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Understanding the Variables Associated with Mathematics Achievement

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Understanding the Variables Associated with Mathematics Achievement

BY

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THESIS

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Understanding the Variables Associated with Mathematics Achievement

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Abstract

Mathematics achievement scores on standardized test batteries are a major area of concern in public schools. This study examined the relationships among different variables that may affect mathematics achievement as measured by the Iowa Test of Basic Skills (ITBS). Specifically, this study investigated the relationships among gender, mathematics fluency, mathematics accuracy, anxiety toward mathematics, and mathematics composite scores on the ITBS. In addition, the study assessed the effects of gender and anxiety on mathematics achievement as measured by accuracy, fluency, and ITBS math scores. One hundred fourth and sixth grade participants completed the Fennema-Sherman Mathematics Anxiety Scale to measure their levels of anxiety about performing mathematical operations. Students were then presented with timed mathematics probes to measure their accuracy levels (percent correct) and fluency rates (number of digits correct per minute) in basic mathematical operations. Finally, participants' most recent ITBS mathematics composite scores were assessed.

Results indicated that participants' mathematics anxiety was a better predictor of mathematics achievement as measured by the ITBS than participants' levels of mathematics fluency. Results further indicated that

anxiety level had a significant effect on state standardized test performance, but only for students who rated themselves at a high level of mathematics anxiety. Current results also suggested that participants' levels of anxiety did not affect accuracy of basic mathematical operations. This study provides a better understanding of the variables to investigate further in attempting to increase students' mathematics achievement.

Understanding the Variables Associated with Mathematics Achievement

Mathematics achievement is a topic of national importance. Achievement in mathematics is valuable not only for students' academic success throughout their schooling, but is equally important for adults to be successful throughout their daily lives. In fact, according to Hembree (1990), the country's resource base in science and technology is dependent upon students' study of and participation in mathematics.

The importance of mathematics achievement is highlighted by the variety of instruments offered for measuring mathematics achievement in the United States. Of the various instruments available, standardized tests are a common method for gauging students' relative mathematics achievement across individuals and groups (e.g. classrooms, schools, and districts).

Standardized achievement test scores are used by school districts to measure the effectiveness of academic instruction and determine students' current levels of educational functioning as well as to design future curriculum (Qualls & Ansley, 1995). Standardized achievement test scores are also utilized in making placement decisions and recommendations throughout a student's school career (i.e., advanced or remedial course placement) (Qualls & Ansley, 1995). Such standardized batteries have also provided useful information related to individual students' college potential (Darling & Hammond, 2002). A common use of standardized test scores in urban school districts is to retain students in grade as a means of ending "social promotion" of students and to deny diplomas (Darling & Hammond, 2002).

Scores on standardized tests affect not only individual students, but also school personnel and school systems as whole entities. For example, scores on standardized test batteries can affect teachers and principals when the results are used to determine merit pay and contract renewal (Darling & Hammond, 2002). Entire school systems are affected when schools are awarded extra governmental funds when their standardized test scores improve. In addition, when standardized test scores are low, school funding is withdrawn and some schools are placed into intervention or sanction status (Darling & Hammond, 2002).

Many standardized test batteries are available for use in school districts in the 47 states that have in place statewide testing systems. For example, the Iowa Test of Basic Skills (ITBS) is a commonly used standardized battery. The ITBS is an annual achievement test that can be administered individually or in groups. It measures year-to-year growth in academic skills, compares a student's achievements with others in the same grade or level, and it shows a student's academic strengths and weaknesses. Research has indicated that 1994-1995 ITBS scores predicted student dropout (e.g., Robinson, 2001).

The ITBS requires approximately four to six hours to administer and can be taken over a two to five day period (pesdirect.com/itbs.html). The ITBS measures a variety of student skills including listening, word analysis, reading, vocabulary, comprehension, language, science, social studies, and mathematics. Three types of mathematics tasks comprise the ITBS composite mathematics achievement score: concepts, problem solving, and computation. The focus of this research was on understanding the variables related to students' mathematics scores on the ITBS. These variables include gender, previous course work in mathematics, anxiety toward mathematics, accuracy, and fluency in basic math skills.

Gender

One factor of particular interest to educational researchers of mathematics achievement is the influence of gender on ITBS math scores. Gender differences in mathematics achievement have been the focus of extensive research over the years and the results of many studies have produced controversy (Kianian, 1996). Some researchers (e.g. Kianian, 1996; Swafford, 1980) present evidence supporting the notion that there are no significant gender differences in mathematics achievement. In a meta-analysis of 100 recent studies on mathematics achievement, results indicated that the gender gap is very small and statistically insignificant (Hyde, Fennema, and Lamon, 1990).

Other researchers have argued that gender differences in mathematics performance exist but they do not usually appear until at least the beginning of the secondary school years, and when they do appear, they almost always favor males (e.g. Fennema & Sherman, 1978). However, other studies suggest that females perform better than males in mathematics (Galbraith, 1986).

Still other researchers argue that neither gender has superior mathematics achievement overall, but that each gender might be superior in different areas of mathematics achievement. For example, according to Hyde et al., (1990), females tend to outperform males in computation while males score higher in the area of problem solving. Various hypotheses are suggested as to the causes of these gender differences, for instance, biology and differential treatment of males and females.

Beside gender, an internal factor may affect students' participation and success in mathematics courses.

Anxiety

Anxiety toward mathematics is another possible predictor of mathematics achievement. According to Ho, Senturk, and Lam (2000), a majority of studies on math anxiety have been conducted with students in the United States and have highlighted its debilitating effects on mathematics performance. In fact, some researchers (e.g., Betz, 1978) suggest that people anxious about mathematics may actually avoid mathematics classes.

Anxiety is defined as apprehension, tension, or uneasiness from the anticipation of danger, the source of which is largely unknown (Reyes, 1984). However, not all researchers agree on this definition. For example, mathematics anxiety is a more specific form of anxiety in which students are not confident with their skills and they feel tension and worry when required to manipulate numbers (Reyes, 1984). Mathematics anxiety has also been described as an anxious state in response to mathematics-related situations that are perceived as threatening to self-esteem (Cemen, 1987). Another definition of the construct describes mathematics anxiety as a condition in which pupils experience negative reactions to mathematical concepts (i.e., numbers) and evaluation procedures (i.e., testing) (Richardson & Woolfolk, 1980). Still other experts (Hembree, 1990) define mathematics anxiety as a subject-specific manifestation of test anxiety.

The lack of an agreed upon operational definition may help explain why the search for determinates of mathematics anxiety is largely unsuccessful. Although researchers do not generally agree on one definition of mathematics anxiety, they do agree as to the negative consequences suffered by students who experience mathematics anxiety. Such consequences may include the inability to do mathematics, the decline in mathematics achievement, and the avoidance of mathematics courses (e.g., Armstrong, 1985).

Research on mathematics anxiety has generally supported the notion that a relationship between mathematics anxiety and mathematics performance exists (e.g. Cates, Rhymer, Smith and Skinner, 1998; Cates & Rhymer 2002; Ma, 1999). Ma (1999) conducted a meta-analysis of 26 studies examining the relationship between anxiety toward mathematics and achievement in mathematics among elementary and secondary school students. Ma (1999) concluded that the common population correlation for the relationship is significant (-.27). Further, a series of general linear models indicated that the relationship is consistent across gender groups, grade-level groups, and ethnic groups (Ma, 1999).

While researchers recognize the relationship between mathematics anxiety and mathematics achievement, many disagree as to the appropriate methods of decreasing mathematics anxiety or increasing mathematics achievement. Some researchers of mathematics anxiety suggest that applied counseling and teaching techniques should be used in reducing mathematics anxiety (Hunt, 1985). In a meta-analysis of 151 studies, Hembree (1990) listed several examples of mathematics anxiety treatments, such as systematic desensitization, anxiety management, and cognitive restructuring combined with relaxation training. In addition, various treatment clinics in the United States use and promote techniques such as: progressive relaxation training, guided imagery, discussion of negative feelings, identification of negative behaviors, and classroom assertiveness for the treatment of mathematics anxiety (Kostka & Wilson, 1986).

Fluency

Still other researchers advocate a much different approach for reducing mathematics anxiety by emphasizing the importance of increasing mathematics achievement while simultaneously and indirectly decreasing mathematics anxiety. For instance, Wittman (1996) examined the relationship between fluency (i.e., automatization) of multiplication facts and elementary school children's mathematics anxiety. Groups of fourth grade elementary school children exhibiting high and low mathematics anxiety were given extended drill and practice training in multiplication facts using a computer-assisted instruction program designed to bring student proficiency to the fluency level. Results of the Wittman (1996) study suggested that increasing fluency of multiplication skills could reduce mathematics anxiety.

Evidence of the relationship between mathematics anxiety and lack of mathematics skills was also obtained by Adams and Holcomb (1986). This research consisted of analyses of mathematics anxiety measures and performance measures with college students enrolled in a statistics course. Analysis yielded one significant factor that explained the correlation between mathematics anxiety and mathematics performance. Adams and Holcomb (1986) labeled this factor mathematics efficiency (i.e., fluency). Findings of this study are congruent with the Wittman

(1996) study, which suggests that mathematics anxiety is correlated with mathematics fluency.

Cates et al. (1998) used a measure of digits correct per minute to examine mathematics anxiety and mathematics fluency among college students. Students were asked to complete the Fennema-Sherman Mathematics Anxiety Scale (FSMAS; Fennema & Sherman, 1976), before beginning a series of mathematics assignments.

Students were allotted two minutes to complete each of four mathematics assignments: addition, subtraction, multiplication, and division. Each assignment consisted of 30 1-digit by 1-digit problems that were considered to be of fourth grade mastery level. That particular level was chosen under the assumption that the basic mathematics skills acquired by fourth grade students should be fluent by senior level university students. Results suggested small but significant relationships between mathematics anxiety and number of problems completed, number of problems correct, and accuracy across the academic assignments. This study supported previous findings that suggested mathematics anxiety is negatively related to mathematics performance.

A limitation of the Cates et al. (1998) study was that participants were too homogenous. Participants of the study were mostly college of education majors showing little variability in levels of mathematics fluency (i.e., problems correct per minute). The authors of the study recommended that future research investigate the relationship between mathematics anxiety and mathematics achievement with a more heterogeneous sample since previous research has shown that student characteristics contribute to the diverse results in the literature on this topic (Cates et al., 1998).

Perhaps the most limiting aspect of the Cates et al., (1998) study lay within the curriculum used to measure mathematics fluency in college students. Specifically, the study employed fourth grade curriculum in testing college student fluency. Because the curriculum of most college students does not involve the multiplication of one-digit by one-digit numbers, generalizability of results of this study is limited (Cates et al., 1998).

A more recent study by Cates & Rhymer (2002) investigated the relationship between mathematics fluency and mathematics anxiety with different problem types and measured achievement differently in two ways: accuracy (i.e., percent of problems correctly completed) and fluency (i.e., how many digits were correctly completed per minute). Participants were first required to complete the

FSMAS to measure their levels of mathematics anxiety. Participants were then organized into high- or low-mathematics-anxiety groups based on their FSMAS scores. Both groups of students were then required to complete a series of five timed mathematics probes of addition, subtraction, multiplication, division, and linear equations.

Students were asked to work as quickly as they could on the five timed mathematics probes without risking accuracy. Students were allotted one minute to complete each of the addition, subtraction, multiplication, and division probes and four minutes to complete the linear equation probe. An experimenter independently scored a percentage of the probes to check for reliability. Fluency was calculated across all five probes.

The results of independent samples t-tests yielded statistically significant differences for addition, subtraction, multiplication, division, linear equations, and overall fluency rates between the high- and low-anxiety groups (Cates & Rhymer, 2002). The students who had lower anxiety completed more digits correct per minute on all probes than those students who had high anxiety as measured by the FSMAS. Results of the study further demonstrated no statistically significant differences in error rates between the high- and low-anxiety groups on any of the five math probes. This indicates that students who had high math anxiety were roughly equally accurate on basic mathematics operations as students who had low math anxiety (Cates & Rhymer, 2002). Cates & Rhymer's (2002) results support the notion that mathematics anxiety may be related to the level of learning (i.e., fluency) as opposed to overall mathematics performance (i.e., accuracy). Cates & Rhymer's (2002) study also showed that level of anxiety becomes a factor when multiple operations (i.e., regrouping) are required and problem types are lengthened.

Summary

As has been demonstrated by various studies (e.g., Cates et al., 1998; Cates & Rhymer, 2002; Ma, 1999; Wittman, 1996) mathematics anxiety is negatively correlated with mathematics achievement. Further, mathematics fluency is positively correlated with mathematics achievement (Cates et al., 1998). Previous research has primarily focused on grade school and college age students. Previous research has sometimes included gender with mixed results.

Purposes

There were five major purposes to the present study. First, this study attempted to extend the Cates & Rhymer (2002) study by making two basic design changes. The present study 1) held the number of digits in each of the mathematics probes constant, and 2) measured performance among fourth and sixth graders as opposed to college students.

A second purpose of the present study was to determine which variable(s): (anxiety levels, fluency levels or accuracy levels), best predicted mathematics performance for students as measured by the ITBS.

The third purpose of the study was to determine the extent to which gender and anxiety level (i.e. high or low) may affect state standardized test performance as measured by the ITBS.

The fourth purpose of the present study was to investigate what effects anxiety and gender have on accuracy of mathematics performance as measured by the four timed mathematics probes.

The fifth purpose of the present study was to investigate the effects anxiety and gender have on fluency of mathematics performance as measured by the four timed mathematics probes.

Methods

Participants and Setting

One hundred fourth and sixth grade students from two school districts in small Midwestern towns were participants in this study. The majority of residents in both districts was Caucasian, and from middle-class backgrounds. This number of participants was chosen in order to achieve a representative sample of fourth and sixth grade students without evaluating entire classes. Parents or guardians of fifty students from each grade, fourth and sixth, were asked to consent to their respective child's participation (Appendix A). Of the fifty students from each grade, the study attempted to examine equal numbers of males and females. All student participants were asked to sign informed assent (Appendix B). Participants were chosen on a strictly volunteer basis and were not paid. Participation took place during classes at both schools during times prearranged by the researcher and cooperating teachers.

Materials

Participants used pencils during the study and the researcher used a stopwatch. At the start of the study, all participants received packets of six 8.5 X 11-inch white sheets of paper, stapled together in the upper left corner of the packets. Each packet contained a page collecting identifying information from participants (Appendix C). Each participant was asked to indicate his or her first and last name, gender, age, and grade in school. Another page contained the Fennema-Sherman Mathematics Anxiety Scale (Appendix D).

The four remaining pages (Appendices E, F, G, H) contained the mathematics tasks. The Fennema-Sherman Mathematics Anxiety Scale (FSMAS) consists of 12 statements about mathematics that can be answered by circling 'Strongly Agree,' 'Agree,' 'Neither Agree or Disagree,' 'Disagree,' or 'Strongly Disagree.' An example of a statement on the FSMAS is: "Mathematics usually makes me feel uncomfortable and nervous." Split-half reliability of the FSMAS is reported to be .89 and scores on the FSMAS have been found to be related to student grades in mathematics as well as student confidence in learning mathematics (Cates et al., 1998). The FSMAS instrument was used to assess student levels of mathematics anxiety.

The four types of mathematics tasks included addition, subtraction, multiplication, and division assignments. Each assignment consisted of 25 problems. Problems were arranged in five rows with five problems per row. All problems were constructed from a curriculum builder computer program for mathematics teachers, and all problems were of similar length. All problems were three-digit by two-digit tasks (e.g., 253 - 66) and required regrouping (i.e., borrowing or carrying). Problems were presented in a traditional vertical format with one three-digit number placed above a two-digit number, with the exception of the division probe. This probe was presented with a radical sign between the divisor and the dividend (e.g. 26/598). All fourth and sixth grade participants were administered the same problems on each of the probes. Although all students received the demographic sheet and the FSMAS first and second, respectively, the four mathematics tasks were presented in a counterbalanced fashion.

Procedure

All participants were given a six-page packet that contained the demographic page, the FSMAS, and the four mathematics probes. After students completed the demographic page, they were informed that they would be taking a series of brief timed tests in mathematics. Students were then instructed to complete the FSMAS. Students were allotted ample time to complete the FSMAS. Upon completion of the FSMAS students were instructed to work as quickly as they could on each of the mathematics probes without jeopardizing accuracy. Students were then told that if they finished any of the probes before they were directed to stop, to immediately raise their hands and be prepared for the experimenter to provide them with a time of completion to write on the top of their probe.

All four math probes were presented for one minute. After the allotted time expired, the experimenter said, "Stop, look up at me" and visually checked to make certain all students had stopped working. Students were then told, "Good, now I want you to flip to the next page and take the next brief timed test. You have one minute. Ready? Go!" Students were then given two seconds to flip to the next before the one minute timer was started. These procedures were repeated until the addition, subtraction, multiplication, and division probes had all been administered.

Variables of interest were 1) student demographics, 2) mathematics anxiety as measured by the FSMAS, 3) number of digits correctly completed per minute for each of the mathematics probes, 4) a total digits correct per minute score calculated by summing all digits correct per minute across the four probes, 5) accuracy of all individual probes, 6) combined accuracy across the four probes, 7) students' most recent ITBS composite mathematics score.

Research Questions

Research question 1: Which variable(s) best predict mathematics achievement as measured by the ITBS for all students?

Research question 2: What effects do anxiety levels and gender have on mathematics achievement as measured by the ITBS?

Research question 3: What effects do anxiety levels and gender have on mathematics performance as measured by the total digits correct per minute across the four fluency measures of addition, subtraction, multiplication, and division?

Research question 4: What effects do anxiety and gender have on accuracy of mathematics performance as measured by the total number of errors across the four fluency measures?

Analysis

Linear regression statistics were used to answer research question 1. For the purpose of answering research question 2, a 2 X 2 Analysis of Variance (ANOVA) was used. To answer research question 3, Analysis of Variance (ANOVA) statistics was employed on each of the four measures of mathematics fluency. Analysis of Variance (ANOVA) was also used on the total number of errors across the four fluency measures.

Results

Multiple linear regression analysis was used to develop a model for predicting mathematics achievement from students' mathematics fluency, accuracy, and students' anxiety. Basic descriptive statistics and regression coefficients are provided in Table 1. Results indicate that students' anxiety level was the best predictor of mathematics achievement for all students.

Table 2 displays the means and standard deviations of the National Percentiles Iowa Test of Basic Skills Math Composite scores for males and females with high and low anxiety. A 2 (gender) x 2 (anxiety level) Analysis of Variance yielded a significant interaction effect $F(1, 92) = 5.78$, $p = .02$, $\eta_p^2 = .06$. The Partial Eta Square suggests that the effect of gender accounted for about six percent of the variation. Specifically, females (M = 59.54, SD = 17.62) significantly outperformed males (M = 40.85, SD = 19.55) when students had high math anxiety. There was no significant difference between female (M = 73.64, SD = 19.89) and male (M = 74.14, SD = 19.23) performance when students had low mathematics anxiety. The main effect of anxiety was significant $F(1,88) = 35.27$, $p = .00$, $\eta_p^2 = .29$. The Eta Square suggests that the effect of anxiety accounted for about thirty percent of the variation. Specifically, those students with low mathematics anxiety (M = 73.87, SD = 19.34) outperformed students with high anxiety (M = 51.75, SD = 20.48).

Table 3 displays the means and standard deviations of the digits correct per minute measures across the four fluency probes for males and females with high and low anxiety. A 2 (gender) x 2 (anxiety) Analysis of Variance did not yield a significant interaction effect $F(1, 97) = .04$, $p = .84$, $\eta_p^2 = .00$. The Partial Eta Square indicates that the effect of gender accounted for no variation. This indicates that females (M = 77.07, SD = 36.62) with high anxiety did not perform significantly different across the four fluency probes than males (M = 63.45, SD = 43.44) with high anxiety, and that females (M = 107.08, SD = 40.41) with low anxiety did not perform significantly different across the four fluency probes than males (M = 96.78, SD = 41.63) with low anxiety. The main effect of gender was also not significant $F(1, 93) = 2.10$, $p = .15$, $\eta_p^2 = .02$. The Partial Eta Square suggests that the effect of gender accounted for about two percent of the variation. The number of digits correct per minute was comparable for males and females. However, the main effect of anxiety was significant $F(1, 93) = 14.74$, $p = .00$, $\eta_p^2 = .14$. The Eta Square indicates that the effect of fluency accounted for about fourteen percent of the variation. Those students with low anxiety (M = 102.15, SD = 40.89) completed more digits correctly per minute than those with high anxiety (M = 71.51, SD = 39.69).

Table 4 displays the means and standard deviations of accuracy across the four fluency measures for males and females with high and low anxiety. A 2 (gender) x 2 (anxiety group) Analysis of Variance yielded a significant interaction effect $F(1, 93) = 5.09$, $P = .03$, $\eta_p^2 = .05$. The Partial Eta Square suggests that the effect of gender accounted for about five percent of the variation. This indicates that females (M = 5.28, SD = 5.88) with high mathematics anxiety significantly performed more accurately across the four mathematics probes than males (M = 9.35, SD = 10.42) with high mathematics anxiety, and that females (M = 3.76, SD = 3.79) with low mathematics anxiety performed significantly more accurately across the four mathematics probes than males (M = 5.96, SD = 6.41) with low mathematics anxiety. The main effect of gender was significant $F(1, 93) = 5.09$, $p = .03$, $\eta_p^2 = .05$. The Partial Eta Square indicates that the effect of accuracy accounted for about five percent of variability. This suggests that females made fewer errors than did males. The main effect of anxiety group was not significant $F(1, 93) = 3.12$, $p = 0.8$, $\eta_p^2 = .03$. The Partial Eta Square suggests that the effect of accuracy accounted for about three percent of variability. This suggests that a student's amount of anxiety does not affect accuracy levels for basic mathematics operations.

Discussion

The current study examined the relationships among gender, anxiety level as measured by the FSMAS, fluency, and mathematics achievement as measured by a state standardized achievement test, the ITBS. The current study had five purposes. The first purpose was to extend the Cates & Rhymer (2002) study by making two design changes, holding the number of digits in each math probe constant, and measuring performance among fourth and sixth graders as opposed to college students.

The second purpose of the study was to determine which variable(s) best predict mathematics performance for students as measured by the ITBS, the participants' anxiety levels, or the participants' levels of fluency. Results indicated that participants' mathematics anxiety was a better predictor of mathematics achievement as measured by the ITBS than participants' levels of mathematics fluency.

The third purpose of the study was to determine the extent to which gender and anxiety level (i.e. high or low) affect standardized test performance. Current findings suggest that both gender and anxiety level had significant effects on state standardized test performance, and that anxiety level had a stronger effect on performance than gender. This study found that when students had low anxiety, gender did not affect state standardized test performance. Conversely, when students' levels of mathematics anxiety were high, females performed significantly better than their male counterparts on the Iowa Test of Basic Skills mathematics composite. Results further indicated that anxiety level had a significant effect on state standardized test performance, but only for students who rated themselves at the higher level of mathematics anxiety. In other words, a student's perception of his or her anxiety or him or herself appeared to affect standardized test performance.

The fourth purpose of the study was to investigate the effects anxiety and gender have on accuracy of mathematics performance as measured by the four mathematics probes. The current study found that neither anxiety nor gender had significant effects on students' accuracy across the four mathematics probes.

The fifth and final purpose of the study was to investigate the effects anxiety and gender have on fluency across the four timed mathematics probes. Current results suggest that both anxiety and gender had significant effects on fluency across all four mathematics probes.

Results of the current study supported previous findings in that both studies showed that anxiety did not affect accuracy of digits correct per minute mathematics performance (Cates & Rhymer, 2002). In addition, the current study indicated that anxiety level had a significant effect on fluency across the math probes, and also indicated that students with higher levels of mathematics anxiety performed at a significantly slower rate than students with lower levels of mathematics anxiety across all four mathematics probes (Cates & Rhymer, 2002).

The current study also extended previous findings in that it showed mathematics anxiety did not affect accuracy of responses across the mathematics probes. Cates et al. (1998) found that mathematics anxiety had a small but significant effect on accuracy across the mathematics assignments. Cates & Rhymer's (2002) study found no significant differences in accuracy between students with high and low anxiety across any of the math probes.

Although the present study served to extend current knowledge of the relationships among mathematics anxiety, basic mathematics fluency, and achievement in mathematics, specific flaws were apparent in the design of the study.

First, Iowa Test of Basic Skills mathematics scores were chosen as measures of mathematics achievement under the assumption that standard scores or normal curve equivalents would be provided to the schools and thus, available to the examiner. The current study used ITBS National Percentile Rank scores as measures of math achievement, as that information was provided to the school districts in lieu of standard scores. Because National Percentile Rank scores do not have equal intervals between scores, they are far less sensitive measures of mathematics achievement than standard scores. More variability may have been evidenced among participants' ITBS math performance had standard scores been utilized. Future research should consider using alternate state standardized measures of mathematics performance that provide standard scores or normal curve equivalents.

A second limitation of the current study was that, of the 100 fourth and sixth graders who completed the anxiety scale and math probes, current ITBS scores were missing for eight of the would-be participants. These missing data further decreased variability in the study.

A third important design flaw involved the curriculum by which students' mathematics fluency was measured. Particularly on the three-digit by two-digit division probe, most of the fourth grade participants did not attempt a single problem, although the type of problem is consistent with fourth grade curriculum. The students who did not attempt even one problem achieved 100% accuracy on the division probe. This further decreased variability among fourth grade scores. This suggests that accuracy measures lacked validity for students who did not attempt problems on any of the four probes. Future research should measure accuracy using only completed digits-correct-per-minute. Students who do not attempt a single digit should not be considered to have achieved 100% accuracy.

Another limitation of the study involves the participants. Students who participated in this study were too homogenous. Almost 100% of the participants were Caucasian students of similar socioeconomic status and all were from small rural schools in central Illinois.

A final weakness of the present study could be found in the limited variables used to predict mathematics achievement. By focusing on fluency of basic math facts, gender, and anxiety alone, the study excluded other factors known to affect state standardized test performance. For instance, socioeconomic status is widely accepted as a predictor of students' standardized test performance.

Despite the above limitations and recommendations for future research, results of the current do provide implications for school psychologists, educators, and students alike. In the future, school psychologists and other educators may need to redirect their focus with regard to assessing students using standardized testing procedures, as scores appear to be affected more by anxiety than skill fluency. Educators may begin to rely less on strategies that improve fluency, such as drill and practice with flashcards, in favor of classroom-based interventions for anxiety prevention and treatment.

If students' anxiety is more important to their math achievement than their basic skill fluency, educators may begin working from the perspective of anxiety prevention. This might come in the form of emphasizing individual student progress that focuses on accuracy as opposed to rapid responding on timed tests. In the interest of reducing anxiety, teachers may begin to de-emphasize competition among students by not revealing grades in subject areas known to be affected by anxiety. School psychologists and other educators may also find it useful to reduce anxiety through treatments such as systematic desensitization, anxiety management, and cognitive restructuring (Hembree, 1990). If fluency is not as important to students' math achievement as measured by standardized assessment instruments such as the ITBS, teachers should focus on rewarding students for their accuracy of responding rather than the speed with which they solve problems.

If the results of the current study hold true, academic interventions for students struggling in mathematics may need to be modified from focusing only on students' skill development to including other procedures aimed at treating their anxiety, such as guided imagery and progressive relaxation (Kostka & Wilson, 1986), applied counseling (Hunt, 1985), systematic desensitization, anxiety management, and cognitive restructuring (Hembree, 1990).

With future research, perhaps a combination of anxiety reduction and simultaneous fluency building will prove to be the best intervention for increasing students' mathematics achievement.

Table 1: Linear Regression Table

Correlations

Variable	ITBS	Fluency	Anxiety	Accuracy	ß	b
Fluency	.41				.16	.08
Anxiety	-.50	-.39			-.41	-1.04
Accuracy	-.33	-.38	.12		-.22	-.72
Mean	62.22	86.71	27.59	6.03		
Standard Deviation	22.84	44.27	9.04	7.13		

Table 2: ITBS National Percentile Scores

	X	SD	N
Low Anxiety Male Students	74.14	19.23	22
High Anxiety Male Students	40.85	9.55	20
Low Anxiety Female Students	73.64	19.89	22
High Anxiety Female Students	59.54	17.62	28
High Total Mean	73.89	19.34	44
Low Total Mean	51.75	20.48	48

Table 3: Total Digits Correct Per Minute

	X	SD	N
Low Anxiety Male Students	96.78	41.63	23
High Anxiety Male Students	63.45	43.44	20
Low Anxiety Female Students	107.08	40.42	25
High Anxiety Female Students	77.07	36.62	29
High Total Mean	71.51	39.69	49
Low Total Mean	102.15	40.89	48

Table 4: Total Errors

	X	SD	N
Low Anxiety Male Students	5.96	6.41	23
High Anxiety Male Students	9.35	10.42	20
Low Anxiety Female Students	3.76	3.79	25
High Anxiety Female Students	5.28	5.88	29
High Total Mean	6.94	8.20	49
Low Total Mean	4.81	5.27	48

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APPENDIX A
Consent Form

I agree to allow my son/daughter to participate in a study that will examine variables that might affect his/her math achievement scores. I understand that my child's participation is entirely voluntary and that he/she may withdraw at anytime without penalty.

The following points have been explained to me:

1. The purpose of this research is to study how being anxious about math and being fluent in basic math skills (addition, subtraction, multiplication, and division) might affect math scores on the Iowa Test of Basic Skills.
2. Specifically, my child will be given a brief questionnaire that will ask questions about how he/she feels about taking math classes and working math problems.
3. My child will then be asked to take four timed math exercises. He/she will work each type of problem: addition, subtraction, multiplication, and division for one minute.
4. After completion of the brief math exercises, the researcher will collect from the administration my child's most recent Iowa Test of Basic Skills mathematics score.
5. Neither the researcher nor I foresee any potential risks involved in my child's participation in this study.
6. All of the data collected will remain strictly confidential. Only people associated with the study (the researchers, the teacher, my child, and me) will see my child's responses.
7. The experimenter will answer any questions at any time during the study. If I have other questions or concerns, I can address them to the research director Dr. Gary Cates at 581-2128 in the Psychology Department at Eastern Illinois University.

______________________ ______________________

Name of Student Signature of Guardian

______________________ ______________________

Name of Guardian Date

APPENDIX B
Assent Form

I agree to be part of an experiment. I understand that I can quit at anytime and I do not have to participate. I will not suffer consequences if I choose not to participate.

I understand the following points:

1. The purpose of this research is to figure out how different factors affect how well I do on the Iowa Test of Basic Skills math section.
2. I will not be harmed in any way and I might learn something about my own math skills.
3. I will fill out a survey and then complete four timed exercises.
4. The researcher is allowed to find out how I scored on my last Iowa Test.
5. I will not be treated any differently as a result of how I perform on the survey or the exercises.
6. All of my work will be secret. Only my parents, the teacher and researchers will see how I do.
7. I can ask the teacher or researcher questions at anytime.
8. Upon completion of the research, I will receive a written debriefing statement with an explanation of the results.

____
Name

____
Date

APPENDIX C

DEMOGRAPHIC AND DATA CODING SHEET

NAME ____________________

AGE IN YEARS _____

GRADE (circle one) FRESHMAN SOPHOMORE JUNIOR SENIOR

GENDER (circle one) MALE FEMALE

HOW MANY SEMESTERS OF MATH HAVE YOU TAKEN IN HIGH SCHOOL?

_____

WHAT MATH COURSE ARE YOU ENROLLED IN CURRENTLY? __________

PLEASE WAIT FOR INSTRUCTIONS

F ____ A ____ S ____ M ____ D ____ I ____

APPENDIX D

Please rate the following statements on this scale:

SA = Strongly agree	A= Agree	N= Neither Agree Or Disagree	D= Disagree	SD= Strongly Disagree

1. Math doesn't scare me at all. (Circle one.)	SA	A	N	D	SD
2. Mathematics usually makes me feel uncomfortable and nervous.	SA	A	N	D	SD
3. It wouldn't bother me at all to take more math courses.	SA	A	N	D	SD
4. Mathematics makes me feel uncomfortable, restless, irritable and impatient.	SA	A	N	D	SD
5. I haven't usually worried about being able to solve math problems.	SA	A	N	D	SD
6. I get a sinking feeling when I think of trying hard math problems	SA	A	N	D	SD
7. I almost never have gotten shook up during a math test.	SA	A	N	D	SD
8. My mind goes blank and I am unable to think clearly when working mathematics.	SA	A	N	D	SD
9. I usually have been at ease during math tests.	SA	A	N	D	SD
10. A math test would scare me.	SA	A	N	D	SD
11. I usually am at ease in a math class.	SA	A	N	D	SD
12. Mathematics makes me feel uneasy and confused.	SA	A	N	D	SD

APPENDIX E
Addition Probe

287 +58	384 +28	352 +98	588 +99	238 +87
435 +79	597 +54	856 +74	785 +89	485 +37
185 +55	399 +89	678 +43	268 +74	598 +77
289 +88	644 +77	766 +87	187 +56	485 +56
763 +78	436 +85	655 +55	248 +82	357 +84

APPENDIX F
Subtraction Probe

253 -66	524 -68	204 -75	554 -76	444 -67
814 -26	564 -76	555 -87	576 -98	334 -76
363 -76	641 -63	256 -77	234 -47	654 -66
936 -48	256 -88	821 -55	426 -87	233 -56
436 -68	755 -57	226 -38	917 -35	321 -47

APPENDIX G

Multiplication Probe

462 x48	147 x72	752 x26	677 x84	875 x85
726 x32	222 x57	795 x29	343 x97	732 x74
462 x26	866 x72	134 x69	859 x49	416 x63
132 x56	448 x72	546 x33	527 x65	754 x67
227 x72	437 x53	262 x64	682 x82	324 x99

Division Probe

32/800	23/598	58/464	43/817	65/715
37/407	27/108	36/540	87/783	43/774
53/530	26/598	74/666	48/432	85/425
82/328	85/765	46/368	26/286	22/154
64/256	55/935	44/792	64/640	71/568

APPENDIX I

Debriefing Statement

Project Title: Understanding Mathematics Achievement

Investigator: Kelsie Buker

Researchers have studied how being anxious about math can affect how well students perform in mathematics. A small amount of research has looked at whether being quick and correct with basic math facts helps students score higher on math tests, but most of that research has been done with younger children and college students. You recently filled out a page that asked your name, age, and your current grade in school. You also completed four math exercises as well as a questionnaire that asked how you feel about doing mathematics. The specific purpose of this study was to add to the research already done on how being quick and correct with basic math facts and being anxious about doing math can affect how well students do in math. The purpose was also to see gender, grade, and age affect students' math achievement. This research could someday help math teachers change the way they teach math courses.

Please do not discuss this study with friends outside this classroom until I have informed your teacher that all participating classes have completed this study. Your teacher will tell you when you may discuss the study with your friends. If you have any questions or concerns regarding this study or your responses, please contact Kelsie Buker, graduate research student, at (217) 433-6001, or Dr. Gary Cates, research advisor, at 581-2128.

Thank you for your participation,

Kelsie Buker