

An examination of the relationship between high school students' levels of mathematics anxiety and their fluency in the mathematics language

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INTRODUCTION

Most adults, when asked to discuss their experiences with mathematics, recount negative events, claim they were often anxious about mathematics, and that they were confused, not understanding mathematics both in terms of what was asked of them and of all the language involved. Some recall that they were never able to solve the problems, or give the correct answer, and felt embarrassed. Unfortunately, these feelings are quite common among the adult population. Of particular interest to educators is the cause of these anxious feelings and the lack of understanding of the language of mathematics, and how to develop effective intervention strategies to alleviate anxiety and improve fluency.

Students at the high school level are preparing themselves for what they will be doing after they finish their public school education. In particular, these students are choosing courses that will help shape their future careers and goals in life. Past experiences in mathematics can impact these choices by students choosing to avoid careers or advanced courses in mathematics (Meece, Wigfield, & Eccles, 1990). By selecting certain courses they can often limit their options later on in life. For example, not taking the academic level mathematics courses in Nova Scotia, and choosing instead to take foundation level courses, these students are unable to pursue studies to complete a science degree in University. Students who graduate from high school in Nova Scotia only need to complete two math courses in order to meet the graduation requirements. Consequently, if a student is experiencing mathematics anxiety, or is not fluent in the mathematics language at the start of high school, he or she does not have much opportunity and time to improve disposition and language skills.

As a high school mathematics teacher, I am often confronted with students' feelings of anxiety and their lack of fluency in the mathematics language, regardless of

the mathematics course or the grade level that I teach. Seeing these struggles that a student often faces when attempting problems and the feelings of anxiety when assessment events are soon to happen makes me, as a teacher, want to help these students get to the root of their difficulties with mathematics. There are very few resources available in high school to help students overcome mathematics anxiety, and to help improve their mathematics language. Presently, there are no formal assessments available to determine how anxious students are in Nova Scotia high schools, and how fluent they are in the mathematics language. In reviewing the literature on mathematics anxiety and on fluency in the mathematics language, I was surprised to find that few studies focus on students' anxiety or their understanding of the mathematics language at the high school level. In light of this absence of literature on the subject matter combined with my own experience as a high school mathematics teacher, I decided to conduct the current research project. In particular, I created a fluency questionnaire that aims to measure incoming high school students' level of fluency in the mathematics language. In addition, I have purchased copies of the Mathematics Anxiety Rating Scale which assesses the level of anxiety that students experience. I was particularly interested in the correlation that may exist between students' anxiety levels and their levels of fluency in the language of mathematics. Teachers are not trained psychologists, and thus may not be equipped to help students with their anxiety. However, if there was a correlation between fluency and anxiety, teachers could improve students' fluency and thus improve students feelings toward mathematics. This study aimed to provide important insight into how anxious high school students are and to determine their level of fluency in the mathematics language. Such insight will then have significant implications on designing effective pedagogical approaches to support students.

I discuss the problem of anxiety and fluency in greater detail in the first chapter and present there the purpose of my study and the research questions I raised. In Chapter 2, I review relevant literature that then serves to design instruments and interpret the data. The study's design, instruments, and procedures are explained in Chapter 3. In Chapter 4, I present and discuss the results. Finally, in the concluding Chapter 5, I discuss the limitations of the study, future considerations, and practical implications.

Chapter 1: The Problem

INTRODUCTION

Few people would deny that there are many factors that contribute to students successfully understanding and engaging in mathematics. Some of these factors may range from the teaching style of the classroom teacher, family support, levels of anxiety, past experiences, prerequisite knowledge, and fluency in the language of mathematics. All or simply one of these factors could play a part in a student's inability to do mathematics. Most often, mathematics anxiety is a major factor for many students who experience difficulty with mathematics (Chinn, 2009; Hembree, 1990). Another important factor in students' failure to achieve the outcomes specified in the mathematics curriculum is their inability to communicate in the language of mathematics (Adams, 2003). These two findings are of concern because they imply that many teachers face these particular obstacles in their classrooms. Without the proper tools and effective intervention strategies, these teachers may be wasting valuable time rather than providing the help needed because they do not know where the problem lies. High school students in Nova Scotia must succeed in at least two high school mathematics courses in order to graduate. Most of the current research examines anxiety levels in either elementary school aged children or adults; very few studies focus on high school students.

In this chapter, I first present the problem of students' anxiety and fluency in mathematics. Then, I explain the purpose of the study, the goals I am seeking to achieve, and the research questions I aim to answer.

STATEMENT OF THE PROBLEM

Most mathematics teachers are aware that students' attitude toward mathematics is a major factor that affects the student's will to do mathematics both in the school setting, and later on in life (Baloglu & Kocak 2006; Richardson & Suinn, 1972). Mathematics anxiety is one of the major factors that might impact a student's attitude toward mathematics (Beilock et al, 2009; Chinn, 2009; Newstead, 1998). Another factor which might affect students' attitude toward mathematics is their level of fluency in the mathematics language (Cates & Rhymer, 2003; Wakefield, 2000). Research has shown that each of these factors affects students' ability to be successful in mathematics (Cates & Rhymer, 2003; Ma & Xu, 2004, Chinn, 2009).

Mathematics anxiety has been shown to correlate negatively with students' performance, with their enrolment in subsequent mathematics courses, and with their career planning by avoiding careers that involve mathematics. (Suinn & Edwards, 1982; Meece, Wigfield & Eccles, 1990). In terms of students pursuing post secondary careers in mathematics and technology the United States have seen a decline in those numbers and are investing a lot of resources to encourage students in these areas (Feller, 2010). The ability to communicate effectively in mathematics requires reading comprehension and an ability to express mathematical phenomena in writing and orally. Fluency in the language is essential to understanding mathematics (Esty, 1992; Wakefield, 2000; Adams, 2003). Although there are several studies examining the impact of mathematics anxiety on the learning of mathematics (Newstead, 1998; Cates & Rhymer, 2003; Bessant, 1995) and the role language fluency plays in the development of mathematical thinking (Wakefield, 2000, Adams, 2003; Gough, 2007), I could find none that really consider how these two significant factors, anxiety and fluency, are linked.

PURPOSE OF THE STUDY

This study aimed to correlate the levels of mathematics anxiety experienced by incoming grade 10 students with their levels of fluency in the mathematics language. In particular, I was interested in investigating the types of difficulties students are having with respect to their understanding of the mathematics language and how these may be impacting their level of anxiety. It was the intention of this study to assess students' levels of anxiety and of fluency, and not how well students are achieving the outcomes in the grade 10 mathematics course.

This research project thus has two main goals. The first goal was to examine the relationship between the levels of mathematics anxiety among grade 10 students and their level of fluency in the language of mathematics. The second was to explore those aspects of the mathematics language students are struggling with, and how that may relate specifically to their anxiety levels.

RESEARCH QUESTIONS AND HYPOTHESES

The proposed research aimed to find answers to the following five questions.

1. How mathematics-anxious are grade 10 students in the Halifax Regional Municipality?
2. What is the level of fluency in the mathematics language of grade 10 students in the Halifax Regional Municipality?
3. Is there a relationship between levels of mathematics anxiety and levels of fluency in the mathematics language?

H_0 : There is no significant relationship between students' levels of mathematics anxiety and their level of fluency in the mathematics language

H_a: There is a relationship between students' levels of mathematics anxiety and their level of fluency in the mathematics language

4. Are specific areas of difficulty with the mathematics language related to levels of mathematics anxiety?

SIGNIFICANCE OF THE STUDY

Nova Scotia uses an outcome-based curriculum that is founded on the National Council of Teaching Mathematics' (NCTM) Curriculum and Evaluation Standards for School Mathematics (Atlantic Provinces Education Foundation, 1996; NCTM, 1989). The foundation document for Atlantic Canada Mathematics Curriculum claims that as students move through the grades in school, the curriculum ensures a natural progression in the development of the topics. The foundation document also specifies that students must be able to communicate in mathematics, have confidence in their abilities, and that mathematics literacy "needs to permeate the breadth and depth of the mathematics curriculum at all instructional levels" (Atlantic Provinces Education Foundation, 1996, p.1).

The Nova Scotia Curriculum (1996) document specifies the concepts and the skills that students are required to master in order to graduate. Most notably, students are required to show confidence and competence in their ability to use mathematics to solve problems and to apply mathematical concepts to real-world situations. As well, students are required to communicate effectively using mathematics language. In particular, students must be able to express and clarify their mathematical thinking, make generalizations, recognize multiple representations of concepts, and be able to communicate both orally and in writing.

In order for students to master the concepts and skills specified in the mathematics curriculum, they must develop a positive disposition toward the subject-matter and learn to be fluent in the language of mathematics. The intent of the proposed research is to investigate levels of mathematics anxiety and how they correlate with levels of fluency in the mathematics language of a sample of grade 10 students entering high school. This grade level is the first of three in high school and is thus of utmost importance. It is at this grade level that students make decisions about the remainder of their mathematics experience. This study provides the insight needed to plan appropriate intervention strategies that will help these students successfully complete subsequent mathematics courses. Since students are expected to be confident in their mathematical abilities and to be able to communicate effectively when they graduate, both of these factors, mathematics confidence and fluency, may play an important role in their learning. Research shows that anxiety impacts students' ability to do mathematics confidently, to make appropriate career choices, and to pursue further studies in mathematics (Baloglu & Kocak 2006; Richardson & Suinn, 1972). As well, in order to communicate effectively, a student is required to understand the language. This entails an understanding of the vocabulary, grammar, syntax, synonyms, conventions, abbreviations, and sentence structure of mathematics (Esty, 2007; Wakefield, 2000). Consequently, it is important to identify those aspects of the mathematics language that students are struggling with in order to help overcome the problem with the language. The findings from this research have important implications for both teachers and students. They will bring to light the specific areas of mathematical language with which students have difficulty and it will also help them recognize how anxious they are in mathematics situations—the first step in overcoming anxiety. For teachers, the findings

will help them with the delivery of the mathematics curriculum; the results will provide insights into the selection of innovative approaches that may alleviate anxiety and improve mathematical fluency.

In summary, the overall purpose of this study is to examine levels of mathematics anxiety in grade 10 students in Nova Scotia, and to correlate these with their levels of fluency in the mathematics language. Research suggests that both factors, levels of anxiety and levels of fluency in mathematics language, may impact students' success in mathematics as well as their career choices and their ability to engage in everyday mathematical activities. A major goal of the Nova Scotia Mathematics Curriculum is to have students become confident in their mathematical abilities and to communicate effectively in mathematics. A first step then to achieve these goals is to determine the specific areas students are struggling with. That is the aim of this study: to gain insight into how fluency and anxiety interact in the learning of mathematics.

Following is a review of the literature on mathematics anxiety and on fluency of the mathematics language as it relates to the purpose of this study.

Chapter 2 - Literature Review and Theoretical Framework

When people discuss mathematics anxiety, or when they talk of fluency in the language of mathematics, there are many things that they would be referring to. Many studies reveal that mathematics anxiety feelings begin when students are in elementary school (Newstead, 1998; Hembree 1990). Research is also now recognizing that language plays a key role in the understanding of mathematics (Esty & Teppo, 1996). Consequently, it is important to have a clear understanding of both of these factors, mathematics anxiety and mathematics fluency, before examining the relationship between the two. I first provide a general review of research on mathematics anxiety and then on the language of mathematics (figure 1). Finally, I consider how these two factors work together in the process of learning mathematics.

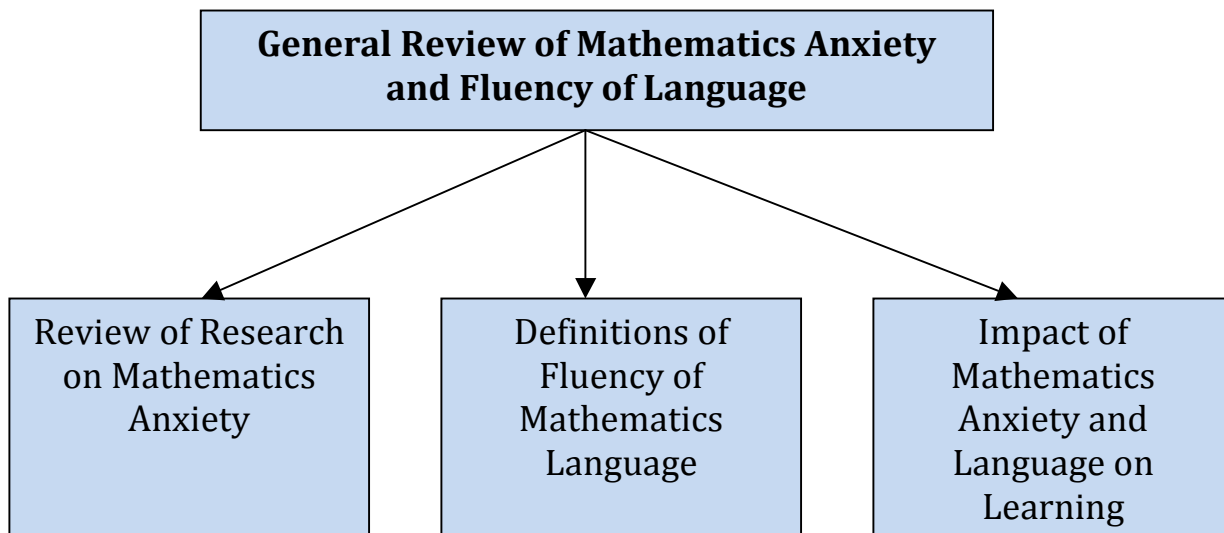


Figure 1: Review of Literature Strategy

REVIEW OF RESEARCH ON MATHEMATICS ANXIETY

The concept of mathematics anxiety has been defined in many different ways in research over the years. When researchers first began to look at mathematics anxiety, many of them believed it was just a form of test anxiety (Hembree, 1990; Ho et al, 2000; Newstead, 2000). More recent research suggests that there are many components to mathematics anxiety that are not shared with general feelings of anxiety in other contexts. (Chinn, 2009; Hembree, 1990; Baloglu & Kocak, 2006). Anxiety can be defined broadly as a “state of arousal that surfaces through the bodily, emotional, and mental changes that an individual experiences when faced with a specific type of with a stimulus” (ibid Aiken, 1976 as stated in Ertekin et al, 2009). When people feel anxious, they may suffer from a number of possible symptoms such as panic, tension, feelings of helplessness, fear, distress, shame, inability to cope, sweaty palms, a nervous stomach, difficulty breathing, and loss of ability to concentrate (ibid Postamentier & Stepelman, 1990 as stated in Mji & Mwambakana, 2008). In education, it became decidedly important for researchers to separate mathematics anxiety from test anxiety in order to study the unique experience of mathematics anxiety (Richardson & Suinn, 1972). However, the distinction between mathematics anxiety and test anxiety has been debated by many. The lack of agreement as to whether these two types of anxiety should be separated or studied together has lead to many different definitions of mathematics anxiety (Kazelskis et al, 2000). A number of researchers contend that the two types of anxiety should be studied together because of the high correlations between measures of mathematics anxiety and those of test anxiety (Wood, 1988; Rounds & Hendel, 1980). On the other hand, a number of researchers argue that while there are similarities between the two types of anxiety, they are not one and the same (Hembree, 1990; Dew,

Galassi & Galassi, 1983). Kazelskis *et al.*, (2000) assert that more work needs to be done in order to distinguish mathematics anxiety from test anxiety. In fact, because many of the tools to measure mathematical anxiety have questions that deal with test anxiety, this distinction is still ambiguous in the literature.

Ma & Xu (2004) state that mathematics anxiety is at play when a student feels discomfort when asked to perform mathematical tasks and this discomfort may take on the look of dislike, worry, and fear. It may also be exhibited by specific behavioural characteristics such as tension, frustration, distress, indifference, helplessness, and mental disorganization. This type of definition focuses on the emotional aspects of the person experiencing the mathematical anxiety. Many other researchers view mathematics anxiety as performance-based in that it brings about feelings that inhibit a person's ability to perform mathematical tasks. (Richardson & Suinn, 1972; Chinn, 2009; Beilock, 2010). Establishing this relationship between mathematics anxiety and performance explains a student's poor performance on standardized tests, lower grades in mathematics courses, and his or her plans not to enrol in further mathematics courses (Meece et al, 1990; Suinn & Edwards, 1982).

Other definitions of mathematics anxiety highlight the effects that this type of anxiety has on students. According to Bessant (1995), students who suffer from mathematics anxiety often experience debilitating test stress, low self-confidence, fear of failure, and boast negative attitudes toward mathematics learning. Other research suggests that when students are put in situations that induce pressure such as test-taking, their performance decreases (Beilock, 2008). Wood (1988) and Kazelskis *et al.* (2000) claim that there is a lack of agreement as to what constitutes mathematics anxiety as some focus on physical reactions (Mji and Mwambakana, 2008) while others

focus on emotional states such as fear, hatred, and avoidance (Suinn & Edwards, 1982). Although there is no consensus on the definition of mathematics anxiety, all agree that it interferes with learning and performance (Richardson & Suinn, 1972; Newstead, 1998; Hembree, 1990).

REVIEW OF RESEARCH ON MATHEMATICS LANGUAGE AND FLUENCY

The language of mathematics is very complex and “has its own grammar, syntax, vocabulary, word order, synonyms, negations, conventions, abbreviations, sentence structure and paragraph structure” (Esty, 1992, p.31). It is these components of the mathematics language as well as such additional features as the use of abstractions, special symbols, graphical expressions, algorithms, translations and interpretations, encoding and decoding that make mathematics language intricate. Furthermore, learning mathematics follows a continuous trajectory from early childhood experiences to the final year of schooling and beyond, which entails that any drifting results in significant knowledge gaps (Wakefield, 2000; Adams, 2003). Some researchers contend that mathematics constitutes a language in itself (Wakefield, 2000). Gough (2007), in particular, argues that the mathematics language is an artificial, deliberately constructed language that is supported by alphanumeric symbols, non-alphanumeric symbols, special formats, groupings, and that it involves both verbal and non verbal components. All of these definitions are consistent in that each explains the mathematics language in terms of the conventions and notations that it has and that students need to learn this language in order to engage in mathematical activities.

Cates & Rhymer (2003) define fluency in mathematics as the ability to perform a mathematical task correctly, quickly, and with little effort. They present fluency as the

second stage of four in an instructional hierarchy (Cates & Rhymer, 2003). The four stages of this instructional hierarchy are

- 1) acquisition which is to produce the correct answer no matter the time frame,
- 2) fluency
- 3) generalization where students can perform the behavior under different conditions than what was done in the training.
- 4) adaption and this is where students are using the mathematics learned to go beyond the first three stages (Cates & Rhymer, 2003).

This view of fluency is focused on the ability to perform tasks, but does not require the student to transcend the performance to reach meaning-making. Another study extends this performance-based definition further. Ramos - Christen *et al* (2008) argue that it is the accuracy along with the response speed that shows competency. In their view, if a student lacks fluency, he or she often spends a great deal of time and effort simply decoding the problem and the task at hand, which leaves little time for comprehension and the learning of more complex ideas. This is consistent with Dougherty and Johnson (1996) who claim that fluency is the ability to respond accurately, quickly, and without hesitation to a mathematical problem. According to these researchers, the ability to respond rapidly and accurately has three major advantages. First, the learner benefits from both long and short term retention gains. Second, these learners tend to have increased perseverance and get less distracted. Finally, the ability to respond rapidly and accurately seems to improve performance on related yet more complex tasks (Dougherty & Johnson, 1996).

There is consistency among all of these definitions of fluency; they all stipulate that fluency in mathematics is demonstrated when the student shows ability in correctly

completing mathematical tasks quickly and accurately (Dougherty & Johnson, 1996; Ramos Christen et al, 2008; Cates & Rhymer, 2003). In other words, if two students complete a worksheet accurately, but one of them does so in a shorter amount of time, the quicker student would be considered the more fluent one (Axtell *et al.*, 2009). Indeed, automaticity refers to this ability to perform different mathematical skills without conscious attention to the problem, and fluency is often defined in terms of automaticity (Dougherty & Johnson, 1996; Axtell et al, 2009). In terms of the stages in understanding, a person would first acquire the skills and the language, and then attain fluency, and, finally, automaticity would be the last stage where the student is expected to be able to apply or adapt skills and knowledge new situations (Dougherty & Johnson, 1996; Axtell et al, 2009).

For the current study I have defined mathematics anxiety as a student having feelings of anxiousness surround mathematical tasks which occur both in the mathematics classroom and in their everyday life. For fluency of the mathematics language this is defined for the present study as a person who is has the ability to recognize and decode language components of the mathematics language and then are able to apply their knowledge of the language quickly and effective in a variety of situations that may stretch the student's thinking.

IMPACT OF MATHEMATICS ANXIETY AND LANGUAGE ON LEARNING

Tobias (1991) claims that everyone's brain is capable of learning mathematics. However, what is holding many back is not believing that they can. Her research reveals that millions of adults, and more specifically women and minorities, have been blocked from pursuing professional and technical jobs because they fear or perform poorly in

mathematics. Tobias (1991) found that changing student and teacher attitudes improved students' performance on mathematical tasks. However, changing attitudes toward abilities to do mathematics takes time and effort from a variety of sources.

Mathematics Anxiety can have an impact on students in many different ways (Chinn, 2009, Ma & Xu, 2004). In particular, mathematics anxiety can decrease student performance, which then results in avoidance of mathematics and mathematics related courses and jobs (Hembree, 1990; Richardson & Suinn, 1972). Meece, Wigfield, and Eccles (1990) confirmed that mathematics anxiety not only affected performance in courses, it also negatively impacted performance in standardized mathematics tests and grades in mathematics courses. This, of course, leads students to not seek further mathematics education. Mathematics anxiety also affects students' attitudes about themselves and about mathematics (Chinn, 2009; Bessant, 1995, Tobias, 1991). Students will often engage in avoidance behaviours and not attempt questions because they are afraid of failure. (Chinn, 2009; Bessant, 1995). Students' self-esteem, physiological well-being, and confidence in mathematics are also negatively affected, which would impact the students later on in their career choices, selection of math courses, and use of quantitative skills. (Ma & Xu, 2004).

While mathematics anxiety impacts the student's affect, mathematics language impacts the student's cognition (Axtell *et al.*, 2009). When learning new words, concepts and other parts of the mathematical language, students have to distinguish between the mathematical meaning and the everyday meaning of those terms (Axtell *et al.*, 2009, Adams, 2003). More specifically, if a student is not able to distinguish between words and symbols that have multiple meanings, it may confuse his or her understanding of mathematics (Adams, 2003). One of the most crucial abilities in linguistics is to be able to

provide “meaning to what is heard or read and of conveying one’s intentions through the spoken and written channels” (Pimm, 1987, p. 5). Esty (1992) states that for students to understand and do algebra successfully, they need to understand basic language concepts in mathematics. The author explains that the reason students do not understand the basic concepts of language is, in large part, due to the non-recognition of the mathematics language as a foreign language. This means that teaching approaches, textbooks, policies, etc. do not focus on the language and, thus, do not involve strategies that help students develop that language. Yet, to be fluent in the language of mathematics is essential for the development, expression, and comprehension of mathematical ideas (Esty, 1992).

Mathematics language also impacts students’ learning in their ability to communicate effectively (Esty & Teppo, 1996). Teachers who do focus on communication encourage mathematical discourse, and this has been shown to be effective in helping students achieve understanding (Piccolo et al, 2008). Haung *et al.* (2005) report that students’ fluency in the mathematics language is related to their mathematical knowledge. In other words, the ability to communicate effectively is key to understanding. Students often feel that they can learn how to write mathematics through imitation, and so they fail to communicate successfully in mathematics (O’Shea, 2006). The National Council of Teaching Mathematics Standard (2000) highlights that communication is key to understanding and that students must learn to reason out their thinking and to communicate it both to other students and teachers, orally and in writing. The NCTM Standards also state that if students are given the chance and the support to speak, write, read, and listen in mathematics class, they will be able to communicate mathematically. Students also need the experience of doing this so that

they come to understand the “power and the precision of mathematical language” (NCTM, 2000, p. 62). This stance contradicts what a number of researchers claim regarding the manner in which mathematical language is acquired. Many researchers point out that simply being immersed in the mathematics language does not insure students will understand; aspects of the language need to be taught directly and explicitly to the students (Gough, 2007; Esty, 1992; Adams 2003)

This chapter provided a description of mathematics anxiety and fluency. Although there is no definition that has been agreed upon by researchers, it is apparent that mathematics anxiety can impact students negatively in many different ways. As well fluency in the mathematics language plays a key role in the development of students’ understanding of mathematics. How mathematics anxiety and fluency of the mathematics language play in the students’ learning was discussed in order to show the possible link between the two. Studies reviewed suggest that both mathematics anxiety and fluency of the mathematics language have a significant impact on student’s performance and their desire to pursue more courses or careers in mathematics.

This study will contribute to the very limited body of research that examines mathematics anxiety in high school students. It will also provide teachers with significant insight into the possible relationship between mathematics anxiety and fluency in the mathematics language. Given the relatively poor performance of students in high school mathematics as revealed by the provincial exams, it is important to conduct research that may aid educators to identify areas of difficulty. In the next chapter, I describe the methodology that I was followed in order to investigate the research questions of the study.

Chapter 3: Methodology

INTRODUCTION

In the previous chapter, I reviewed the literature on mathematics anxiety, on the mathematics language typically used in school, and on the relationship between these two factors. The purpose of this research study was to look at the relationship between grade 10 students' levels of mathematics anxiety and their level of fluency in the mathematics language. The second goal of this study was to explore specific aspects of the mathematics language with which the students are struggling and how these might be related to their levels of mathematics anxiety. This chapter provides the background information to support the study's methodology. First, I describe the research design and the instruments that were used to assess students' fluency in the mathematics language and their level of mathematics anxiety. I then present the sampling technique along with the procedure for collecting and analysing the data. This study collected quantitative data in order to determine the levels of anxiety and of fluency of each student according to the definitions of fluency and anxiety that were established for this study. This enabled me to determine if there was a correlation between the two factors and which aspects of the mathematics language seem to impact anxiety levels. In a school setting, these results could help provide valuable insights into why students are struggling with mathematics and this, in turn, will inform teachers on how to evaluate ways to help them.

RESEARCH DESIGN

In order to answer the research questions, information was collected on a sample of Grade 10 students' level of mathematics anxiety and on their level of fluency in the

mathematics language. The data collected in those two areas of focus provide a basis for eventually developing strategies to help students succeed in high school mathematics. Two assessment questionnaires were used. One instrument was used to measure anxiety levels and another instrument was used to measure fluency. These are further discussed below in the section on instruments. Each of these assessment questionnaires was administered in the classroom during school hours. This occurred during class time, and they were given one class (approximately one hour) to complete each questionnaire. The teacher administered each of the questionnaires to the students. The administering of these questionnaires is an effective way to measure anxiety and fluency, since students had to determine how they feel about the situations and they needed to interpret various aspects of the mathematics language. Honest disclosure is more difficult to obtain in face-to-face meetings, as students may feel embarrassed or feel pressured to answer “correctly”, however it is not guaranteed that in this method it will as well. It was also not be practical to conduct interviews and observations due to the amount of time these would require students to be away from their learning activities. Responding to these questionnaires achieved the desired results without a large time commitment on the part of the participants.

A quantitative research method provided the opportunity to investigate whether or not there is a relationship between mathematics anxiety and mathematics language fluency in the sample population. The use of quantitative methods was appropriate for this study since I was collecting and relating the data on students' level of anxiety and their level of fluency. The design of the study was based on correlational research and in this design, two variables are measured and recorded for each individual and then the measurements are reviewed to identify any patterns of relationship that exist between

them and to measure the strength of this relationship (Gravetter & Wallnau, 2010). Since the data has two measured components, levels of anxiety and fluency for each student, determining the correlation between them was an appropriate method for the study. I examined the relationship between the two variables in accordance with three main aspects. First, I determined the existence and the direction of the relationship as being either positive or negative. Second, I determined the pattern of the relationship in order to establish whether it is a linear or monotonic dependence, which indicates that the relationship is either consistently positive or consistently negative. The last aspect of the relationship I examined was the strength of the relationship, using the Pearson correlation to determine the strength of a linear relationship and the Spearman correlation to measure the strength of the monotonic correlation.

The importance of a correlation research study is that it allows prediction. In this case, should the correlation be found to be strong, then one variable can be used to predict the other variable. That is, if fluency in mathematics language is found to be strongly correlated with mathematics anxiety, then we may conclude that interventions specifically aimed at improving fluency will help reduce anxiety or it could be that interventions aimed at anxiety will help increase mathematics fluency. This will provide teachers with an idea of what will need to be done to reach struggling students in order to help them achieve better understanding and feel more confident in their mathematics abilities.

The research strategy adopted to answer the research question followed three stages (see Figure 2).

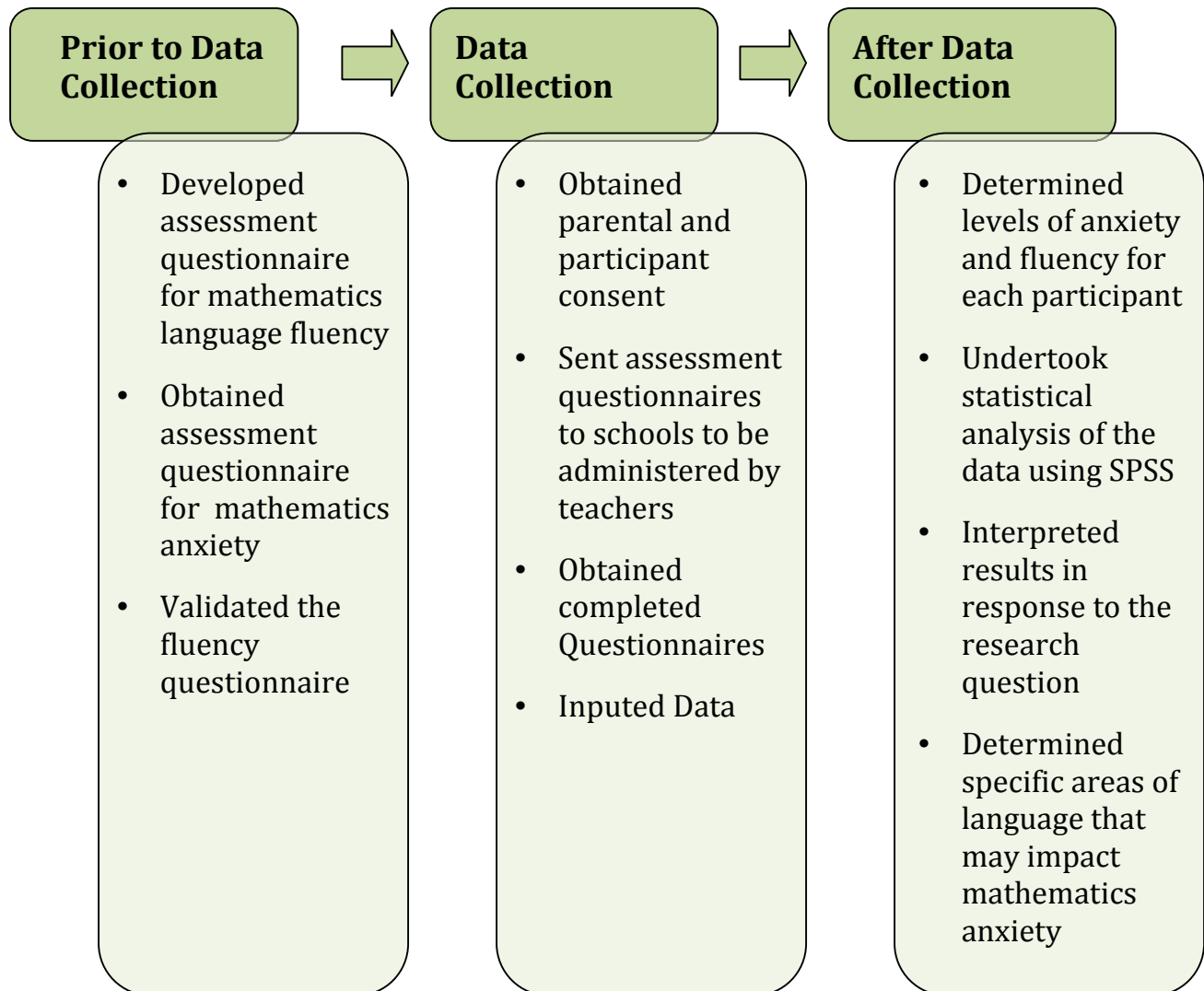


Figure 2: Research Process

INSTRUMENTS

Two instruments were used in the research study; both are assessment questionnaires. The questionnaires were administered by teachers. All of the participating students remained anonymous by using nicknames. They completed both questionnaires over the course of two classes in two consecutive days.

Mathematics Anxiety Rating Scale – Adolescent Version (MARS-A).

The Mathematics Anxiety Rating Scale – Adolescent Version (Suinn, 1979) was used to measure levels of mathematics anxiety in grade 10 students. The scale was obtained directly from the test developer, Richard Suinn, and permission was obtained to use the scale for the purposes of this study (see appendix A).

The MARS-A is a 98 item self-rating scale that assesses mathematical anxiety (Suinn, 1979) (See appendix B). The test consists of narratives of behavioural situations that may give the students a feeling of math anxiety. The students were asked to rate their expected level of anxiety for each item using the scale of “not at all,” “a little,” “a fair amount,” “much,” or “very much”. Possible scores range from 98 to 490 points. The higher the score on the MARS-A, the higher the level of mathematics anxiety for that student.

The MARS-A was selected for use in this study because it has been shown to be a reliable and valid instrument (Suinn & Edwards, 1982). Using a sample of junior high and senior high students in two different states in the United States provided reliability and validity information. The Spearman-Brown split half reliability coefficient was found to be 0.90, and using the Guttman split half method the reliability was 0.89 (Suinn & Edwards, 1982). This means that there is good reliability (Garson, 2010). The index of the internal consistency, a coefficient alpha was computed and found to be 0.96 (Suinn & Edwards, 1982). Furthermore, this instrument has the advantage of having a short completion time--approximately one hour to assess mathematical anxiety in adolescent students (Suinn, 1982).

Fluency Questionnaire

A Fluency Questionnaire was administered to the same students the day after they completed the MARS-A. The Fluency Questionnaire took approximately one hour to complete. This questionnaire obtained information regarding students' ability to understand different language components in mathematics such as syntax, algebraic manipulations, properties, graphical representations, arithmetical manipulations, and terminology. I created the questionnaire that was used in the study. (see appendix C).

The questionnaire was developed to gain insight into students' mathematical fluency in accordance with difficulties demonstrated in previous research (Adams, 2003, Esty, 1992, Wakefield, 2000). In particular, questions were written for each of the 6 categories. These categories were chosen because they are key components of the mathematics language and they are areas in which students typically have difficulties (Esty, 2007, Esty, 1992, Wakefield, 2000).

The Fluency Questionnaire is a 20 item multiple choice questionnaire. The student is asked to circle the correct response or responses to each item. Possible scores range from 0 – 35. A low score on the questionnaire indicates a low level of fluency in the mathematical language. Given that the questions assess students' fluency in 6 important areas, I determined which aspects are more problematic than others, and whether they were connected to levels of anxiety.

To validate the Fluency Questionnaire, the expertise of three individuals, a researcher in mathematics education, a researcher in mathematics language, and a mathematics coach at the junior high school level in the Halifax Regional School Board was sought. The researcher in mathematics education first reviewed the questions for clarity and content, and made several suggestions. The second version was then sent to

the mathematics coach. The mathematics coach made several suggestions as well after examining the questionnaire and verifying that the students would have sufficient experience in mathematics to respond correctly. Finally, the third draft was sent to the researcher in mathematics language who examined the questionnaire to determine if it would assess accurately students' fluency in the mathematics language. The questionnaire was also given to a number of high school students at their homes to determine if the language used in the questions was clear, and to determine the length of time required to complete the assessment. They too, made suggestions to improve the final draft of the questionnaire.

PARTICIPANTS AND SAMPLING TECHNIQUE

The participant sample for this study consist of 66 Grade 10 students in the Halifax Regional School Board. Following ethical approval, participants were selected from 3 high school classes in different locations: rural, suburban and inner-city. Since the students were under the age of legal consent, a parental and participant consent form was signed.

PROCEDURE FOR DATA COLLECTION

This study was conducted during the fall of the school year after ethics approval had been received from both Mount Saint Vincent University and the Halifax Regional School Board. The schools were selected in accordance with the school boards' policies and I contacted the teachers by email and explained the study prior to any of the documentation being sent out. Teachers then received the consent forms that were completed and returned to me. Once the consent forms were returned, a package of questionnaires was sent to the teachers along with a letter that outlined the study and

specified the procedures to follow to administer the questionnaires (see Appendix D). Teachers received the contact information of the researcher and of the supervisor in case they had any questions. Once the assessment questionnaires were completed, the teachers sent them back to the researcher.

DATA ANALYSIS

Data collected from each assessment questionnaire was first analyzed using descriptive statistics. This then allowed me to determine the levels of mathematics anxiety and fluency. The quantitative data was then analyzed with SPSS in order to determine the type and strength the relationship between the variables. As well, I examined the fluency questionnaires in terms of specific areas of the mathematics language that might impact mathematics anxiety. In other words, each section of questions in the fluency questionnaire was analyzed and then related to the level of mathematics anxiety.

CONCLUSION

The research design of the study involved quantitative data that was obtained from the assessment questionnaires. The correlational analysis determined the relationship between mathematics anxiety and mathematics language fluency.

The Mathematical Anxiety Rating Scale was used since it is the standard tool for studying anxiety in the field of research since the 1980's. This scale was evaluated in 1982 with 500 students and it was tested against other mathematics anxiety scales at the time. The researchers found that the MARS-A was the most accurate after it was administered and re-administered to the students (Suinn, 1982). The second instrument on fluency was developed based on the book *The language of mathematics* written by Dr

Warren Esty. Participant classes were selected from a variety of regions and consent forms were signed before any information was collected.

The goals of this study were to examine the relationship between mathematics anxiety and levels of fluency in grade 10 students, as well as examine the specific areas that students are having difficulty with in the mathematical language. Obtaining such results will provide insight into how mathematics language impacts mathematics anxiety, and this in turn, would point to interventions to help students overcome anxiety.

Chapter 4 - RESULTS

The purpose of this study is to determine whether or not there is a relationship between grade 10 students' levels of mathematics anxiety and their fluency in the mathematics language. Data on students' levels of mathematics anxiety were collected using the Mathematics Anxiety Rating Scale for adolescents (MARS-A) and data were collected regarding the same students' fluency in the language of mathematics using a questionnaire designed by the researcher. One hundred consent forms were submitted to three schools, each classified as either inner city, suburban, or rural, based on their location within the regional municipality. Of the 100 consent forms sent to the schools, 66 respondents agreed to participate in the study, 14 from an inner city school, 23 from a suburban school, and 29 from a rural school. In this chapter, I present and discuss the results of the study. In the first part, I present the statistical analysis of the data collected for the entire sample of 66 respondents and then I present the statistical analysis of the data collected at each of the three participating schools. In the second part, I discuss the results in order to glean insights into how anxiety and fluency may impact student learning.

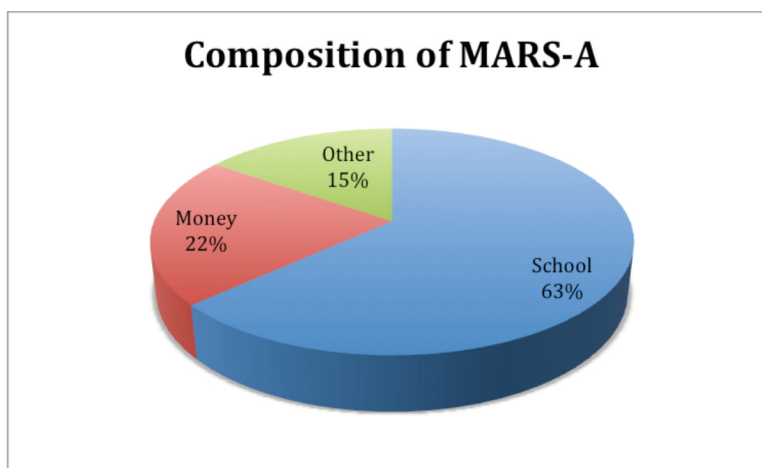
Part I – Statistical analysis of the data

In this first part of the chapter, I present the correlations calculated between fluency and anxiety as well as between the six components of fluency and the three different contexts of anxiety. I present the results for the entire sample and then for each of the participating schools. In order to help understand the numbers calculated, I provide scatter plots in the more general cases.

Results for the entire sample

The two questionnaires were administered over two consecutive days with the MARS-A being completed first. I did not want the fluency test to raise levels of anxiety, and so it was administered on the second day. The MARS-A is a 98-item self-reporting questionnaire with scores ranging from 98 to 490 points (Suinn, 1979). A score of 200 points indicates that a participant exhibits more anxiety than 60% of the normative group (i.e. junior high and high school students). In order to test various components of the anxiety, I organize the responses to the MARS-A into three categories: anxiety arising in school context, in money context, and other contexts. The percentage of each type of questions on the MARS-A is shown in figure 3.

Figure 3: The Composition of MARS-A



The fluency questionnaire, testing various components of the mathematics language, is scored from 0 to 35 points. The fluency components and their respective scores are: syntax (7 points), algebraic manipulations (8 points), arithmetic (8 points), representations (6 points), properties (4 points), and terminology (2 points).

Table 1. Descriptive Statistics for each test factor for all students.

	N	Minimum	Maximum	Mean	Std. Deviation
Anxiety	66	100.00	324.00	198.1515	50.94137
School	66	61.00	201.00	129.0455	35.03907
Money	66	22.00	92.00	39.7576	12.23496
Other	66	16.00	55.00	29.3485	8.69570
Fluency	66	5.00	30.00	17.6515	5.37084
Syntax	66	1.00	7.00	4.1667	1.54505
Algebra	66	1.00	7.00	3.7273	1.63185
Arithmetic	66	.00	7.00	3.9091	1.68913
Represent	66	.00	6.00	3.6970	1.66382
Properties	66	.00	3.00	1.0455	.93532
Terminology	66	.00	2.00	1.0606	.78208
Valid N (listwise)	66				

Data was analyzed using SPSS and organised into two tables: the descriptive statistics are presented in Table 1. The correlations between anxiety and fluency as well as the correlations between anxiety and each of the components of mathematics fluency are presented in table 2.

Sixty-six respondents form the sample that served to calculate the descriptive statistics for the MARS-A as well as for the fluency questionnaire presented together in Table 1. The statistical analysis of the data from the fluency questionnaire is shown first as a whole and then in accordance with each of the components of the mathematics language. The data for the MARS-A show that grade 10 students in this study have scores that range from 100 to 324 points, with a mean anxiety score of 198 points (40%) and a standard deviation of 50.85 points. For this questionnaire, the higher the score, the greater is the level of mathematics anxiety. For the fluency questionnaire, students' scores range from 5 to 30 points with a mean of 17.65 points (50%) and a standard deviation of 5.37points. On this test, high scores indicate higher fluency in the mathematics language.

The next table presents the correlations between the results on the Mathematics Anxiety Rating Scale for Adolescents questionnaire and those on the fluency questionnaire for the whole sample. First, the MARS-A results are compared to the fluency results, and then compared to the results of each of the components of the fluency questionnaire. To determine if there are statistically significant correlations, I used a 2-tailed Pearson correlation test with degrees of freedom of 64 and a level of significance of 5%. Each of the comparisons are then analyzed and addressed below the presentation of the correlation coefficients in table 2.

Table 2: Correlations between Anxiety and each component of fluency for all students.

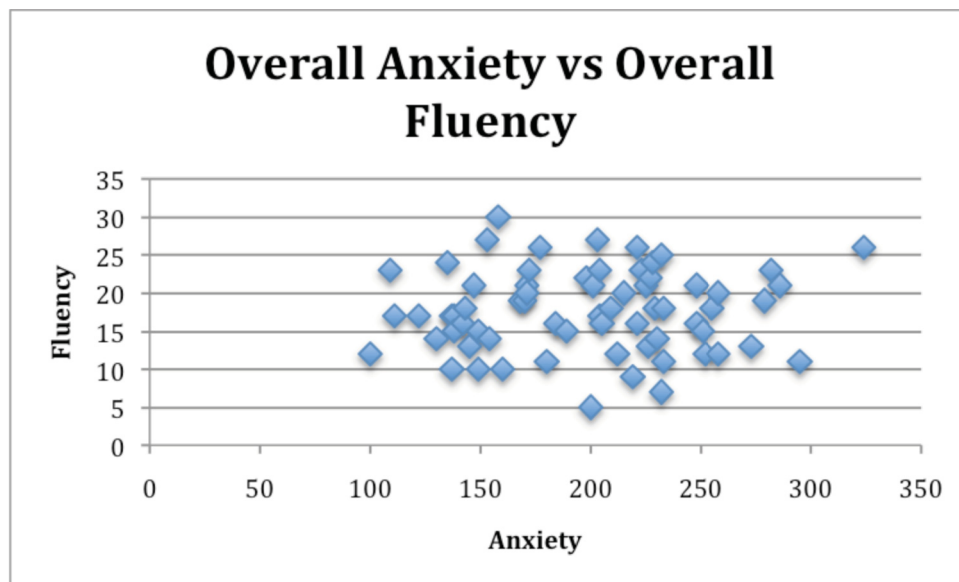
		Overall Fluency	Syntax	Algebra	Arithmetic	Represent	Properties	Terminology
Overall Anxiety	Pearson Correlation	.049	-.012	-.009	.136	.160	-.203	.046
	Sig. (2-tailed)	.694	.923	.941	.275	.201	.102	.715
	N	66	66	66	66	66	66	66
School Anxiety	Pearson Correlation	-.058	-.111	-.087	.061	.114	-.263*	-.012
	Sig. (2-tailed)	.645	.374	.485	.629	.362	.033	.925
	N	66	66	66	66	66	66	66
Money Anxiety	Pearson Correlation	.219	.162	.142	.222	.191	-.068	.161
	Sig. (2-tailed)	.077	.192	.257	.073	.125	.590	.197
	N	66	66	66	66	66	66	66
Other Anxiety	Pearson Correlation	.212	.149	.099	.241	.207	-.034	.090
	Sig. (2-tailed)	.087	.232	.429	.051	.095	.786	.474
	N	66	66	66	66	66	66	66

Correlation between Overall Anxiety and Overall Fluency, whole sample

$H_0: \rho = 0$ (there is no correlation between Anxiety and Overall Fluency)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.053$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency. Figure 4 illustrates how the relationship is situated midrange for both anxiety and fluency for the whole sample of 66 respondents.

Figure 4: Scatter plot of Anxiety versus Fluency



Correlation between School Anxiety and Overall Fluency

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Overall Fluency)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.058$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency.

Correlation between Money Anxiety and Overall Fluency

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Overall Fluency)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.219$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency.

Correlation between Other Anxiety and Overall Fluency

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Overall Fluency)

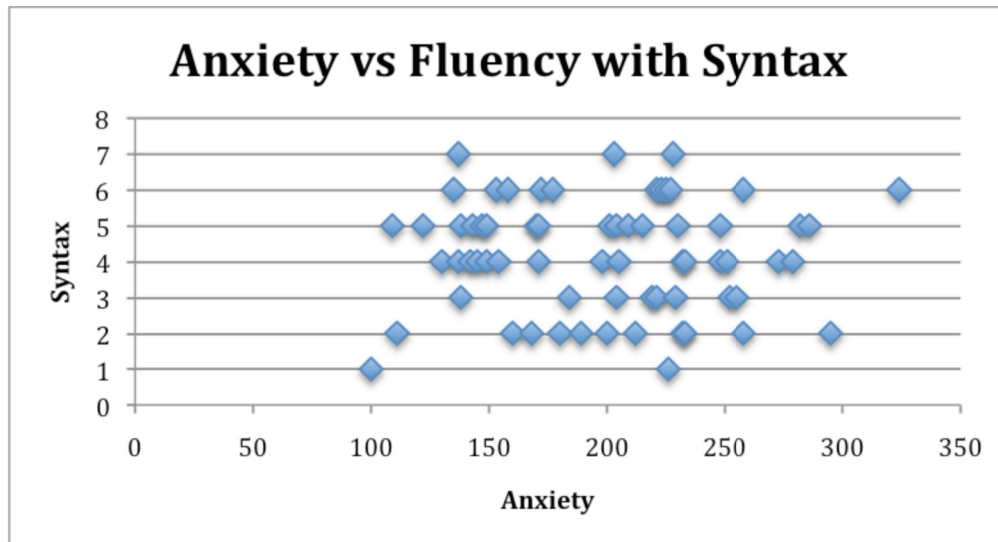
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.212$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency.

Correlation between Anxiety and Fluency with Syntax

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.008$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Syntax.

Figure 5: Scatter plot of Anxiety versus Fluency with Syntax



Correlation between School Anxiety and Fluency with Syntax

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.111$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency with Syntax.

Correlation between Money Anxiety and Fluency with Syntax

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.162$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Syntax.

Correlation between Other Anxiety and Fluency with Syntax

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Syntax)

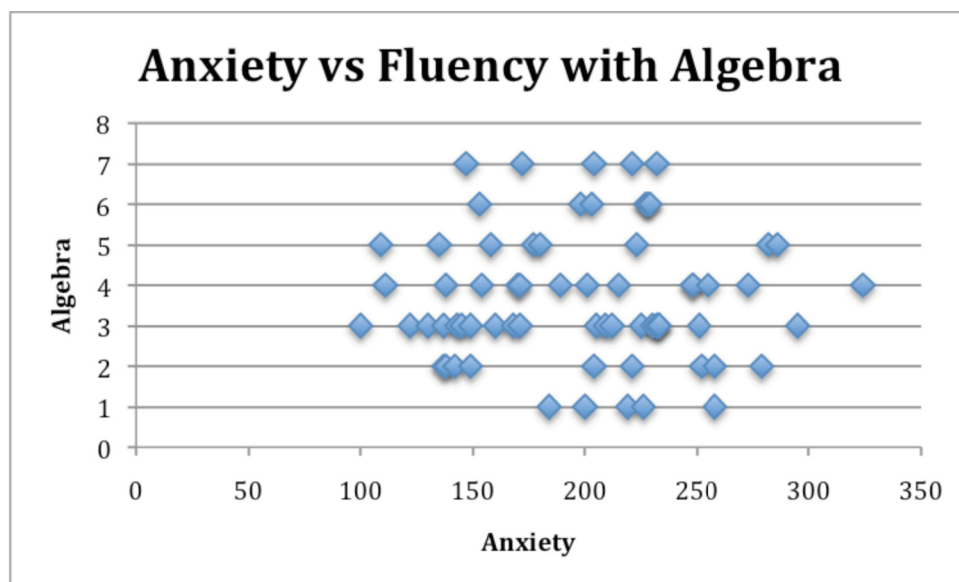
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.149$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Syntax.

Correlation between Anxiety and Fluency with Algebra

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.008$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Algebra.

Figure 6: Scatter plot of Anxiety versus Fluency with Algebra



Correlation between School Anxiety and Fluency with Algebra

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.087$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency with Algebra.

Correlation between Money Anxiety and Fluency with Algebra

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.142$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Algebra.

Correlation between Other Anxiety and Fluency with Algebra

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Algebra)

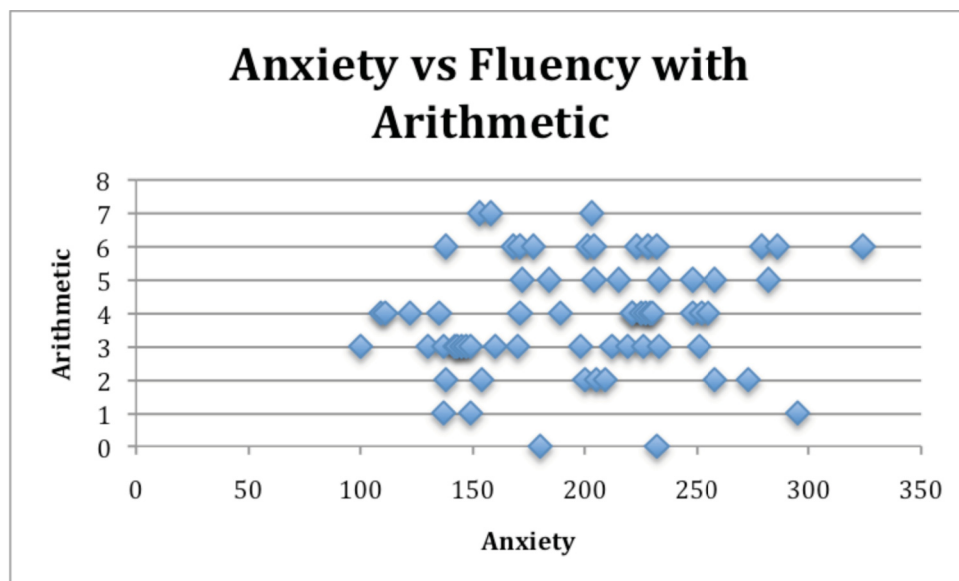
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.099$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Algebra.

Correlation between Anxiety and Fluency with Arithmetic

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.138$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Arithmetic.

Figure 7: Scatter plot of Anxiety versus Fluency with Arithmetic



Correlation between School Anxiety and Fluency with Arithmetic

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.061$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency with Arithmetic.

Correlation between Money Anxiety and Fluency with Arithmetic

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.222$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Arithmetic.

Correlation between Other Anxiety and Fluency with Arithmetic

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Arithmetic)

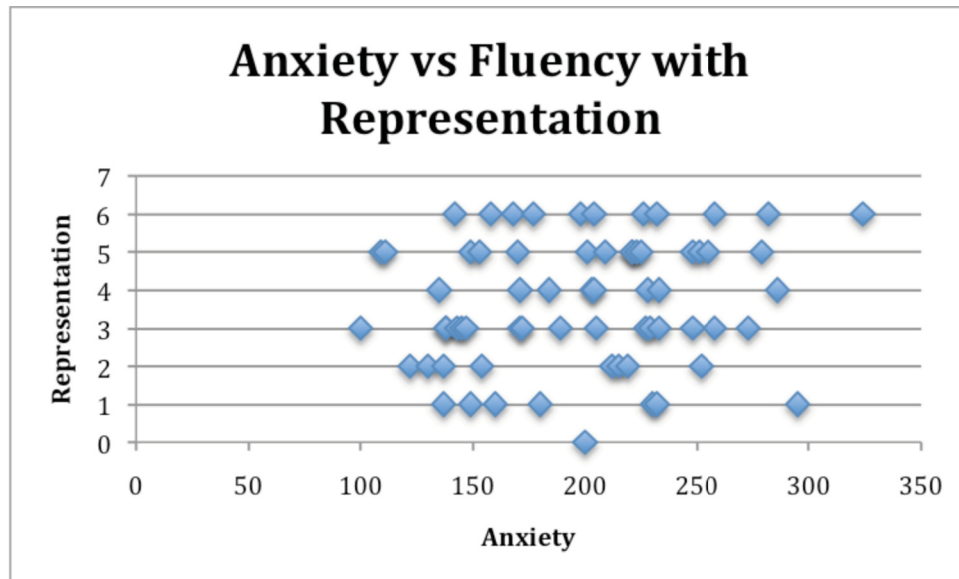
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.241$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Arithmetic.

Correlation between Anxiety and Fluency with Representation

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.161$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Representation.

Figure 8: Scatter plot of Anxiety versus Fluency with Representation



Correlation between School Anxiety and Fluency with Representation

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.114$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency with Representation.

Correlation between Money Anxiety and Fluency with Representation

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.191$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Representation.

Correlation between Other Anxiety and Fluency with Representation

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Representation)

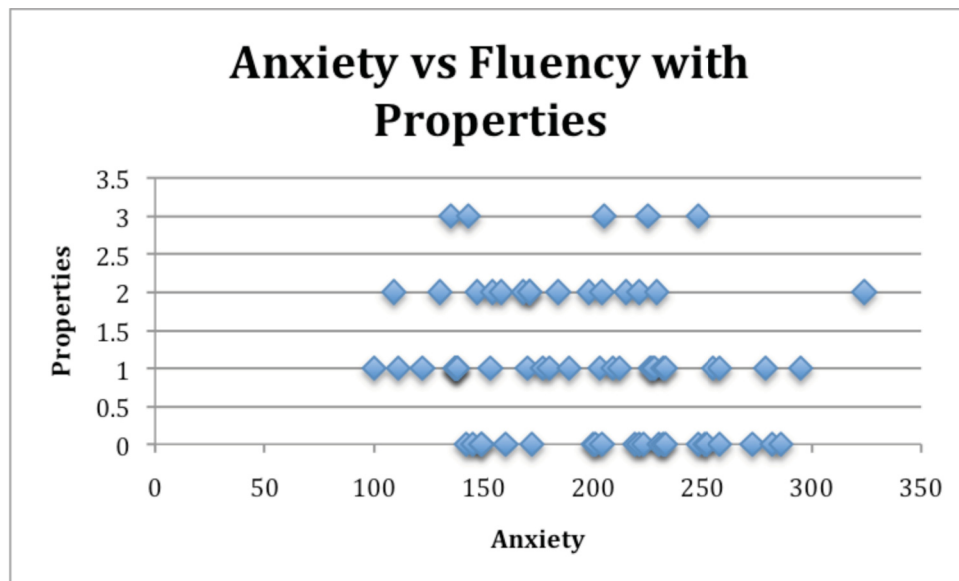
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.207$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Representation.

Correlation between Anxiety and Fluency with Properties

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.200$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Properties.

Figure 9: Scatter plot of Anxiety versus Fluency with Properties



Correlation between School Anxiety and Fluency with Properties

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.263$ for the sample is in the critical region, we must reject the null hypothesis, H_0 , and conclude that there is a statistically significant relationship between School Anxiety and Fluency with Properties.

Correlation between Money Anxiety and Fluency with Properties

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.068$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Properties.

Correlation between Other Anxiety and Fluency with Properties

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Properties)

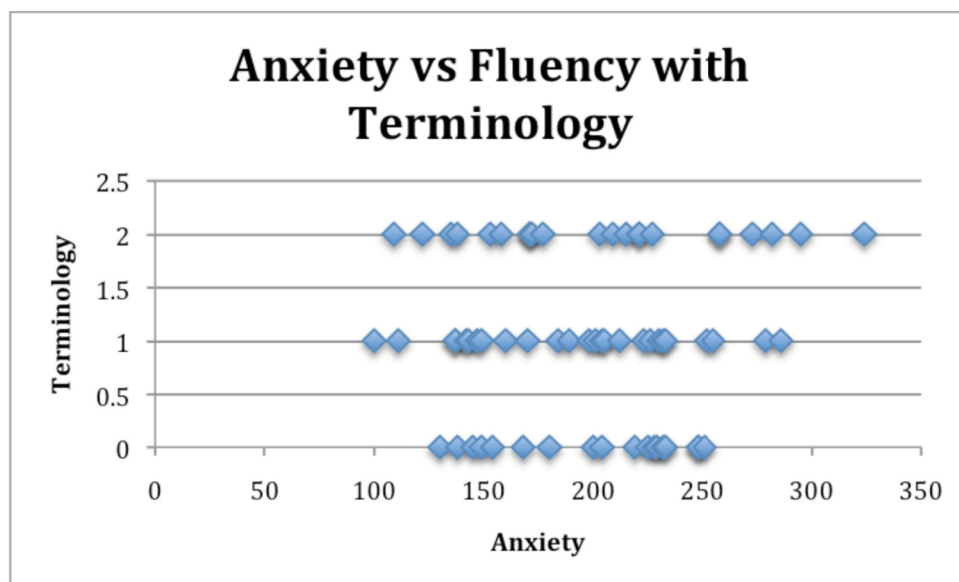
For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.034$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Properties.

Correlation between Anxiety and Fluency with Terminology

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.050$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Terminology.

Figure 10: Scatter plot of Anxiety versus Fluency with Terminology



Correlation between School Anxiety and Fluency with Terminology

$H_0: \rho = 0$ (there is no correlation between School Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.012$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between School Anxiety and Fluency with Terminology.

Correlation between Money Anxiety and Fluency with Terminology

$H_0: \rho = 0$ (there is no correlation between Money Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.161$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Money Anxiety and Fluency with Terminology.

Correlation between Other Anxiety and Fluency with Terminology

$H_0: \rho = 0$ (there is no correlation between Other Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 64$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.090$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Other Anxiety and Fluency with Terminology.

From all the relationships examined there were no statistically significant relationships between any of the three contexts of anxiety and overall anxiety to fluency

and the components of fluency except for between school anxiety and fluency with properties.

Results for each of the three schools

Inner-city School

For the participating students attending a school classified as inner-city, there were 14 respondents who form the sample that served to calculate the descriptive statistics for the MARS-A as well as the fluency questionnaire presented together in Table 3. The statistical analysis of the data from the fluency questionnaire is shown first as a whole and then in accordance with each of the components of the mathematics language. As revealed from the MARS-A data, grade 10 students from this school have overall anxiety scores that range from 109 to 324 points, with a mean anxiety score of 213.57 points and a standard deviation of 63.75 points. For the fluency questionnaire, students' scores range from 10 to 27 points with a mean of 17.14 points and a standard deviation of 5.75 points from this school

Table 3. Descriptive Statistics for each test factor for the inner city school.

	N	Minimum	Maximum	Mean	Std. Deviation
Anxiety	14	109	324	213.57	63.75
Fluency	14	10	27	17.14	5.75
Syntax	14	2	7	4.07	1.59
Algebra	14	2	6	3.57	1.22
Arithmetic	14	1	7	3.14	1.79
Represent	14	1	6	3.50	1.61
Properties	14	0	3	1.36	.93
Terminology	14	0	2	1.57	.65
Valid N (listwise)	14				

Table 4 presents the correlations between the results on the Mathematics Anxiety Rating Scale for Adolescents questionnaire and those on the overall fluency

questionnaire, for the inner city school. First, the MARS-A results are compared to the overall fluency results, and then compared to the results of each of the components of the fluency questionnaire. To determine if there are significant correlations, a 2-tailed Pearson correlation test was used with a level of significance of 5%. Each of the comparisons are analyzed and addressed following the presentation of the correlation coefficients in table 4.

Table 4: Correlations between Anxiety and each component of fluency for the inner city school.

		Fluency	Syntax	Algebra	Arithmetic	Represent	Properties	Terminology
Anxiety	Pearson Correlation	-.100	-.284	-.219	.077	.130	-.383	.307
	Sig. (2-tailed)	.733	.325	.453	.794	.658	.176	.286
	N	14	14	14	14	14	14	14

Correlation between Anxiety and Overall Fluency for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.100$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Overall Fluency.

Correlation between Anxiety and Fluency with Syntax for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.284$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Syntax.

Correlation between Anxiety and Fluency with Algebra for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.219$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Algebra.

Correlation between Anxiety and Fluency with Arithmetic for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.770$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Arithmetic.

Correlation between Anxiety and Fluency with Representation for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.130$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Representation.

Correlation between Anxiety and Fluency with Properties for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.383$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Properties.

Correlation between Anxiety and Fluency with Terminology for the inner city school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 12$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.307$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Terminology.

From the data collected and analyzed on the inner-city school it was found that there were no statistically significant relationships between anxiety and overall fluency and each of its components.

Suburban School

For the students attending the school classified as suburban, there were 23 respondents that form the sample that serve to calculate the descriptive statistics for the MARS-A as well as the fluency questionnaire presented together in Table 5. The statistical analysis of the data from the fluency questionnaire is shown first as a whole and then in accordance with each of the components of the mathematics language. As can be derived from the MARS-A data, grade 10 students in this study from this school have overall scores that range from 100 to 232 points, with a mean anxiety score of 178.91 points and a standard deviation of 41.55 points. For the fluency questionnaire, students' overall scores range from 5 to 24 points with a mean of 15.69 points and a standard deviation of 5.29 points.

Table 5. Descriptive Statistics for each test factor for the suburban school.

	N	Minimum	Maximum	Mean	Std. Deviation
Anxiety	23	100	232	178.91	41.55
Fluency	23	5	24	15.69	5.29
Syntax	23	1	7	4.13	1.77
Algebra	23	1	7	3.69	1.72
Arithmetic	23	0	6	3.35	1.64
Represent	23	0	5	2.57	1.16
Properties	23	0	3	1.00	.95
Terminology	23	0	2	.83	.83
Valid N (listwise)	23				

Table 6 presents the correlations between the results on the Mathematics Anxiety Rating Scale for Adolescents questionnaire and those on the overall fluency questionnaire for the suburban school. First, the MARS-A results were compared to the fluency results, and then compared to the results of each of the components of the fluency questionnaire. To determine if there are significant correlations, a 2-tailed Pearson correlation test was used with a level of significance of 5%. Each of the comparisons are analyzed and addressed following the presentation of the correlation coefficients in table 6.

Table 6: Correlations between Anxiety and each component of fluency for the suburban school.

	Fluency	Syntax	Algebra	Arithmetic	Represent	Properties	Terminology
Anxiety Pearson Correlation	-.035	-.017	.126	.030	-.021	-.133	-.397
Sig. (2-tailed)	.874	.938	.566	.893	.926	.545	.061
N	23	23	23	23	23	23	23

Correlation between Anxiety and Overall Fluency for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Overall Fluency)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.035$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Overall Fluency.

Correlation between Anxiety and Fluency with Syntax for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.017$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Syntax.

Correlation between Anxiety and Fluency with Algebra for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.126$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Algebra.

Correlation between Anxiety and Fluency with Arithmetic for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.030$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Arithmetic.

Correlation between Anxiety and Fluency with Representation for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.021$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Representation.

Correlation between Anxiety and Fluency with Properties for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.133$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Properties.

Correlation between Anxiety and Fluency with Terminology for the suburban school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 21$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.397$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Terminology.

From the data collected and analyzed on the suburban school it was found that there were no statistically significant relationships between anxiety and overall fluency and each of its components.

Rural School

For the students attending the school classified as rural, there were 29 respondents that form the sample that served to calculate the descriptive statistics for the MARS-A as well as the fluency questionnaire presented together in Table 7. The statistical analysis of the data from the fluency questionnaire is shown first as a whole and then in accordance with each of the components of the mathematics language. As can be derived from the MARS-A data, grade 10 students in this study from this school had overall scores that ranged from 111 to 286 points, and had a mean anxiety score of 205.62 points with a standard deviation of 47.74 points. For the fluency questionnaire, students' overall scores ranged from 10 to 30 points with a mean of 19.45 points and a standard deviation of 4.79 points.

Table 7. Descriptive Statistics for each test factor for the rural school.

	N	Minimum	Maximum	Mean	Std. Deviation
Anxiety	29	111	286	205.62	47.74
Fluency	29	10	30	19.45	4.79
Syntax	29	1	6	4.24	1.38
Algebra	29	1	7	3.83	1.77
Arithmetic	29	3	7	4.72	1.33
Represent	29	1	6	4.69	1.44
Properties	29	0	3	.93	.92
Terminology	29	0	2	1.00	.71
Valid N (listwise)	29				

Table 8 presents the correlations between the results on the Mathematics Anxiety Rating Scale for Adolescents questionnaire and those on the fluency questionnaire for the rural school. First, the MARS-A results were compared to the fluency results, and then compared to the results of each of the components of the fluency questionnaire. To determine if there are significant correlations, a 2-tailed Pearson correlation test was used with a level of significance of 5%. Each of the comparisons are analyzed and addressed following the presentation of the correlation coefficients in table 8.

Table 8: Correlations between Anxiety and each component of fluency for the rural school.

		Fluency	Syntax	Algebra	Arithmetic	Represent	Properties	Terminology
Anxiety	Pearson Correlation	.069	.190	-.009	.198	.032	-.219	.070
	Sig. (2-tailed)	.720	.323	.962	.303	.869	.253	.719
	N	29	29	29	29	29	29	29

Correlation between Anxiety and Overall Fluency for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Overall Fluency)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.069$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Overall Fluency.

Correlation between Anxiety and Fluency with Syntax for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Syntax)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.190$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Syntax.

Correlation between Anxiety and Fluency with Algebra for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Algebra)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.009$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Algebra.

Correlation between Anxiety and Fluency with Arithmetic for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Arithmetic)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.198$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Arithmetic.

Correlation between Anxiety and Fluency with Representation for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Representation)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.032$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Representation.

Correlation between Anxiety and Fluency with Properties for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Properties)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = -0.219$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Properties.

Correlation between Anxiety and Fluency with Terminology for the rural school

$H_0: \rho = 0$ (there is no correlation between Anxiety and Fluency with Terminology)

For $\alpha = 0.05$ and $df = 27$, the critical Pearson product-moment correlation coefficient is $r = 0.2423$. Since the test $r = 0.070$ for the sample is not in the critical region, we must accept the null hypothesis, H_0 , and conclude that there is *no* statistically significant relationship between Anxiety and Fluency with Terminology.

From the data collected and analyzed on the rural school it was found that there were no statistically significant relationships between anxiety and overall fluency and each of its

components.

The statistical analyses of the entire sample data demonstrate that the students experience moderate levels of anxiety (40%) and that they do not have a good grasp of the mathematics language (50%). There were particular sections of the fluency questionnaire on which students' fluency scores were higher, such as the one testing their ease with graphical representations, while other sections posed more difficulty, such as the ones treating properties and algebraic manipulations. There was no statistically significant correlation between components of mathematics anxiety and levels of fluency. As well, there was no statistically significant correlation between levels of mathematics anxiety and each of the components of the fluency questionnaire except for one situation between school anxiety and fluency with properties. This exception was just over the statistically significant threshold so its relationship was very weak. This held true for the entire sample of students as well as sub-samples of students from each of the three schools. However, in spite of the absence of correlations, the data do reveal that incoming grade 10 students' levels of fluency are low and that they do experience moderate levels of anxiety.

Part 2 – Discussion of the data

The purpose of this study is to determine if there exists a correlation between incoming grade 10 students' levels of mathematics anxiety and their levels of fluency in mathematics language. If such a correlation was determined, then the development of intervention strategies would have focused on mathematical literacy in order to improve students' disposition. The five research questions I raised for the study are:

1. How mathematics – anxious are grade 10 students in the Halifax Regional Municipality?
2. What is the level of fluency in the mathematics language of grade 10 students in the Halifax Regional Municipality?
3. Is there a relationship between levels of mathematics anxiety and levels of fluency in the mathematics language?
4. Are specific areas of difficulty with the mathematics language related to levels of mathematics anxiety?

In this part of the chapter, I discuss the answers to these questions and examine the results in order to gain a better understanding of how the levels of both mathematics anxiety and fluency of mathematics language may impact student learning.

How mathematics – anxious are grade 10 students in the Halifax Regional Municipality?

From the data that was collected using the MARS-A questionnaire on students' mathematics anxiety levels, it was found that on average the sampled students experienced a moderate level of anxiety. This number is based on the normative data from Suinn (1979). Looking at these numbers means that approximately half of the students are experiencing moderate levels of anxiety, and this would have an impact in a classroom. These findings are shared among the three schools; that is the same results hold true whether the students are from an inner city school, a suburban school, or a rural school. Overall, all of the students showed moderate levels of anxiety. A slightly higher level of anxiety was detected in students in the inner city school. However, given that the sub-samples were rather small (14 students in the inner city school, 23 students

in the suburban school, and 29 in the rural school), the slight difference could be explained by the number of participating students.

The Mathematics Anxiety Rating Scale was broken down into the three categories: those questions that pertain to anxiety experienced in a school setting, those questions that pertain to anxiety experienced when handling money, and those questions that do not have any particular context for the anxiety. The majority of the questions in the MARS-A fall within the school anxiety category. The results show that the students experienced moderate levels of anxiety regardless of the context. In other words, the students experience a moderate level of anxiety in all areas where mathematics is used, and not just in a school setting. It has been shown in other studies (Bessant, 1995; Hembree, 1990; Meece *et al*, 1990; Suinn & Edwards, 1982) that those students suffering from mathematics anxiety often do not choose careers paths that require mathematics or do not choose to continue their studies in mathematics and that the anxiety impacts on their performance on standardized tests and course grades. The moderate levels of anxiety students' results in areas other than the school setting on the MARS-A supports the claim that experiencing mathematics anxiety in all aspects of life is a reason why students do not choose careers that involve knowledge of mathematics.

The MARS-A is a self-reporting questionnaire. Students may or may not have been candid in their answers. Consequently, the results may not genuinely reflect students' anxiety levels. In particular, it is highly probable that the participating students suffer from higher levels of anxiety than reported. Nevertheless, the moderate levels of anxiety reported by the students are sufficiently significant to warrant intervention. Relieving anxiety would improve student achievement in mathematics, which would then increase the number of students choosing career paths that involve knowledge of

mathematics (Hembree, 1990; Suinn & Edwards, 1982). In particular, a clearer awareness of students' level of anxiety should guide teachers in tailoring their classroom practices in a way that might improve their disposition.

What is the level of fluency in the mathematics language of grade 10 students in the Halifax Regional Municipality?

The Fluency Questionnaire collected data on various components essential to students' understanding of the language of mathematics. The results of this questionnaire were analysed as a whole and then in accordance with the various categories. As a whole, students showed a moderate level of fluency in the mathematics language. The questionnaire revealed that the students were familiar with approximately half of the mathematics language that incoming grade ten students should understand with the students that were sampled in this study. It has been shown in previous studies that not understanding various components of the language of mathematics affects a student's ability to do mathematics successfully (Axtel *et al.*, 2009, Adams, 2003; Esty, 1992). The information collected from this study confirm the findings of these studies. Levels of fluency differed slightly among the locations of the schools. In the rural school, they had the highest fluency in mathematics language whereas in the suburban school it had the lowest levels of mathematics fluency. These levels ranged from a 15.69 to a 19.45 out of a possible score of 35. However, the results from all of these schools showed moderate levels of fluency.

The fluency questionnaire tested six components of mathematics language: syntax, algebra, arithmetic, representations, properties, and terminology. The results show that students have more difficulty in some areas of fluency than others. In

particular, the area in which the students had the most difficulty was in recognizing properties of mathematics with only 27% correct and then followed difficulties in the areas of algebra 47%, arithmetic 49%, and terminology 53% in that order. The areas that students performed the best were in syntax 60% and representations 62% in correct responses. However, even in these areas their knowledge was lacking because students were not able to achieve an expected higher number of correct responses. The results are similar in each of the school locations except in the case of the suburban school where students demonstrated much lower levels of understanding representations 43%, compared to the overall average of 62% of correct responses. Similarly, the results in the rural school show higher levels of fluency with 56% rather than the overall average of 50%. In the school located in the inner city, the students' results show higher than average understanding of terminology. Overall, students, either by school or as one large group, do not sufficiently understand the language of mathematics to be considered fluent.

There are a number of implications arising from this part of the study that may guide teachers. In knowing the specific areas in which students do not understand the language, teachers may better focus their interventions. Helping students with regards to the language improves their understanding of the mathematics concepts (Adams, 2003; Esty, 1992, Esty & Teppo, 1996; NCTM, 2000; Piccolo *et al*, 2008). If teachers, and the students themselves, were aware of each student's particular areas of difficulty with the mathematics language, they could develop strategies to overcome them more efficiently. As well, it is well-established that the ability to communicate in the language helps with understanding.

Is there a relationship between levels of mathematics anxiety and levels of fluency in the mathematics language?

One of the most interesting finds of this study was that there was no correlation between anxiety and fluency. Thus, improving one of the factors may not necessarily directly improve the other. However, since improving fluency in the language of mathematics improves understanding and that understanding improves students' disposition toward the subject, we may presume that tackling language issues will ultimately relieve anxiety. The data from the sample also show that there is no statistically significant correlation between levels of anxiety and each of the different factors of fluency. There was a slight correlation between anxiety in the school setting and fluency with properties of mathematics, but the relationship is quite weak since the correlation coefficient is -0.263 which is slightly less than the test r -value of -0.2423 . However, this correlation is interesting due to the fact that the questions regarding mathematical properties are items that students may see mainly in school, and have probably not encountered in other aspects of their life, particularly since the items focused on exponents; skills students develop with regards to the other components of the questionnaire (syntax, algebra, arithmetic, terminology, representations) may be required in other subject areas or in daily life. The data were also analysed with respect to each sub-sample determined by the schools' locations. There were no statistically significant correlations between anxiety and fluency within each school.

An absence of correlation between mathematics anxiety and fluency in the language of mathematics does not imply there are no pedagogical repercussions of each of these components. What the study does reveal is that both grade 10 students' anxiety

and their fluency levels are mid-range and thus point to an important malaise. For teachers, the results indicate a clear need for further pedagogical interventions that tackle both anxiety and fluency. For students, the MARS-A results reveal that their anxiety levels are sufficiently high to necessitate support and the fluency questionnaire highlights areas in their mathematical language skills on which to focus their efforts. The moderate levels of anxiety and fluency, although not significantly correlated, do call for further study, and in particular, for research into effective classroom methods directed specifically toward improving disposition and fluency.

Are specific areas of difficulty with the mathematics language related to levels of mathematics anxiety?

Overall, there was no correlation between specific areas of the language of mathematics and levels of anxiety. The results show that every component of the mathematics language needs improvement, regardless of the students' disposition toward mathematics.

This study allowed me to answer many questions that I have been posing over my years of teaching and I have arrived at interesting and surprising findings. The most surprising finding was to learn that there is relationship between levels of mathematics anxiety and levels of fluency in the mathematics language. The results do, however, reveal that the students who participated in the study experience moderate levels of mathematics anxiety with a mean of 198.15 and do not have a solid grasp of the mathematics language, with an average of 50% on the fluency questionnaire. There are a number of ways in which the information obtained in this study could be put to use in helping both students and teachers achieve greater success in the mathematics

classroom, which in turn would help students overcome their fears and develop the skills they need in order to choose career or study paths that are more in line with their actual interest and potential. Indeed, the results of this study suggest a number of possible directions for further research in order to gain a better understanding of how fluency and anxiety play key roles in students' mathematical studies. These are discussed in the concluding chapter.

Chapter 5 - Conclusion

INTRODUCTION

The purpose of this study was threefold: I wished to determine the levels of mathematics anxiety incoming grade 10 students experience, to learn to what extent they are fluent in the language of mathematics, and to examine the relationship between these two factors that have important implications for the learning of mathematics. With my experience as a teacher, I suspected that students' levels of mathematics anxiety would be high, that their fluency in the mathematics language would be limited, and that there would be a strong relationship between these two factors. However, while the results of this study indicate that levels of anxiety are in the moderate range, and that levels of fluency are in the moderate to low range, I was surprised to learn that there is no correlation between the two.

Many research studies underscore that anxiety plays an important role in student achievement and in their choice of mathematics courses as well as in their choice of career paths (Baloglu & Kocak 2006; Beilock et al, 2009; Chinn, 2009; Newstead, 1998; Richardson & Suinn, 1972). As well, studies do confirm that fluency in the mathematics language plays a part in a student's attitudes toward mathematics (Cates & Rhymer, 2003; Wakefield, 2000). The relationship between the two, however, had not been studied before. In order to examine both of these factors and how they may be related, I asked grade 10 mathematics teachers in three different schools—suburban, urban, rural — to administer two questionnaires that assessed their students' levels of anxiety and their levels of fluency. Students responded to these questionnaires during two classes in

the same week. The first questionnaire the students responded to was on mathematics anxiety and the second was on fluency in the language of mathematics language. The reason for administering the questionnaires in this order was to ascertain that the anxiety questionnaire was not affected by the response to the fluency questionnaire. The responses to the questionnaire then served to gain insight into incoming Nova Scotian high school students' levels of anxiety and of fluency.

The results of the mathematics anxiety rating scale show that students' levels are in the moderate range when compared to the norm (Suinn, 1979). These results, although moderate, still indicate that students do experience high enough levels of anxiety to interfere with their success in mathematics. The results to the fluency questionnaire reveal that students do not have a sufficiently good grasp of the mathematics language, which also affects their potential success in high school mathematics courses. The results of each of the questionnaires match my expectations. However, I am surprised to discover that there is no correlation between fluency and anxiety. Even after examining the relationship between components of anxiety (in school contexts, in monetary contexts, and in other contexts) and components of fluency (syntax, algebraic manipulation, arithmetic, representations, properties, and terminology), I found that there was no statistically significant correlations exist. I also analysed the data to determine if there are correlations between anxiety levels and fluency levels within a school. Again, no statistically significant correlations exist. As discussed in the previous chapter, this does not entail that there is no relationship between the two factors. The relationship may be indirect rather than linear. In other words, since fluency in the language of mathematics impacts the understanding of

mathematics and that understanding reduces anxiety, tackling fluency issues may indirectly improve students' disposition toward mathematics.

Limitations

The main limitation of this study is that the assessment instruments are self-reporting questionnaires. The limiting implication of self-reporting in the case of the MARS-A questionnaire is that students were asked to judge their own feelings and attitudes for each of the items on the questionnaire and thus may not have provided authentic, unbiased measures of their anxiety levels. The limitation of the fluency questionnaire is that students volunteered to participate in the study and thus may not have put as much effort into answering the questions as they would have should their scores have counted toward their grade in the mathematics course. As well since it was voluntary it may not even be an accurate representative within their school. Consequently, in both cases, the results obtained may not tell the whole truth about their levels of anxiety and their levels of fluency.

Another limitation of the study is the number of participants. Although 66 students out of the 110 distributed consent forms participated in the study—a large number of positive responses in this kind of sampling approach—this number does not allow me to use sample results to generalise my conclusions about the whole grade 10 student population in Nova Scotia.

Future Considerations

The current study's purpose was to measure the levels of anxiety and of fluency in selected grade 10 mathematics classrooms in Nova Scotia, and to determine the possible

relationship between the two. It did not, however, examine the effect of the demonstrated levels of anxiety and fluency on Nova Scotian high school students' achievement in mathematics. Further research studies may be needed to uncover the starting point of the anxiety, to trace its development before students arrive in high school, and to determine its impact on student achievement and on their choices. Further research is also needed to determine when and where difficulties with fluency in the language of mathematics arise and how to intervene effectively to ensure that issues are resolved before commencing high school. The current study reveals that certain components of the language of mathematics are less problematic than others and thus the development and testing of alternative teaching approaches focusing on those problematic language areas would be highly beneficial. Improving students' mathematics language skills should provide them with more opportunity to become more successful in mathematics, and thus more students would feel encouraged to choose career options that involve mathematics. Indeed, North American students are not pursuing education and careers options in similar ways to students in other countries which show greater success in mathematics. Friedman (2008, pg1) states that "only 15% of U.S. graduates are attaining degrees in the natural sciences and engineering, compared to 50% in China". Since the United States is falling behind in the technology and innovation race, the government promoting and supporting a substantial number of initiatives that aim to interest more students in pursuing science and technology careers (Feller, 2010).

Practical Implications

There are a number of practical suggestions resulting from this study. The first is that communicating results obtained on incoming students' levels of anxiety and fluency to grade 10 mathematics teachers would benefit students immediately. If teachers were more clearly aware of these contributing factors, they could adapt or develop strategies that involved more focus on disposition and understanding the language of mathematics. In particular, teachers could design learning experiences in which students feel more at ease and are provided with coping mechanisms that relieve anxiety. For the fluency factor, teachers could design learning experiences that address the different components more specifically and focus on those areas that are more problematic. Furthermore, knowing each student's strengths and weaknesses in the language of mathematics, teachers could provide differentiated homework assignments and provide more focused support during resource periods. Clearly, adapting teaching strategies in order to support students with respect to both of these factors, would help student success improve (Adams, 2003; Chinn, 2009; Hembree, 1990).

A second instance where this information could be put to practical use is at the policy setting level, and in particular, with regards to developing the provincial curriculum. The National Council of Teaching Mathematics has identified ten main standards in learning mathematics, and although all of these standards apply to each grade level, emphasis on some of them will vary both within and between the grade levels (NCTM, 2000). Examining these standards in light of the students' difficulties with the language of mathematics, policy makers could design a provincial curriculum that

offers more opportunities for developing fluency. Increased fluency leads to increased understanding, and increased understanding reduces anxiety.

In conclusion, this study informs on the levels of mathematics anxiety and fluency experienced by grade 10 mathematics students in the three selected schools. Given that the results were similar in each of the three schools, we may be able to infer that the results would not be significantly different for a larger sample. In light of this study, further research studies as well as short-term strategies can be developed in order to help students overcome their difficulties.

Appendix A: Permission for MARS - A

Date: Sun, 28 Feb 2010 13:31:46 -0700 [28/02/10 04:31:46 PM ADT]
From: Richard Suinn <suinn@lamar.colostate.edu>
To: Erin Schaus <eschaus@staff.ednet.ns.ca>
Subject: Re: Permission

Yes you have my permission to use the MARS-A as purchased by you.

On Feb 28, 2010, at 12:52 PM, Erin Schaus wrote:

[Hide Quoted Text]

Hello Dr Suinn, I am in my final stages of writing my thesis proposal and I realized that I need your written permission to use the MARS-A version that I purchased from you. Could you please confirm with me that I have your permission to use this instrument in my study. My study will be examining levels of mathematics anxiety and fluency among grade 10 students in Nova Scotia.

Thank you
Erin Schaus

--

Ms Erin Schaus
Dartmouth High School
[REDACTED]

Appendix B: MARS A

Sample items from MARS – Adolescents

Mathematics Anxiety Rating Scale (MARS-A)

The items in the questionnaire refer to things and experiences that may cause tension or apprehension. For each item, place a color in the circle under the column that describes how much you would be made anxious by it. Work quickly, but be sure to think about each item.

How anxious.....	Not at all	A little	A fair amount	Much	Very Much
1. Deciding how much change you should get back from buying several items					
2. Having someone watch you as you divide a five digit number by a two digit number.					
3. Figuring out your grade average for you last term.					
4. Doing a word problem in algebra					
5. Listening to another student explain a math formula.					
6. Being called on to put a problem on the board when you are not sure your answer is right.					
7. Measuring how much border to leave and how to place five pictures on a bulletin board					
8. Figuring the sales tax for something that costs more than \$1.00					
9. Studying for a driver's license test and memorizing the numbers involved, such as the distances it takes to stop a car going at different speeds.					
10. Being given a set of multiplication problems to solve on paper					

Appendix C: Fluency Questionnaire

Fluency Questionnaire

Nickname: _____ 80

1. Please circle all of the expressions that are equivalent to: $-2(x+5)$

- A) $-(2x+10)$ B) $-2x+5$ C) $-2x-10$ D) $-2x+3$ E) $-2x-5$

2. Please circle all of the expressions that are equivalent to $a-(b-c)$

- A) $a-b-c$ B) $a+b-c$ C) $a-b+c$ D) $a+b+c$ E) $(a-b)-c$

3. Please circle all of the expressions that are equivalent to $x+9=7$

- A) $x=7+9$ B) $x=7-9$ C) $x=7 \times 9$ D) $x=-7-9$ E) $x+2=0$

4. Please circle all of the expressions that are equivalent to $\frac{3x+12}{3}$

- A) $x+4$ B) $\frac{1}{3}(3x+12)$ C) $3x+4$ D) $x+3$ E) $x+12$

5 Please circle all of the expressions that are equivalent to $-36x^3 + 6x^2 - 18x^5$

- A) $6(x^3 + x^2 - 3x^5)$ C) $-6x^2(6x-1+3x)$ E) $6x(-6x^2 + x - 3x^4)$
B) $x^2(-36x-6-18x^3)$ D) $6x^2(-6x+1-3x^3)$

6. Please circle all of the expressions that are equivalent to $3x+2y-6x+8y$

- A) $-3x+10y$ B) $3x+10y-6x$ C) $5x+2y$ D) $10y-3x$ E) $-3x-6y$

7. Please circle all of the expressions that are equivalent to $-2x > 8$

- A) $x > -4$ B) $x < -4$ C) $\frac{-x}{4} > 1$ D) $-4 > x$ E) $-4 \geq x$

8. Please circle all of the expressions that are equivalent to $3\left(\frac{4}{5}\right)$

- A) $\frac{3 \times 4}{3 \times 5}$ B) $\frac{3 \times 4}{5}$ C) $\frac{4}{3(5)}$ D) $\frac{3 \times 5}{4}$ E) $\frac{3(4)}{5}$

9. Please circle all of the expressions that are equivalent to $\frac{3}{5} \div \frac{1}{7}$

A) $\frac{3}{5} \times \frac{1}{7}$

B) $\frac{5}{3} \times \frac{1}{7}$

C) $\frac{3}{5} \times \frac{7}{1}$

D) $\frac{(3)(7)}{(5)(1)}$

E) $\frac{5}{3} \times \frac{7}{1}$

10. Please circle all of the expressions that are equivalent to $\sqrt{2} \times \sqrt{2}$

A) $\sqrt{2}$

B) 2

C) 4

D) $2\sqrt{2}$

E) $\sqrt{4}$

F) -2

11. Please circle all of the expressions that are equivalent to $\frac{1}{6} + \frac{3}{6}$

A) $\frac{1+3}{6+6}$

B) $\frac{1 \times 3}{6 \times 6}$

C) $\frac{6+18}{6 \times 6}$

D) $\frac{1+3}{6}$

E) $\frac{4}{36}$

12. The coordinates of the following point are:

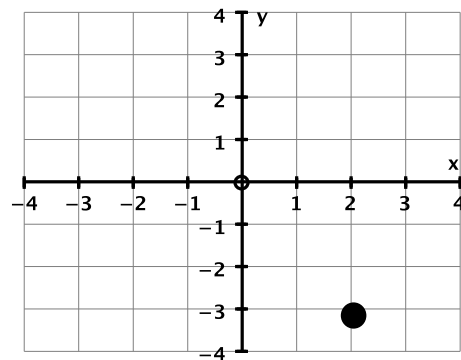
A) (2,3)

B) (-3,2)

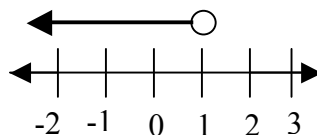
C) (2,-3)

D) (-2,-3)

E) (3,-2)

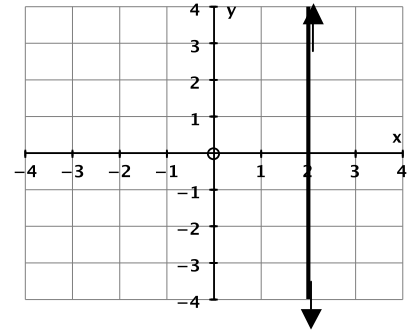


13. Given the following number line, which of the following expressions identify the interval? Please circle all of the expressions that are equivalent

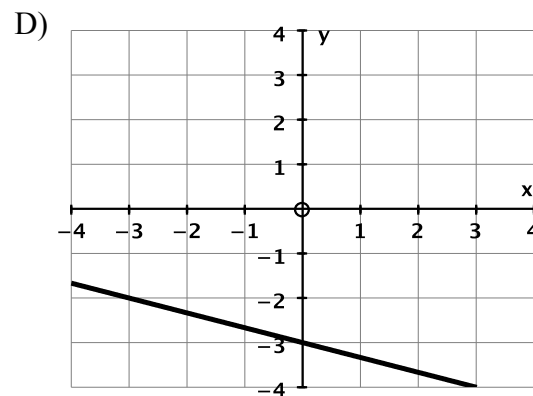
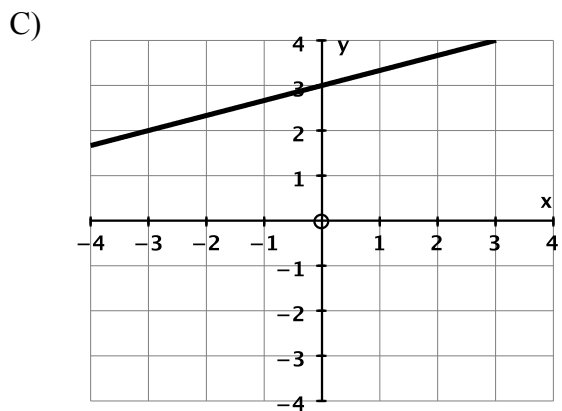
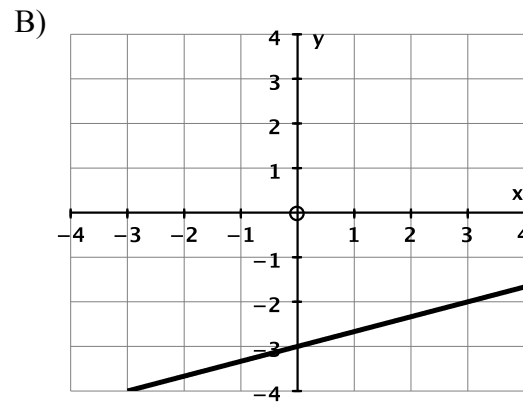
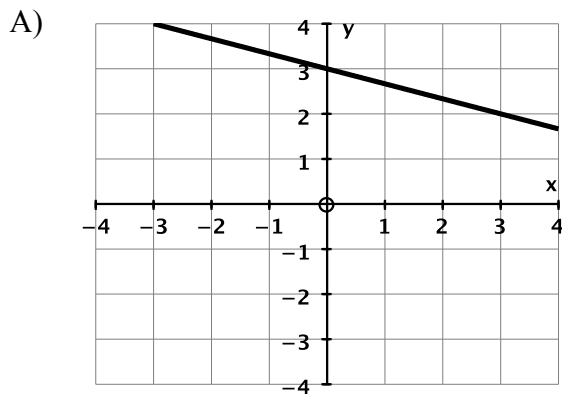
A) x is greater than 1B) $1 < x$ C) $x < 1$ D) x is less than or equal to 1E) x is less than 1

14. The equation of the following graph is:

- A) $y = 2$
- B) $x = 2$
- C) $y = 2x + 2$
- D) $y = 2x$
- E) $x = 2y$

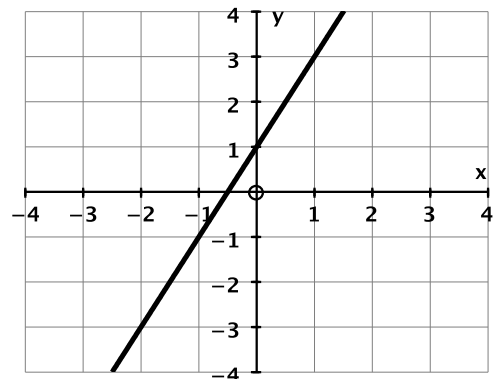


15. Choose the graph that represents $y = -\frac{1}{3}x + 3$:



16. The equation for the following graph is:

- A) $y = -2x + 1$
- B) $y = \frac{x}{2} + 1$
- C) $y = 2x + 1$
- D) $y = 2x - 1$
- E) $y = \frac{x}{2} - 1$



17. Please circle all of the expressions that are equivalent to $(ab^{-1})^3$

- A) a^3b^3 B) a^3b^{-3} C) $\frac{a \times a \times a}{b \times b \times b}$ D) ab^{-3} E) $3ab^{-1}$ F) $\left(\frac{a}{b}\right)^3$

18. Please circle all of the expressions that are equivalent to $(-3)^2$

- A) -9 B) 9 C) -3^2 D) -6 E) $\frac{1}{3^2}$

19. Please circle the definition of similar figures:

- A) Geometric figures that are the same shape and same size
- B) Geometric figures that are the same shape and different sizes
- C) Geometric figures that are different shapes and same size
- D) Geometric figures that are different shapes and different sizes

20. Please circle the correct definition of product:

- A) is the result given by the operation of addition
- B) is the result given by the operation of subtraction
- C) is the result given by the operation of multiplication
- D) is the result given by the operation of division

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