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Research Article

Mathematics Anxiety and Prevention Strategy: An Attempt to Support Students and Strengthen Mathematics Education

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Abstract

In the process of reaching a medium income country, science, mathematics and technology have become an emphasis of Ethiopia. But, currently, students' interest to study mathematics and ability in mathematics is declining. This study therefore aimed to investigate the prevalence of mathematics anxiety and its effect on students' current mathematics achievement. Additionally, by grounding on the literature, some strategies supposed to reduce the negative effects of math anxiety were identified for practice. The study was conducted on five randomly selected public secondary schools of East Shoa Zone in Oromia region. Math anxiety was measured using a validated instrument called Math Anxiety Rating Scale (MARS), whereas students' current mathematics achievement was measured using achievement test. Structural model was developed to examine causal relationship of the variables treated in the study. The finding revealed that there was a significant negative relationship between mathematics anxiety and achievement. There was also a statistically significant gender difference in mathematics anxiety and current math achievement, with effect size small and typical respectively. Based on the findings of the study, imperative implication for practice and future research were made.

Keywords: Coping strategy, Current mathematics achievement, Mathematics anxiety, Mathematics education.

1 Introduction

Though there is an agreement that mathematics is a fundamental subject for the development of any country in general and development of individual's minds in particular, many students experience an anxiety or dislike of mathematics during the school years (Attard, 2013) [3]. Because of this, achievement of students in mathematics is low (National Educational Assessment and Examinations Agency, NEAEA, 2014) [20], students' interest to study the field as well as their foundation skills in mathematics is at a predicament state. In the process of reaching a medium income country, science, mathematics and technology have become an emphasis in the education system of Ethiopia. But, currently in Ethiopia, students' interest to study mathematics and ability in mathematics is declining. That is solving basic mathematical problems become

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a problem to many students in all levels of schooling. Many mathematicians in Ethiopia and other part of the world have often expressed unhappiness that the majority of students do not understand mathematical concepts, or do not see why mathematical procedures work, or do not know when to use a given mathematical technique. For instance, Halat (2007) [10] demonstrated that many students have learning difficulties and show poor performance in mathematics. That is there is a manifestation of carelessness in doing mathematics. This manifestation is actually the result of mathematics anxiety. Mathematics anxiety is psychological factors that hinder students learning of mathematics. Though this factor plays a prominent role in the learning process, it was not thoroughly studied by researches in Ethiopia.

The negative effects of mathematics anxiety include disturbance during the process of learning mathematics, department and career selection in higher education. According to Hembree (1990) [13] when students avoid the study of mathematics, it erodes the country's resources base in science and technology, since it is a base for science and technological fields. Mathematics anxiety is defined as the negative emotions that interfere with the solving of mathematical problems. It is more than just disliking mathematics and leads to a total avoidance pattern, students avoid taking math classes and avoid situations in which math will be necessary (Sparks, 2011 [27]; Hellum-Alexander, 2010 [12]; Ashcraft & Krause, 2007 [2]).This article is concerned with the investigation of the prevalence of mathematics anxiety and its effect on students' current mathematics achievement. Additionally, by grounding on the literature, some strategies supposed to reduce the negative effects of math anxiety were identified for practice by contextualizing to Ethiopian context.

Though there are many studies conducted on gender comparison, contrasting finding exists and also effect size was missing, the direction of the relationship between math anxiety and achievement is not clear. Also, different studies have used different measures of both mathematical performance and of math anxiety, making their results hard to compare given that some measures used may have been less reliable than others. Given the contrasting results in the field, it is clear that further research, utilizing reliable measures of math anxiety and achievement is necessary. Hence in this study, gender differences were investigated in terms of both math anxiety and achievement. This was done to lay foundation for the escalation of the belief that females cannot be competent as male in mathematics Furthermore, structural model was investigated for modeling plausible sets of causal relations among the variables treated in the study.

Students who view mathematics as a difficult and boring subject tend to avoid mathematics whenever or wherever possible (Daane & Tina, 2002) [9]. This avoidance intern has a negative effect on students' academic achievement, because the knowledge of mathematics is used to understand not only mathematics but also other subjects such as physics, chemistry and engineering (Hembree, 1990) [13]. Mathematical skills are essential to any person's success in technical and nontechnical fields of education, business, social and behavioral sciences, humanities and the arts (Patricia, 1986) [22]. Math anxiety also influence students' everyday life, academic careers and even contribute to stress, which is well known to cause many other problems. Hence, there is a need to strengthen students' mathematics performance in schools as it was a basis for their future career. At the same time, for students to become competitive and successful in this rapidly changing environment coping strategies are important.

The present study was directed towards achieving the following specific objectives:

- To investigate the prevalence of mathematics anxiety in East Shoa zone secondary school students.
- To investigate the relationship between mathematics anxiety and current achievement
- To investigate gender difference in mathematics anxiety and current mathematics achievement.

2 Research Methodology

This study employed quantitative approach. This type of method is helpful to allow the researcher to solve the intended problem (Patton, 1980). The quantitative part involves a survey. The study was conducted in East Shoa zone, Oromia region, Ethiopia and participants included 370 grade 9 students randomly selected from five different schools.

Table 1: Demographic information of participants of the study

Gender	N	Total
Male	184	370
Female	186	

2.1. Data Collection Instruments

Data for this study was collected using the Mathematic Achievement Test (MAT), Mathematics Anxiety Rating Scale (MARS).

Mathematics Anxiety Rating Scale (MARS): According to Thijsse (2002) [29], math anxiety is measured in two ways. The *first* is by a self-examination and evaluation of anxiety when presented with various types of mathematical situations, possibly with the help of a pre-fabricated anxiety scale. A degree of anxiety is determined and usually falls under categories such as "very anxious", "moderately anxious", and so on. The *second* method of measuring anxiety is by a second party, usually by someone who is trained to see physiological signs of anxiety and the actions associated with them. Psychiatrists and psychologists are an ideal outside opinion to diagnose such a problem.

In this study, 22 items and 5-point likert scale was used to measure students' level of math anxiety. The scale was revised as to fit the levels of the participants under the study based on the comments of professionals which insures face and content validity. Pilot study was also conducted to determine its validity and reliability. Using Cronbach's alpha, the degree of internal consistency reliability of MARS for this study was found to be 0.76. Based on the idea of Khatoon (2010) [16], the anxiety levels of students were taken between the following ranges: low level of math anxiety 22-55, moderate level 56-77 and high level of math anxiety 78-110. Moreover, to reduce obtaining wrong data due to language confusion, the English version of the MARS was changed to Oromic version of MARS. However, for students, who do not understand Afan Oromo clearly, the English version was given. Accordingly, there were 90 (25 male and 65 female) participants who declared that they did not understand Afan Oromo and hence the English version of MARS was provided. The translation of language was made by colleagues having rich experience in the area and it was also checked by two language teachers for consistency with the English version. Hence, it is evident that that the scale was modified and contextualized to fit the purpose of the study.

The Mathematic Achievement Test (MAT): Students' scores on MAT were served as the basis for obtaining their achievement in math. This test was developed by the researcher in order to assess the level of acquisition of mathematical concepts of students. It covers the main topics of mathematics taught in the first semester. It includes concepts such as the number system, solution of equations and set theory. It consists of 30 multiple choice questions with 4 options A-D and was based on three cognitive levels that is knowledge, understanding (skill) and application. To identify the achievement domains being measured and to ensure that a fair and representative question appear on the test, table of specification was developed. The test was scored manually by the researcher. Each correct answer holds one mark while a wrong answer was scored zero. The level of achievement of a student was taken as students total test score.

MAT was piloted on 49 students prior to the main study. Using Kuder- Richardson formula KR- 21 the internal consistency reliability of the test was found to be 0.57 and the average difficulty index obtained was 0.41, which shows the instrument was neither too difficult nor too simple. This value is acceptable and excellent according to Mukherjee & Lahiri, (2015) [19], who stated items with p value between 40-60% are considered excellent since discrimination index is maximum at this range. They also confirmed that items with p value (difficulty index) less than 20% (too difficult) and more than 90% (too easy) are not acceptable and need modification. For discrimination index, the cut of point is 0.40 and greater are considered excellent.

Furthermore, prior mathematics achievement was taken as the average scores of students on three different measurements, namely: the first semester mid exam, the first semester final exam and students' score of mathematics in their ministry examination (a national examination for grade 8).

2.2. Method of Data Analysis

The analysis of data was carried out using parametric statistical tests such as t-test, Pearson correlation, regression and path analysis. The software used for date analysis was IBM SPSS Statistics for Windows, Version 19.0. A p-value of less than 0.05 was considered to be statistically significant.

3 Results and Discussion

3.1. Descriptive Statistics and Students Level of Mathematics Anxiety

To determine students' level of math anxiety, the mathematics anxiety mean scores of students were used.

Table 2: Descriptive Statistics of the variables treated in the study

Variables	N	Min	Max	Mean	Std. Deviation	Skewness	
						Statistics	Std. Error
Math anxiety	370	26	88	57.33	11.063	-.179	.127
Current Math achievement	370	10	87	46.90	15.633		
Prior math achievement	370	20	79	43.96	9.435		

As could be seen in table 2, students' mean scores on MARS were 57.33 and standard deviation of the scores was 11.063. This shows that grade nine students' mathematics anxiety is at a moderate level. This does not mean that mathematics anxiety plays no role in the variability of students' achievement. To say that there is little or no math anxiety the anxiety level should be in the lowest stage. Hence the study shows the existence of math anxiety among Ethiopian students.

Table 2 also shows the skewness of math anxiety; it was used to determine the distribution of the data. According to Cohen (1988) [8] if the skewness is less than plus or minus one (< +/-1.0), the variable is at least approximately normal which is the assumption of parametric tests. The skewness of math anxiety was -0.179 which shows the variable was approximately normal. Thus parametric tests were used to analyze the data.

3.2. Gender Difference in Mathematics Anxiety and Achievement

Mathematics anxiety mean scores of students and their score in achievement test and the results of independent sample t-test was carried out to determine the differences according to gender:

Table 3: Comparison of male and female students on math anxiety and math achievement

Variables	Male (n=184)		Female (n= 186)		t	df	p
	M	SD	M	SD			
Math anxiety	55.47	11.141	59.17	10.70	-3.258	368	.001
Math achievement	50.97	14.956	42.87	15.277	5.151	368	.000

The result of independent sample t-test indicated in table 3 shows the existence of gender difference in math anxiety (df = 368, t = -3.258, p < .05, d=.338). Since high score represents high anxiety, this confirms that female students were more anxious about mathematics than male. This difference, according to Cohen (1988) the effect size d=.338 was small or smaller than typical. The small effect size shows less practical significance, which means the difference is very small. Moreover, male students are also superior in current mathematics achievement in a statistically significant extent (df = 368, t = 5.151, p < .05, d = .535). This difference, according to Cohen (1988) [8] is medium or typical. Reporting effect size allows judging the

magnitude of the differences between or among groups, which increases the capability to compare current research results to previous research and judge the practical significance of the results (Joe, Atherton, Williams & Khata, 2011) [14]. Educational researchers have indicated that effect sizes around 0.20 are of policy interest when they are based on measures of academic achievement (Hedges & Hedberg, 2007) [11]. Hence in this study, male students are superior in current mathematics achievement and female students are more anxious about mathematics. The finding of the study was aligned with the findings of the research by (Witt, 2012 [31]; Hembree, 1990 [13]; Tobias &Weissbrod, 1980 [30]).

3.3. The Relationship between Math Anxiety and Achievement

Table 4: Pearson correlation coefficient of the variables treated in the study.

Variables	1	2	3	4
Gender	--			
Current Math Achievement	.259**	--		
Math Anxiety	-.167**	-.250**	--	
Prior Math Achievement	.192**	.418**	-.324**	--

** P < 0.01

As shown in the table 4, gender (the dichotomous variable) was negatively and significantly correlated with math anxiety (r = -0.167, p < 0.05) which shows the high score on the part of female students in math anxiety than male students, revealing that female students are more anxious. Gender was positively and significantly correlated with math achievement (r = 0.259, p < 0.05) which shows that male students have scored larger values in current mathematics achievement than female. Thus, sex of students had adverse relationship with math achievement than math anxiety.

The results of the study further revealed the existence of significant negative relationship between mathematics anxiety and current mathematics achievement (r = - 0.250, p < 0.05). This shows that students who have high mathematics anxiety tended to perform fewer score in current mathematics achievement. However, those who have low mathematics anxiety tended to perform high score in current mathematics achievement. On the other hand math achievement was positively and significantly correlated with prior math achievement (r = 0.418, p < 0.05) which shows students who have a good prior math achievement scored better on math achievement test. Prior math achievement in turn was negatively and significantly correlated with math anxiety (r = -0.324, p < 0.05). This shows that math anxiety manifested among students with poor prior math achievement. The finding of this study was in line with the find of Hembree, 1990 [13]; Khatoon, 2010 [16]; Karimi & Venkatesan, 2009 [15]; Ashcraft & Kirk, 2001 [1]; Luo, et.al, 2009 [17]). All of which report a negative relationship between math anxiety and achievement. However, it was against with the finding of (Lupkowski & Schumacker, 1991 [18]; Resnick, Viehe & Segal, 1982 [24]; Ping, 2005 [23]), all of which found insignificant relationship between math anxiety and achievement.

3.4. Regression Analysis for Current Mathematics Achievement and Components of Variables

To determine the effect or contribution of each independent variable on the dependent variable, multiple regression analysis was used. Accordingly, a significant model emerged ($F_{(3,366)}$ = 34.076, P < 0.05). Table5 shows summary of results from regression analysis:

Since $R^2 = 0.218$, then the combined effect of gender, prior mach achievement and math anxiety was 21.8% of the total variability on current mathematics achievement. According to Cohen (1988) [8] the effect size is medium or typical, hence the study have practical significance. The percent of effect of each variable on current mathematics achievement can be found by:

$$(R^2 = r_G\beta_G + r_{PMA}\beta_{PMA} + r_{CMA}\beta_{CMA}) \times 100\%$$

$$[R^2 = (0.259 \times 0.174) + (0.418 \times 0.350) + (-0.250 \times (-0.107))] \times 100\%$$

$$21.2\% \approx 4.50\% + 14.63\% + 2.67\%$$

Thus the contribution of gender enhanced achievement of mathematics by 4.50%, the contribution of prior math achievement enhanced achievement of mathematics by 14.63% while the contribution of math anxiety lessen achievement of mathematics by 2.67%. Thus the variables other than those studied in this study accounted for 78.2% of the variability in students' achievement.

3.5. Structural Model for Current Mathematics Achievement

It is important to investigate causal relationship of the variables to know whether high math anxiety cause a decline in students' achievement, whether high prior math achievement causes high current math achievement, whether the variability in prior achievement causes math anxiety. Hence the present study also investigated these conditions using a causal path analytic model. The residual path coefficient (R) in fig 1 represents factors that affect the indicated variable that were not accounted in the model. Current mathematics achievement was considered to be a function of gender, prior math achievement and math anxiety. Table 6 shows direct, indirect and total effect of each predictor variable on the criterion variable:

Table 5: Direct, indirect and total effect of each predictor variable on the criterion variable

Effect	**r**	Direct effect	Indirect effect	Total effect	R^2
On current mathematics achievement					.218
Of gender	.259	.174	.078	.252	
Of prior math achievement	.418	.350	.032	.382	
Of math anxiety	-.250	-.107	-	-.107	
On math anxiety					.116
Of gender	-.167	-.109	-	-.109	
Of prior math achievement	-.324	-.303	-	-.303	
On prior math achievement					.037
Of gender	.192	.192	-	.192	

The result of table 5 depicts that prior math achievement had a stronger direct effect on current mathematics achievement than did any of the variables in the study. There was also a strongest direct effect of prior math achievement on current mathematics achievement. Thus, prior mathematics achievement was the strongest predictor of current achievement and math anxiety. The effects of prior math achievement and gender on current mathematics achievement were more direct than indirect. Both gender and prior math achievement mediated the negative direct effect on math anxiety. figure 1 shows the final path model for current mathematics achievement.

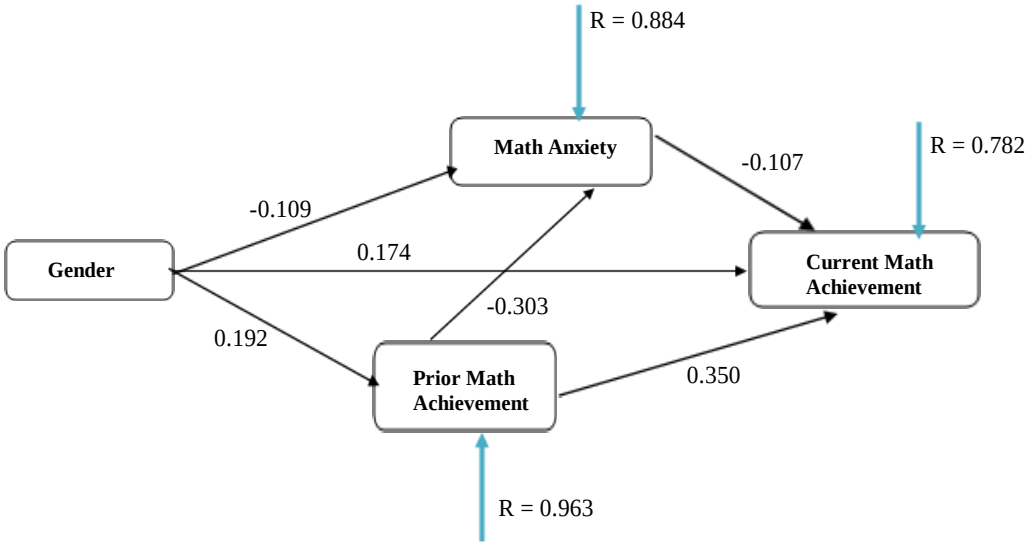

Figure 1: Path model for current mathematics achievement

Figure 1 illustrates the path analysis model. Gender was considered as the only exogenous variable. Math anxiety and prior math achievement were considered as endogenous variables, whereas current mathematic achievement was a dependent variable. As could be seen, prior math achievement is the strongest predictor of both math anxiety and current math achievement. This effect is statistically significant and it has also practical significance, since the effect size according to Cohen (1988) was typical or above average.

4 Discussion

Mathematics Anxiety and Achievement

The results of the study have revealed that there was a significant negative relationship between math anxiety and math achievement. The math anxiety level was found at the average level which indicates the existence of the construct in Ethiopian schools. The finding confirms with the pervious findings such as Hembree, 1990 [13]; Khatoon, 2010 [16], Karimi & Venkatesan, 2009 [15]; Ashcraft & Kirk; 2001 [1]; Luo, et.al, 2009 [17]) all of which reports a significant negative relationship between math anxiety and math achievement. However, it was against with the finding of (Lupkowski & Schumacker, 1991 [18]; Resnick, Viehe & Segal, 1982 [24]; Ping, 2005 [23]), all of which found insignificant relationship between math anxiety and achievement.

The contribution of prior math achievement significantly affected the current mathematics achievement and was the highest contributions (14.63%) for the current math achievement. Prior math achievement was also the strongest predictor of math anxiety. This shows that students previous experience in mathematics adversely affect the current status of achievement and anxiety level. This result was in agreement with the study conducted by Rossnan, 2006 [25]; Yenilmez, Girginer, & Uzun; 2007 [32]), that is math anxiety develops as a result of a student's prior negative experiences when learning mathematics in the classroom or at home, which can leave a student with the view that they have poor math ability. Another factor contributing for math anxiety is teaching strategies involving independent and competitive mathematics activities (Sutter, 2006 [28]; Sheffield & Hunt, 2007 [26]).

According to Yenilmez, et al, (2007) [32], many students who suffer from mathematics anxiety have little confidence in their ability to do mathematics and tend to take the minimum number of required mathematics courses, greatly limiting their career choice options. Research suggests that anxiety is more of a factor in math than in other subjects. The present study revealed that girls exhibit more math anxiety than boys, though the effect size was small. This result is in line with the study conducted by (Tobias &Weissbrod, 1980 [30];

Hembree, 1990 [13]). Based on the findings, it is evident to conclude that prior math experience affects students to manifest math anxiety and as a result they possess weak current mathematics achievement. This study therefore, urges to take measures mainly on reducing levels of math anxiety. Though there are many different strategies in the current literature, strategies that are mostly cited and tested by researchers were collected and presented here as a coping strategy.

5 Conclusion and Implications

The purpose of this study was to investigate the prevalence of mathematics anxiety and its effect on students' current mathematics achievement. Additionally, by grounding on the literature, some strategies supposed to reduce the negative effects of math anxiety were identified for practice. Based on the aforementioned discussion and the findings of the study, the following conclusions were drawn:

The study revealed that math anxiety occurs among students with poor performance; since there was a significant negative correlation between math anxiety and math achievement. As a result, it predicts students' future employment and their success in higher education. Thus, this issue might be a major concern. Therefore, the result of the study have some practical implication, since the effect size for the model is above average; and also students current mathematics achievement (46.9) was below average, showing that they had difficulty in solving mathematical problems.

The math anxiety level of students was found to be at the average level which indicates the existence of the construct in Ethiopian schools. Though the effect size is small, female students' are more anxious about mathematics than male. The result of the study further shows the superiority of male students in current math achievement as well as prior math achievement. The contribution of all variables namely: gender, prior math achievement and math anxiety collectively significantly affected the current students' mathematics achievement. On the other hand, prior math achievement was the strongest predictor of both math anxiety and current math achievement.

Producing positive thinking, building support group, building effective assessment strategies, minimizing the component of competition, students' self-motivation, teachers support and classroom structure are strategies that reduce students level of math anxiety. Generally, the researcher believes that the findings of this study have the potential to add value to educators as well as those who are interested in furthering the research in more detailed way. Consequently, the following recommendations were forwarded: classroom practice and curriculum materials should not focus only on cognitive factors but also on non-cognitive factors such as math anxiety. School counselors, teachers and parents have to help students to become conscious about mathematics and guide them in the process of meaning making. Teachers have to implement techniques that have been found to reduce the math anxiety of students. On the other hand, students have to use the findings of the study to improve understanding about their own math anxiety. They can reflect on how their own math anxiety fits in with the findings of the study and they may try to know the cause of their own math anxiety and use the strategies. Students may remember their prior activities at which they were good at and might think that they could still be good at those activities, this may develop their confidence.

Mathematics knowledge and skills are required in students' future careers and throughout life time. Accordingly, whatever elements that can hinder students' learning need to be addressed effectively, otherwise the consequence will be failure. Students must change their negative attitudes towards mathematics as it will lead to mathematics avoidance situation which eventually leads to a loss of self-motivation to learn mathematics. Reform is needed to create support group (mathematics club) in schools in such a way that students socialize and engage in the learning process. Future researchers might examine math anxiety with different methodology to give a richer description of students' feeling.

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