-efficacy, were the highest correlation coefficients with math-test anxiety.

A linear regression analysis was done with math-test anxiety as the dependent variable and the factors of preparedness (math attitude, math self-efficacy, and test percent) as the independent variables. It produced a multiple $R = 0.531$, an $Rsquare = 0.282$, and $p< 0.05$ for the data, and this lead to the rejection of the primary null hypothesis. There is strong evidence that preparedness before a test, as measured by a student's attitude, knowledge, and self-efficacy only, is significantly correlated with math-test anxiety. This analysis also revealed that the most significant factor in the association between math-test anxiety test and test-preparedness was math attitude.

Moderate evidence ($r = -0.353$, $rsquare = 0.125$ and $p < 0.05$) was found that performance is significantly correlated with math-test anxiety.

Strong evidence ($R = 0.521, Rsquare = 0.271$ and $p < 0.05$) was found that a student's knowledge and self-efficacy are significantly correlated with his or her last math course mark.

Moderate evidence ($r = 0.409$, $rsquare = 0.167$ and $p < 0.05$) was found that a student's performance is significantly correlated with his or her last math course mark.

There is evidence that performance ($t = -2.817$, $d = 0.526$ and $p < 0.05$) and math attitude ($t = -3.322$, $d = 0.490$ and $p < 0.05$) are significantly correlated with first language. This correlation revealed the ESL students have better attitudes and higher performance in mathematics.

There is no evidence ($t = 1.117$ and $p = 0.269$) that first language is significantly correlated with math-test anxiety.

There is evidence that math self-efficacy ($t = 3.686$, $d = 0.420$ and $p < 0.05$) is significantly correlated with gender. This correlation revealed that female students have lower math self-efficacy.

Chapter V

SUMMARY, DISCUSSION AND CONCLUSION

Chapter V summarizes the purpose, methodology, and findings of this study. It also interprets these results, discusses the implications for educators, and makes suggestions for future research.

Summary and Discussion

There were seven hypotheses, one primary and six secondary, that this study was interested in exploring. Stated as null hypotheses, they were the following:

1. Null Hypothesis: Students' self-reported preparedness for math tests is not correlated significantly with their scores on the math-test anxiety inventory.
2. Null Hypothesis: Students' performance on math tests is not correlated significantly with their scores on the math-test anxiety inventory.
3. Null Hypothesis: Students' preparedness before a math test is not correlated significantly with their success in their last math course.
4. Null Hypothesis: Students' performance on a math test is not correlated significantly with their last math course mark.
5. Null Hypothesis: Students' preparedness is not correlated significantly with whether or not their first language is English.
6. Null Hypothesis: Students' math-test anxiety, as measured by the math-test anxiety inventory, is not correlated significantly with whether or not their first language is English.
7. Null Hypothesis: Students' self-reported preparedness is not correlated significantly with gender.

Statistically significant values were found for all except the sixth hypothesis. Statistically significant figures were not found between the two groups of English and ESL students and math-test anxiety. I fully expected to find that ESL students would have had higher math-test anxiety. I expected this simply because in my mind, it must be more difficult to learn an abstract subject in a language in which one is not fully comfortable. I believed that this would heighten ESL students' math-test anxiety. However, in light of the correlation of positive math attitude and lower math-test anxiety and the fact that the ESL group had better math attitudes, I now wonder what levels of anxiety are truly present between the two groups. The math-test anxiety mean score for ESL students was slightly lower at 28.05 than it was for English students which was at 29.71: a mean difference of only 1.67. Although the data for this hypothesis were not statistically significant, it would seem reasonable, given that ESL students have better attitude and performance, that ESL students would also have lower math-test anxiety.

ESL students who are from abroad pose a problem in interpreting the data. Foreign students pay a premium to attend classes in this country. As stated Chapter II, the socioeconomic factor differentiates the top third of schools from the bottom third (Joshi, 1995; Pungello, 1996). If this holds true in foreign countries, and I see little reason why it would not, then only students from more affluent families, and therefore, with a better education and greater support, are provided the opportunity to come to Canada. It is more likely that these students are already doing well in school, in terms of success, efficacy and attitude, and they may suffer less math-test anxiety.

The seventh hypothesis, which looked at the association between preparedness and gender, found that only math self-efficacy was statistically significant. It would have been informative to see which group had higher attitudes, knowledge and perceived usefulness scores, but these associations were not statistically significant. As it is, it can only be said with some certainty that females see themselves as slightly less capable of successfully completing math tests compared to males. This echoes what has already been found in the literature in terms of female mathematical self-conception (Campbell & Evans, 1997).

When considering the fifth hypothesis (i.e., the association between first language and test preparedness), it is interesting that math attitude and performance are so closely linked in terms of their behavior in the data. The similar variations in the standard deviations of the two groups of English and ESL students implies that each is affected in similar ways. The analysis indicates that the non-English group has significantly better attitudes towards mathematics and that they perform significantly better on math tests. However, there may be a problem with this data that needs to be explored: its validity has been brought into question. It was not until sometime after I had collected the data that I found a problem with the wording of the question that deals with first language. The concern that I have is that it does not take into account students whose first language is English but who may not have been educated in English. All the classes where my questionnaire was administered were taught in English. However, there are a couple of students in my class, for example, who were taking math for the first time in English because they were French Immersion students. This could not be reflected in the data simply because my questionnaire fails to address this issue. I am unsure how this data, if properly collected, would affect the results obtained here. Because of this, the conclusions about first language need to be cautiously considered.

A negative correlation was found for the second hypothesis, the association between math-test anxiety and performance. A negative correlation indicates an inverse variation association between the variables. For the second hypothesis, this means that as math-test anxiety decreases, student performance increases and vise versa. Causality can not be inferred with a correlation. It might seem reasonable that math-test anxiety would cause poor performance on a test and not the reverse. But, this may not be entirely true. It only seems logical that a student's knowledge that he/she is performing poorly during a test could conceivably exacerbate his/her level of math-test anxiety. It also must be remembered that a correlation coefficient of -0.353 is not considered to be a strong association between the variables, because it accounts for only 13 percent of the variance. Clearly, there are other factors at play here that were not measured by the instrument used in this study. In general, however, there was an association found in the data that indicates as a student's math-test anxiety decreases, his/her performance increases.

The same, in terms of the strength of the association, can be said about the fourth hypothesis–the correlation between last math course mark and performance. A positive correlation indicates a direct variation association between the variables. In this case, it was found that students with higher last math course marks tended to do better on the math test that followed the administration of the questionnaire. The correlation coefficient of 0.409 between the variables of last math course mark and performance also falls short of a 0.50 guideline. It accounts for less than 17 percent of the variance present between the variables. Therefore, although only a moderate association between the variables exists, in general, the higher a student's last math course mark the higher his/her test score was for this sample.

The third hypothesis looked at the association between a student's last math course mark and his/her preparedness. It was found that the variables of test percent and math self-efficacy were the only two that were statistically significant. The regression produced a multiple $R = 0.521$. This is a stronger measure of correlation as it accounts for over 27 percent of the variance between the variables. The variable of test percent in this analysis comes as no surprise in light of the discussion in the previous paragraph on the fourth hypothesis. Math self-efficacy, on the other hand, is an interesting addition because it indicates that a student's last math course mark is also associated with a student's confidence in successfully completing a math test. It was found that students with higher last math course marks have stronger self-efficacy and better performance on tests than do students with lower last math course marks.

The primary hypothesis, which looked at the association between math-test anxiety and test preparedness, produced a multiple $R = 0.531$ and was statistically significant at the $p < 0.05$ level. This accounts for more than 28 percent of the variance between the variables and is above the Spielberger's guideline coefficient value of 0.50. These results imply that students who tend to feel better prepared in terms of math attitude, self-efficacy, and knowledge tend to have lower math-test anxiety. The results also show that math attitude contributes twice as much to the regression analysis compared to the next highest contributing variable in test preparedness.

Three out of the four variables defining the concept of test preparedness outlined in Chapter II were entered into the regression. Of these three variables, math attitude and test percent were statistically significant at the $p < 0.05$ level, and math self-efficacy was slightly over this level at $p = 0.056$. Only perceived math usefulness was clearly below the $p < 0.05$ level; therefore, it was removed from the analysis. It is curious that each of the four variables used to define preparedness has figured somewhere in the analysis of the data except math usefulness. I cannot believe that this sub-scale has no bearing here because of the importance it holds in the literature (Miller, 1994; Steele, 1998). However, on reflection, it may be that I have incorrectly interpreted the concept of meaningful learning, as found in the literature, as synonymous with usefulness. This would seem to be a logical conclusion because of the lack of statistical significance that perceived math usefulness has had in the analysis. A closer look at the articles by Miller (1994) and Steele (1998) and their use of the concept of meaningful learning now reveals to me that their use of *meaningful*, although similar, is not interchangeable with *useful*. Both authors are more concerned with the immediate connection of mathematics with what students see in the world around them than they are about potential benefits math may or may not hold for students in the future. Unfortunately, I chose a scale that clearly measures more of what students feel math can provide for them in the future than what connections students are presently making between math and the world around them. I believe it is because of this emphasis on the future potential of mathematics, and the lack of emphasis on present day connections, that this scale is improperly measuring meaningfulness, as the term is defined in the literature. For this reason, it is my inference that this scale is not completely suited to the research objectives set out in this study. Therefore, it did not provide us with a good opportunity to add to the findings on math-test anxiety and test preparedness that have already been found here.

Implications for Educators

This study extends current knowledge on math-test anxiety. As mentioned in Chapter I, if this study were to find a negative correlation between preparedness and math-test anxiety, then, armed with this information, educators could inform, encourage, and support students in their efforts to prepare for evaluations knowing the benefits that being prepared can provide. This negative correlation has been found.

The most important finding, however, is the strong indication that a positive attitude is critical to students with lower math-test anxiety. It may come as no surprise to the reader that attitude has emerged as the paramount variable, in the association between test preparedness and math-test anxiety, given its relevance to learning in general. But, its eclipse of the other two variables in this data, knowledge and self-efficacy, has some clear implications for teachers of mathematics. We, as educators, must find ways to improve the attitudes of those students who have negative outlooks on mathematics, and we must endeavor to help maintain the better attitudes of those students who have positive outlooks. One of the most harmful disservices a teacher can do is to feign enjoyment of, or show outright distaste for, a subject that is becoming more and more of a gatekeeper to the careers of young adults (Miller, 1994; Shawyer, 1985). Steele (1998) states that teachers' attitudes towards mathematics can have tremendous influence on students' attitudes. Students are perceptive and, therefore, they need to see mathematics instructors who are engaging, genuinely interested in the subject, and compassionate to their frustrations. They need instructors who lead by example and who can celebrate their accomplishments.

I do feel, however, that helping to maintain positive attitudes towards mathematics, or improving those that are poor, is almost impossible without the help of parents. As discussed in Chapter II, parents can affect their children's attitude and performance in the following three ways: parental expectations of their children's performance; parental encouragement; and parental attitude towards mathematics. Teachers need to work with parents to ensure that the performance expectations they have for their teenagers are reasonable, that positive parental encouragement is available, and that parents do not inadvertently display their own negative feelings towards mathematics. Negligence in these key areas can create a huge amount of tension that can serve to drive asunder the key players in this math community–students, parents, and teachers. I frequently see the bumper sticker that reads, "it takes a community to raise a child." This rings true because I am unsure of how we, as educators, can help foster in our students a better attitude towards mathematics without their parents' positive support and involvement. This reminds me of the comment that I constantly hear from my colleagues: real change must start in the home.

Suggestions for Future Research

There are three main areas of consideration that future research needs to address to substantially improve upon the results found in this study. These three areas are the sampling techniques, the structure of part of the questionnaire, and the examination of the discriminant validity of the questionnaire.

As stated in the introduction, the major delimitation of this study was that the population sample was not randomly selected. Because of this, the present study can only draw conclusions about, and make pedagogical suggestions for, the actual sample of individuals who answered the survey. No generalizability to the British Columbian high school population as a whole is possible. Future research needs to remedy this by taking a proper random sample of the approximately 50,000 high school students in the province.

Implications for further research are also directed towards the inability of this study to successfully quantify *meaningful* learning in mathematics. The literature is adamant that it is one of several critical aspects involved in good pedagogy. Because of this, more work is needed in the construction of a scale that will properly measure meaningful learning in mathematics. When this is done, a more solid scale of preparedness, as defined by knowledge, attitude, self-efficacy and meaningful learning, can be assessed with math-test anxiety.

Finally, an attempt to determine the discriminant validity needs to be undertaken so that the data can be more fully interpreted. Only then can these instruments be properly adapted so that potential overlapping is eliminated.

Conclusion

The key results found in this study imply that students who feel better prepared in terms of math attitude, self-efficacy, and knowledge tend to have lower math-test anxiety and that lower math-test anxiety is associated with better performance. It also revealed that previous success in a math course is associated with higher math self-efficacy and performance on math tests. But, even the strongest association only accounted for a little over 28 percent of the possible variance between the variables. Clearly there are other factors at work that have not been dealt with in this study. People are incredibly complex and, because of this, it becomes impossible to construct a model that can account for the diversity inherent in humans in any field of research. But this should not deter us from finding relationships between the variables that provide windows to see bits and pieces of the puzzle. Correlations of 0.50 or better are good guidelines when dealing with human subjects, but they also show that there is much more to be understood. Perceived preparedness is, most likely, not the solution to math-test anxiety for any student, but it does appear to be a part of the solution.

Schwabb (1978) states that we need an eclectic in education reform because the problems are too varied, too vast and too personal for there to be one right and all-encompassing solution. This concept can be applied to math-test anxiety. We cannot hope to find one solution that works for everyone, but we can endeavor to gather successful solutions and mold and adapt them to fit any dynamic situation. To help with this, as Miller (1994) states, students need to understand that there is no math intelligence quotient; mathematics is not a subject in which you either have the capability or you do not. And, as Herbert (1997) states, there is no math anxiety gene in the human body; rather, math anxiety is a learned behavior: a product of society. Therefore, if students have learned math anxiety in testing situations, or in general, then students can unlearn it.

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Appendix A

(Consent Form: Printed on UBC letterhead)

Relationships Between Math-Test Anxiety and Preparedness Before a Test

Graduate Advisor:

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University of British Columbia
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Graduate Student:

Stefan Zabek
Department of Mathematics
Merritt Secondary School
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I am asking your son/daughter to take part in a research study on how the level of math-test anxiety is associated with the level of preparedness a student may feel before a test. I believe that this survey will shed more light on math anxiety so that we may better understand how to help students control it. This study is being conducted as part of my master's thesis through the University of British Columbia.

The research consists of a questionnaire that your son/daughter will answer anonymously. This will be done during class on a date chosen by his/her math instructor. The questionnaire should take approximately 15 minutes to complete. This survey is strictly voluntary and you or your son/daughter may refuse or withdraw at any time. If you or your son/daughter do refuse to participate in the study, then he or she will be given curriculum based math problems to work on during the time in which the other students will be completing the questionnaire. These problems will not be collected. All data from the questionnaires will be kept locked in a storage cabinet for a period of three years. It will then be destroyed.

If you have any questions about the procedures used in this study, you may contact me (the graduate student) or my advisor for clarification. Please use the contact information printed on this page above.

Enclosed please find two copies of this consent form. I ask that both you and your son/daughter sign one copy and have him/her return it to the instructor administering the questionnaire. You may keep the other copy.

If you have any concerns about your son/daughter's rights or treatment as a research subject, you may contact Dr. Richard Spratley, Director of the UBC Office of Research Services and Administration, at (604) 822-8598.

Please sign below indicating your decision.

Thank you for your time.

Sincerely,

S.P. Zabek

CONSENT

Parent:

I understand that my child's participation in this study is entirely voluntary and that I may refuse his/her participation, or withdraw him/her from the study, at any time without jeopardy to his/her class standing.

I have received a copy of this consent form for my own records.

Please circle one of the following:

I consent / I do not consent to my child's participation in this study.

Student:

I understand that my participation in this study is entirely voluntary and that I may refuse to participate, or withdraw from the study at any time, without jeopardy to my class standing.

Please circle one of the following:

I consent / I do not consent to participate in this study.

Parent/Guardian	Date	Student	Date

Appendix B

Math-Test Anxiety and Test Preparedness Survey

You are being asked to participate in a research study on math test anxiety and test preparedness. This questionnaire is set up to measure how prepared you usually feel before a math test and your corresponding level of math test anxiety. It is hoped that this research will help us in our understanding of how to cope with math anxiety in general. The University of British Columbia is sponsoring the research and a graduate student in the Faculty of Education is conducting the survey. It will take about fifteen minutes. Your participation in this survey is voluntary and your answers will be kept confidential. If you have questions or concerns about this survey, you may contact Dr. J Belanger (604) 822-5479 at the University of British Columbia, or Mr. S. Zabek (250) 378-5131 at Merritt Secondary School. If you have any concerns about your rights or treatment as research subjects you may contact Dr. Richard Spratley, Director of the UBC Office of Research Services and Administration, at (604) 822-8598. **Please ensure** that the signed consent form indicating your decision to have your data included in the analysis of this survey is attached to this questionnaire and Scantron sheet when you are finished. An adult at your school will separate the Scantron sheet, consent form and questionnaire. Your Scantron sheet with no name will be forwarded for analysis. The rest will be destroyed. Please answer **all** the questions. Print your name on the top of your consent form. **Do not** write your name on the Scantron sheet.

General Questions

Please answer the following by shading in the corresponding letter on the Scantron sheet.

1. Are you male or female? .... **a**. Male **b**. Female
2. Is your first language English? .... **a**. Yes **b**. No
3. If you answered yes to number 2, then go to question number 4. Otherwise, please indicate how many years you have been studying Math in English........ **a**. 1-2 **b**. 3-5 **c**. More than 5
4. You are in which grade of math? **a**. Grade 8 **b**. Grade 9 **c**. Grade 10 **d**. Grade 11 **e**. Grade 12
5. Is this the first time you have taken this course?.. **a**. Yes **b**. No
6. What mark did you receive in your LAST math course? ....**a**. 86% to 100% - "A" **b**. 73% to 85% - "B" **c**. 67% to 72% - "C+" **d**. 60% to 66% -"C" **e**. Less than 60% "C-"or "F".
7. As you understand the term "Math Anxiety", do you feel you experience it before and/or during math tests? .... **a**. Yes **b**. No
8. As you understand the word "prepared", do you feel you properly prepare yourself for math tests? .... **a**. Yes **b**. No

Please turn the page.

Math Test Anxiety Inventory

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and, with reference to the given scale, shade the appropriate circle on the Scantron sheet to indicate how you *generally* feel. There are **no wrong or right** answers. Please continue to use the same Scantron sheet.

a = Almost Never, b = Sometimes, c = Often, d = Almost Always.

9. While taking math tests I have an uneasy, upset feeling ....**a b c d**
10. Thinking about my grade in a math course interferes with my work on math tests ....**a b c d**
11. I freeze up on math exams ....**a b c d**
12. During math tests I find myself thinking about whether I'll ever get through the course............................**a b c d**
13. Thoughts of doing poorly interfere with my concentration on math tests ....**a b c d**
14. I feel very jittery when taking a math test ....**a b c d**
15. Even when I think I'm well prepared for a math test, I feel very nervous about it ....**a b c d**
16. During math tests, I feel very tense............................**a b c d**
17. I seem to defeat myself while working on math tests ....**a b c d**
18. I feel very panicky when I take a math test ....**a b c d**
19. I worry a great deal before taking a math test ....**a b c d**
20. During math tests, I find myself thinking about the consequences of failing ....**a b c d**
21. I feel my heart beating very fast during math tests ....**a b c d**
22. During math tests I get so nervous that I forget facts I really know ....**a b c d**

Please turn the page

Math Attitude Scale

Directions: Each of the following statements expresses a feeling that a particular person has toward mathematics. Using the five-point scale, express the extent of agreement between the feeling expressed in each statement and your own feeling. Please continue to use the Scantron sheet provided.

The five-point scale is:

a = Strongly Disagree, b = Disagree, c = Undecided, d = Agree, e = Strongly Agree.

23. I am always under a terrible strain in a math class .... **a b c d e**
24. I do not like mathematics, and it scares me to have to take it .... **a b c d e**
25. Mathematics is very interesting to me and I enjoy math courses .... **a b c d e**
26. Mathematics is fascinating and fun .... **a b c d e**
27. My mind goes blank, and I am unable to think clearly when working math **a b c d e**
28. Mathematics makes me feel uncomfortable, restless, irritable and impatient **a b c d e**
29. Mathematics is something which I enjoy a great deal .... **a b c d e**
30. When I hear the word math, I have a feeling of dislike .... **a b c d e**
31. I approach math with a feeling of hesitation, resulting from a fear of not being able to do math .... **a b c d e**
32. Mathematics is a course in school which I have always enjoyed studying ... **a b c d e**
33. It makes me nervous to even think about having to do a math problem ...... **a b c d e**
34. I am happier in a math class than in any other class .... **a b c d e**
35. I feel at ease in mathematics and I like it very much .... **a b c d e**
36. I feel a definite positive reaction to mathematics; it's enjoyable .... **a b c d e**

Please turn the page

Math Usefulness Scale

Directions: Each of the following statements expresses a feeling that a particular person has toward mathematics. Using the five-point scale, express the extent of agreement between the feeling expressed in each statement and your own feeling. Please continue to use the Scantron sheet provided.

The five-point scale is the same used for questions numbered 22-36.

a = Strongly Disagree, b = Disagree, c = Undecided, d = Agree, e = Strongly Agree.

37. I'll need mathematics for my future work.. **a b c d e**
38. I study mathematics because I know how useful it is........................... **a b c d e**
39. Knowing mathematics will help me earn a living............................... **a b c d e**
40. Mathematics is a worthwhile and necessary subject............................ **a b c d e**
41. I will use mathematics in many ways as an adult............................... **a b c d e**
42. Mathematics is of no relevance to my life....................................... **a b c d e**
43. Mathematics will not be important to me in my life's work.................... **a b c d e**
44. I see mathematics as a subject I will rarely use in my daily life as an adult. **a b c d e**
45. Taking mathematics is a waste of time.. **a b c d e**
46. I expect to have little use for mathematics when I get out of school.......... **a b c d e**

Please turn the page

Math Self - Efficacy Scale

Directions: Each of the following statements expresses a feeling that a particular person has toward mathematics. Using the five-point scale, express the extent of agreement between the feeling expressed in each statement and your own feeling. Please continue to use the Scantron sheet provided.

The five-point scale is the same used for questions numbered 22-46.

a = Strongly Disagree, b = Disagree, c = Undecided, d = Agree, e = Strongly Agree.

47 I am sure that I can learn mathematics... **a b c d e**

48 I think I can handle more difficult mathematics.................................. **a b c d e**

49 I am sure I can do advanced work in mathematics............................... **a b c d e**

50 I can get good grades in mathematics... **a b c d e**

51 I have a lot of self-confidence when it comes to math........................... **a b c d e**

52 I am no good in mathematics.. **a b c d e**

53 I don't think I could do advanced mathematics.................................. **a b c d e**

54 For some reason even though I study, math seems unusually hard for me..... **a b c d e**

55 Most subjects I can handle okay, but I have a knack for messing up math.... **a b c d e**

56 Math has been my worst subject.. **a b c d e**

57 I know I can apply the concepts covered for a test.............................. **a b c d e**

58 I know I can use the functions on my calculator to get the correct answer ..... **a b c d e**

59 I know I can work longer algebraic equations without making a mistake....... **a b c d e**

60 I know I can extract information shown in different ways (e.g. graphs, tables etc.) .... **a b c d e**

61 I know I can have difficulty determining when and where to use the right formula .... **a b c d e**

62 I know I can have difficulty manipulating the necessary equations to arrive at the correct answer .... **a b c d e**

63 I know I can have difficulty extracting all the information from a word problem necessary to solve it .... **a b c d e**

You have now completed the questionnaire. Thank you for your participation.
END OF QUESTIONNAIRE