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The Relationship between Mathematics Score and Mathematics Anxiety among Biology Education Students

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Abstract
Students need to be anxiety free when it comes to Mathematics. This phenomenon is an unpleasant sensation that interferes with someone's ability to communicate well with Mathematics. Although several studies have investigated the relationship between Mathematics anxiety and Mathematics proficiency, none has explored the effect of Mathematics anxiety on individual student's Mathematics scores, particularly of Biology education students. A correlational analysis was performed with quantitative research method to explore the association between Mathematics scores and Mathematics anxiety. 68 participants were recruited for the study, using non-probability sampling, voluntarily and purposively. A student's mathematics anxiety was assessed using a mathematical anxiety scale. The data was analysed by correlation and regression analysis to determine whether Mathematics anxiety was associated with the students' success. The mathematical model is the best approximation of the relationship between variables described by the equation (3.6 + 0.0 A1 - 0.5 A2 - 1.6 A3 - 2.3 A4 - 2.9 A5). The results suggest that poor Mathematics skills increase with levels of anxiety. Students with the least amount of anxiety are predicted to get passing grades of A and B, whereas those with more anxiety are likely to get lower grades of D and E.

Keywords: Mathematics Anxiety, Correlation and Regression, Biology Education

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INTRODUCTION

Although advance in science and technology is growing faster and faster, people still face Mathematics as a technological and scientific language. Consequently, learning Mathematics and acquiring mathematical skills at any stage has become more than ever inevitable. Mathematics is the primary method for understanding the universe's organization and order through science and technology. The success level in Mathematics has been one of the main factors for school success and the professional selection. Therefore, it is necessary to know and to remove obstacles in the face of mathematical achievement, if possible. One of the biggest barriers to mathematical achievement is mathematical anxiety (Sevindir et al., 2014).

Mathematics anxiety is the discomfort that students get when they are faced with Mathematics and mathematical conditions. Research into how Mathematics anxiety and Mathematics cognition relate has been previously performed. Negative correlations have been found at various stages in the mathematical education process, from basic counting (Maloney, Risko, Ansari, & Fugelsang, 2010) to complex Mathematics problem-solving (Ramirez, Gunderson, Levine, & Beilock, 2013). These negative associations are noticeable at different development stages of students (Maloney et al., 2010; Ramirez et al., 2013), spanning from elementary school students through high school and college students.

Anxiety about Mathematics begun with research conducted by Dreger and Aiken (1957), that defines the phrase as the presence of a syndrome of emotional reactions to Arithmetic and Mathematics. They introduce mathematical anxiety as a new concept to explain students' mathematical difficulties. Since then, numerous researchers have proposed the following definitions of Mathematics anxiety: Richardson and Suinn (1972) described Mathematics anxiety as feeling of tension and anxiety that interfere with the manipulation of numbers and the solving of Mathematics problems in a wide variety of ordinary life and academic situations. Tobias and Weissbrod (1980) describe mathematical anxiety as panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem. Meanwhile, Suinn & Winston (2003) state that Mathematics anxiety is a feeling of tension, worry, and fear in circumstance involving activities related to mathematics. Thus, Mathematics anxiety can be defined as negative psychological reactions involving panic, fear, apprehension, helplessness, a lack of confidence, and tension toward mathematical-related activities.

Furthermore, the causes of Mathematics anxiety remain a significant concern after Richardson & Suin (1972) develop the Mathematics Anxiety Rating Scale (MARS). The instrument allows researchers to test for Mathematics anxiety in students, providing a clearer picture of their problem. Next, the other research team has designed a number of instruments to measure Mathematics anxiety. As a result, anxiety in Mathematics has been reported to be connected with other variables, such as learning behaviour and self-efficacy that affect academic performance (McMullan, Jones, & Lea, 2012; Feng, Suri, & Bell, 2014; Paechter, Macher, Martskvishvili, Wimmer, and Papousek, 2017). Some other researches confirm that Mathematics anxiety is associated with students' poor Mathematics performance (Ashcraft & Faust, 1994; Devine, Fawcett, Szűcs, & Dowker, 2012; Fan, Hambleton, & Zhang, 2019).

Mathematics anxiety afflicts nearly all students. Just seven percent of students report to have positive Mathematics experiences from kindergarten through university (Jackson & Leffingwell, 1999). This phenomenon usually affects students who are not majoring in Mathematics, even though they will need mathematical knowledge in their profession. For example, engineering students (Prahmana, et al., 2019), STEM and social science students (Rozgunjuk, et al., 2020), require Mathematics as knowledge to support success in their studies and career development.

Furthermore, our findings indicate that Biology education students at University of Papua have lower Mathematics scores than their science classmates. The students are unenthusiastic and disengaged towards learning Mathematics. As a result, their grade in Mathematics appears to be lower than that of other science education students. This is in line with the results presented by Wachsmuth, et al. (2017), who report that Biology students generally need one or more Mathematics courses, but they are not interested in Mathematics. They are considered to have negative feelings about Mathematics.

On the other hand, Mathematics is a critical topic for students enrolled in Biology education. Students of Biology education require Mathematics to study Statistics, Bioinformatics, Evolution, and Epidemiology. Additionally, He argues that many theories in Biology, such as Mendel's inheritance theory, require a substantial mathematical foundation (May, 2004). Mathematics is a subject that helps students develop their thinking skills. By studying Mathematics properly, students develop their critical and creative thinking skills (Anim & Saragih, 2019; Mumu & Tanujaya, 2019). Mathematical thinking is a necessary prerequisite for students to possess because it facilitates mastery of other disciplines of science outside Mathematics (Delima et al. 2021).

Consequently, Mathematics anxiety inhibits progress in their mathematical activities, leading to the following questions. Do Biology education students at the University of Papua also have anxieties in Mathematics? Has this Mathematics anxiety led to their Mathematics score? What is the pattern of relationship between anxiety in Mathematics and the student scores? What are the causes of this anxiety?

Hence, a study is required to address several hypotheses:

- There are negative significant relationships between Mathematics anxiety and Mathematics outcome of Biology education students.
- There are positive significant relationships between Mathematics perception and Mathematics outcome of Biology education students.
- There are positive significant relationships between Mathematics anxiety and Mathematics perception of Biology education students.
- There is a significant relationship among Mathematics anxiety, Mathematics perception, and Mathematics education score of Biology education students

Therefore, the purpose of this study is to investigate whether perceptions and anxiety of Mathematics individually or collectively effect on students' learning outcomes in Biology education classes. The results of the analysis, which use a multiple linear regression to construct the best equation model to predict the Mathematics education score as a function of the variables (Mathematics anxiety and Mathematics perception). The analysis also aims to explain the factors that lead students to have difficulty with Mathematics.

METHODS

Correlational research method was used to accomplish this study. According to Gall, Gall, and Borg (2007), correlation research is a subset of non-experimental design that is used to describe the relationship between two or more variables. The study was a study conducted to ascertain the existence and strength of a relationship between two variables without changing the variables. Correlation research is a term that refers to studies that employ correlational statistics to uncover correlations between variables.

The subjects of this study consisted of 86 Biology education students. They had been part of the Biology education class from 2015 to 2019. The subjects were selected through two non-probability sampling method - voluntary sampling, and purposive sampling. The sampling methods were two of the major types of non-probability sampling. The voluntary sampling was made of people who self-select into a survey, while the purposive sampling was made of those who were deliberately selected because of the characteristics they possessed.

The initial step in the subject sampling was the distribution of the questionnaire using a certain WhatsApp Group. The Google form questionnaire was distributed to Biology education students at the University of Papua for voluntary participation. Students who completed the questionnaire were selected purposively as the subjects based on criteria; Biology education students for the 2015 – 2019 academic year, and completed the questionnaire thoroughly and correctly.

The questionnaire comprised of the respondent's identity and an instrument to assess student's anxiety on Mathematics. The measure of mathematical anxiety of students was assessed using the Mathematics Anxiety Scale (MAS) that Zakariya (2018) developed. In this instrument, students ranked themselves at the level of anxiety they would have experienced under various conditions in the Mathematics classroom. The instrument consisted of two subscales: learning Mathematics anxiety (LMA) and the perception of difficulty and motivation (PDM). The instrument was made up of 21 items with a Likert scale, (5) strongly agree, (4) agree, (3) either agree or disagree, (2) disagree, and (1) strongly disagree.

The interviews' characteristics were presented on descriptive statistics using table, stem-and-leaf diagrams and histograms to study data distribution. If the data was normally distributed, a parametric statistical analysis may be carried out. According to Cutillo (2019), parametric statistical tests cannot be used unless assumptions such as normality are fulfilled.

The next step then, the data collected was tabulated in order to classify student's perception and levels of anxiety. Students' perception and anxiety were categorized on 5 levels. At the same time, the outcomes of student's learning were derived from the grade of the Mathematics education course. The grade (score) was the student earned in the first lesson, the remedial course, was not considered.

The three data collections were then statistically analysed using correlation analysis and simple regression analysis. Correlation analysis using Pearson method, while simple regression analysis based on categorical predictor coding (0,1). According to Moore et al (2013), computation of coefficient correlation using formula:

$$r = \frac{1}{n-1}\sum\left(\frac{x_i-\bar{x}}{s_x}\right)\left(\frac{y_i-\bar{y}}{s_y}\right) \quad 1$$

While estimating equation regression using formula:

$$\hat{y} = a + bx \quad 2$$

Where:

$$b = r\frac{s_y}{s_x} \quad 3$$

$$a = \bar{y} - b\bar{x} \quad 4$$

In addition, to estimate the regression equation with categorical predictor coding, the formula used:

$$\hat{y} = a + b_1x_{1i} + b_2x_{2i} + \cdots + b_kx_{ki} \quad 5$$

The analysis of both statistical methods was carried out using the Minitab statistical software.

Correlation analysis was a statistical technique used to determine the strength of the relationship between two variables. High correlation means that two or more variables have a good relationship with each other while a weak correlation means that the variables are unrelated. This method is closely associated to a linear regression analysis, which is a mathematical approach for modelling the relationship between two or more variables (Moore et al., 2011). The strength of relationship between the two variables was interpreted using the correlation coefficient as stated by (Best & Kahn, 1998), as presented in Table 1.

Table 1. Criteria for assessing the relationship of two variables using coefficient correlation

No	Coefficient (+)	Coefficient (-)	Relationship
1	$0.00 \leq r < 0.20$	$0.00 \geq r >$ -0.20	Negligible
2	$0.20 \leq r < 0.40$	-0.20 $\geq r >$ -0.40	Low
3	$0.40 \leq r < 0.60$	-0.40 $\geq r >$ -0.60	Moderate
4	$0.60 \leq r < 0.80$	-0.60 $\geq r >$ -0.80	Substantial
5	$0.80 \leq r \leq 1.00$	-0.80 $\geq r >$ -1.00	High to very high

Whereas, multiple linear regression equation was designed to assess the influence of more than one independent variable (x) on the dependent variable (Y). To obtain the best regression model for predicting the Y variable based on the data variety of the x variables, simultaneous and partial tests can be used. The simultaneous test was used to evaluate the effect of a model consisting of several variables. In contrast, the partial test was intended to test the effect of each variable-on-variable Y.

To assess the resulting of regression model, statistics R-square was used. The coefficient determination (R-square) measured the proportion of the variation in Y which explained by predictor variable. However, it overestimated this proportion, then the Adjusted determination coefficient (R-square Adj.) was used to assess the resulting regression model.

Comparing the results of data analysis, multiple linear regression analysis, and multiple regression analysis, the multinomial regression analysis results will be presented. The data were analyzed using the SPPS program package. This comparison was performed in response to the controversies surrounding the level of data analyzed. Additionally, the data in this study were Likert data. Considering Likert data is interval data (Carifio and Perla, 2008), correlation and regression analysis can be used to examine it (Norman, 2010).

In addition to the main instrument used in this study, there were several additional questions that attempt to investigate the causes of mathematical anxiety in biology education students. The questions have been developed by the research team and used after being tested for validity through expert testing.

RESULTS & DISCUSSION

The Characteristic of Research Subjects

Characteristics of students as research subject presented on the basis of descriptive statistics. Descriptive statistics are numerical and graphical procedures for summarizing the processing of data. Descriptive statistics help to summarize large amounts of data into a simplified representation. The data from the descriptive statistics on the variables Score, Perception, and Anxiety are presented on Table 2.

Table 2. Descriptive statistics of students' score, perception, and anxiety

Variable	N	Mean	St. Dev	Min	Q1	Median	Q3	Max
Score	86	2,128	1,146	0	1	2	3	4
Perception	86	2,977	1,148	1	2	3	4	5
Anxiety	86	2,942	1,172	1	2	3	4	5

Table 2 indicates that the subject has characteristics at all scales, in both score, perception and anxiety variables. The distribution of the subjects' characteristics on the three variables tends to be normal, as the median and the mean values tend to be the same number. The data normality pattern is also seen in the steam and leaf diagrams in Figure 1 and Figure 2, where the mode appears to be the same as the mean and the median.

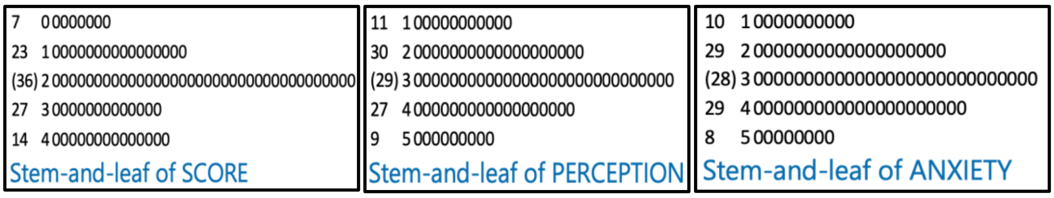

Figure 1. Distribution of variables presented on Stem and Leaf Diagram

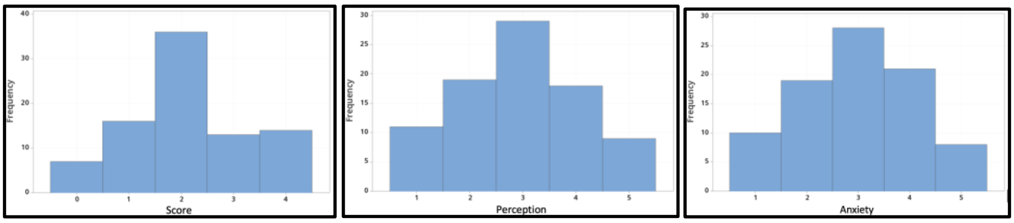

Figure 2. Distribution of variables presented on Histogram

The data set is normally distributed if the values of the mean, median and mode are the same (Moore et al., 2013). The normal distribution of the data set is a required condition for performing parametric statistical analysis, including correlation and regression analysis.

The Relationships among Variables

The study has analysed the relationship between variables using Pearson's correlation. The findings are tabulated in table 3, showing correlations between variables, scores, perceptions, and anxiety.

Table 3. Coefficient of correlation between the variables Score, Anxiety and Perception.

	Score	Anxiety
Anxiety	-0,785	
Perception	-0,625	0,839

Table 3 reveals that the three variables are closely interconnected (substantial relationship). Score has a negative correlation with the other two variables, while the relationship between anxiety and perception is positive. A negative relationship, according to Moore et al. (2013), is the relationship between two variables, as the value of one variable increases, the value of the other variable decreases. On the other hand, a positive coefficient of correlation between two variables means that if one of the variables increases in value, the value of the other variable will also increase.

Based on the results of the study of the correlation between these variables, in particular between x (anxiety and perception) variables, the two variables can replace each other in the regression equation model to predict students' scores. In other word, the regression equation to describe the student's variety in grades is adequate to use only one of the two variables. Which variable should be included in the regression equation is defined after an analysis of variance has been performed?

When using a multiple linear regression model involving the two variables, the regression equation is:

$$\text{Score} = 4{,}418 - 0{,}878 \text{ Anxiety} + 0{,}110 \text{ Perception} \quad 6$$

and the analysis of variance as presented in table 4.

Table 4. Analysis of variance for multiple linear regression models

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	69,185	34,5925	67,70	0,000
Anxiety	1	25,553	25,5526	50,01	0,000
Perception	1	0,415	0,4151	0,81	0,370
Error	83	42,408	0,5109		
Lack-of-Fit	10	3,743	0,3743	0,71	0,715
Pure Error	73	38,665	0,5297		
Total	85	111,593			

S	R-sq	R-sq(adj)	R-sq(pred)
0,714800	62,00%	61,08%	58,85%

Table 4 confirms that the P-value of the Anxiety is lower than 0,05, while the P-value for Perception is greater than 0,05. Therefore, it can be concluded that the estimated parameter value of perception is equal to zero. In other words, perception does not make a significant contribution to the regression model. As consequences, the perception variable could be removed from the model.

The following is a regression model which only involves one independent variable, the mathematics anxiety of students.

$$\text{Score} = 4{,}461 - 0{,}7838 \text{ Anxiety} \quad 7$$

and the analysis of variance as presented in table 5.

Table 5. Analysis of variance for simple linear regression models

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	68,770	68,7700	134,90	0,000
Anxiety	1	68,770	68,7700	134,90	0,000
Error	84	42,823	0,5098		
Lack-of-Fit	3	0,934	0,3113	0,60	0,616
Pure Error	81	41,889	0,5171		
Total	85	111,593			

S	R-sq	R-sq(adj)	R-sq(pred)
0,714001	61,63%	61,17%	59,45%

As shown in the table 5, anxiety has a significant effect on the outcome regression model. The resulting P-value is 0,000 which indicates that the null hypothesis - there aren't negative significant relationships between Mathematics anxiety and Mathematics outcome of Biology education student- is rejected. The negative effects can be identified from the estimated coefficient of the linear regression model (equation 6).

Moreover, as shown in tables 4 and 5, the R-square for the model with one independent variable (61.17 percent) is greater than the R-square for the model with two independent variables (61.08 percent). Similarly, the value of R-sq(adj) in a one-variable regression model is bigger than the value of R-sq(adj) in a two-variable regression model. Thus, the best model is a one-variable regression equation model. Because both values are not significantly different, the best model is a simple one with the fewest variables possible, which simplifies computation (equation 7).

This is consistent with Draper & Smith's (1998) perspective, who argues that the best model for regression analysis can be determined by comparing the values of R-sq or R-sq (adj). The forward stepwise selection or backward elimination approach can be used to select variables. Additionally, it is stated that backward elimination of variables selects subset models by starting with the full model and then deleting the variable that causes the least increase in the residual sum of squares at each stage.

Furthermore, the analysis of variance that does not differ significantly is also provided if a regression analysis is conducted using dummy variables for the degree of anxiety. The regression equation using the dummy variable as follows:

$$\text{Score} = 3{,}6 + 0{,}0\ A1 - 0{,}5\ A2 - 1{,}6\ A3 - 2{,}3\ A4 - 2{,}9\ A5 \qquad 8$$

and the analysis of variance is presented in table 6.

Table 6. Analysis of variance for multiple linear regression models using dummy variable

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	69,70	17,4260	33,70	0,000
Anxiety	4	69,70	17,4260	33,70	0,000
Error	81	41,89	0,5171		
Total	85	111,59			

S	R-sq	R-sq(adj)	R-sq(pred)
0,719130	62,46%	60,61%	56,94%

Table 6 confirms that the regression model highly depends on the anxiety symptoms (equation 8). The results of the analysis also provide statistics including R-squares, R-squares (adj.), and R-squares (pred.), which are quite significant (about 60 percent). This study shows that a student's level of Mathematics anxiety has a significant impact on their Mathematics scores, especially at the University of Papua.

However, the R-sq value of 60% indicates that, in addition to anxiety, there are additional factors that contribute around 40% to the Mathematics scores of Biology education students. The 40% value is produced by combining these factors with anxiety in order to build a regression equation. When the anxiety variable is studied separately, the coefficient of determination may be more, equal, or less than when combined with the anxiety variable. Further research is needed to determine the other factors that affect the Mathematics score of Biology education students.

The Regression Model for Prediction Mathematics Score

Based on the best regression model obtained (see equation 8), the statistical predictions of Mathematics scores for Biology education students are summarized in Table 7.

Table 7. Prediction of Mathematics score using regression model

No	Anxiety Level (x)	Anxiety Score	Score Prediction ($\hat{y}$)
1	Normal	11 – 16	B & A
2	Mild	17 - 27	B
3	Moderate	28 - 38	C
4	Severe	39 - 49	D & C
5	Extreme Severe	50 - 55	E & D

Table 7 indicates that the greater the level of Mathematics anxiety in an education Biology student, the lower his/her Mathematics score will be. Students who do not suffer from Math anxiety have a chance to earn an A or B in Math, however those who suffer from severe anxiety frequently earn low grades, such as D or even E. This occurs as a result of their serenity and comfort during the learning process. Students with low levels of anxiety tend to learn more and attend classes more easily. In comparison, students with high levels of anxiety tend to not focus as effectively in Mathematics.

Why do the two variables have a positive relationship? What factors contributed to these phenomena?

After conducting further study, we conclude that there are several reasons why the majority of Biology education students feel uncomfortable when dealing with Mathematics. One of the most valuable problems is basic Mathematics skills. Weak Mathematics skills are a common cause of Mathematics anxiety among Biology education students.

According to Necka et al. (2015), cognitive factors play a role in Mathematics anxiety. It is well established that a persistent negative relationship exists between low Mathematics abilities (a cognitive factor) and high Mathematics anxiety. As a result, Dowker et al. (2016) assert that one potential explanation for the relationship is that those who have higher Mathematics anxiety levels are more likely to avoid situations where they have to do Mathematics tasks. When students spend less time studying Mathematics, they become less fluent and more likely to have difficulty with mathematical learning.

The second factor is students' lack of motivation to learn Mathematics. One of the reasons is that they are rarely involved in Mathematics learning by their teachers. For instance, they are not permitted to pose questions, respond to their friends' questions, or complete practice questions. Olango (2016) argues that Mathematics anxiety is both mental and cognitive problems. While some anxiety can be motivating or even thrilling, excessive anxiety can be debilitating. Subsequently, Tobias & Weissbrod (1980) state that discomfort varies in intensity depending on the individual; it may be caused by feelings of helplessness in problem-solving, a lack of opportunities to practice Mathematics outside of the classroom, role conflict, or unfortunate experiences with a particular Mathematics teacher.

CONCLUSION

The three factors investigated (anxiety, perception, and Mathematics score) are inextricably linked and exhibit a strong correlation. While score has a negative correlation with the other two factors, anxiety and perception have a positive correlation. A negative relationship is one in which one variable's value increases while the other variable's value decreases. A positive correlation coefficient between two variables, on the other hand, indicates that when one variable's value grows, the value of the other variable decreases. The greater the level of Mathematics anxiety in an education Biology student, the lower his/her Mathematics score will be. Students with low levels of anxiety tend to learn more and attend classes more easily. In comparison, students with high levels of anxiety tend to not focus as effectively in Mathematics. Two regression models can be used to predict students' Mathematics scores in Biology education using level of Mathematics anxiety: Score = 4,461 – 0,7838 Anxiety, or Score = 3,6 + 0,0 A1 – 0,5 A2 – 1,6 A3 – 2,3 A4 – 2,9 A5, where A1, A2, A3, A4, and A5 are the level of Biology students' anxiety.

CONFLICT OF INTEREST

Although the results of this study indicate that students who have a high level of Mathematics anxiety tend to have low Mathematics scores, the study does not examine the relationship between these variable and other variables. As a result, further study is required to resolve this issue.

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