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The Influence of Mathematics Self-Efficacy and Mathematics Anxiety on Students' Intrinsic Motivation in Learning Mathematics-Related Subjects: A Multiple Linear Regression Analysis

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Abstract: This study primarily focuses on students' intrinsic motivation. Specifically, the ultimate aim of this study is to investigate the influential factors contributing to students' intrinsic motivation to learn mathematics related subjects. Participants of this study were 137 students (45 male and 92 female) from Universiti Teknologi MARA (UiTM) Kelantan Branch, Kota Bharu campus. Data were collected using an online questionnaire which was distributed through the WhatsApp platform. A multiple linear regression analysis was employed to achieve the objective of the study. Results show that both mathematics self-efficacy and mathematics anxiety significantly affect students' intrinsic motivation in learning mathematics related subjects. The study also found that mathematics self-efficacy is the most important factor that contributes to the students' intrinsic motivation.

Keywords: Intrinsic motivation, Mathematics anxiety and Mathematics self-efficacy

1 Introduction

Mathematics holds a crucial role for students enrolled in Statistics courses. Despite its fundamental nature, a concerning trend has emerged in recent times, revealing unsatisfactory results among students in mathematics-related subjects like calculus and probability. Multiple factors contribute to this trend, and one key factor is a lack of motivation to delve into these subjects. A previous study found that there is association between motivation and academic achievement in mathematics [1]. Lack of motivation and poor attitude were found to be significantly contributing to low performance in mathematics [2].

Educators often face the challenge of addressing a lack of motivation among their students in learning any subject. When students are not sufficiently motivated, he or she will not be engaged in the class session, potentially diminishing the overall quality of their learning experience. Motivation can be described as student's willingness, need, eagerness, and internal drive to engage in and achieve success in the process of learning [3], where, in general, it can be divided into intrinsic motivation and extrinsic motivation. Intrinsic motivation is driven by internal factors, where we are motivated to do something because of our personal interest or curiosity. In contrast, extrinsic motivation is driven by external reasons to complete the tasks such as to get a reward or a promotion.

Even though both intrinsic motivation and extrinsic motivation are equally important, in the context of learning, intrinsic motivation is considered to be the key element for students to actively participate and fully engage in the classroom. When students are intrinsically motivated, they are more

likely to invest time and effort to understand the subject being taught in class. Understanding the factors influencing students' intrinsic motivation to learn can assist educators to implement effective teaching strategies and interactive learning environment. This study investigates the effects of self-efficacy and anxiety in mathematics on students' intrinsic motivation in learning mathematics-related subjects.

Several studies have revealed that mathematics self-efficacy serves as an important predictor for students to get better results in mathematics [4]–[6]. This is because students who are capable in the subject matter are more motivated to learn [7], which often leads to better achievements in academics [8]. A recent study also suggests that, besides becoming a significant predictor of students' motivation, self-efficacy can also increase students' achievements and foster emotional health and well-being [9]. Therefore, it is crucial to study the effect of self-efficacy on students' intrinsic motivation in learning any subject including mathematics.

Besides self-efficacy, anxiety stands out as another influential predictor of students' academic success. Numerous studies demonstrated how mathematics anxiety can affect academic achievements and motivation. Anxiety is one of the challenges that individuals may face in their life. Students who are experiencing anxiety may find it difficult to focus on learning, which in turn will negatively impact their academic performance. Students who possess high levels of anxiety are mostly not sufficiently motivated and tend to perform below their capability even though they have high levels of skill [10].

Prior research indicates a correlation between anxiety and students' motivation, with higher anxiety being associated with lower motivation in both mathematics and reading [11]. Mathematics anxiety is not only linked to negative attitudes towards mathematics but also correlates with low confidence in the ability to learn mathematics [12]. Individuals with heightened anxiety in mathematics tend to avoid related activities, making it more difficult for them to understand mathematical concepts [13], eventually resulting in lower performance in mathematics [11], [12] [14] and [15].

This study is motivated by the poor academic performance of students in mathematics-related subjects recently. The primary goal of this study is to examine whether self-efficacy and anxiety in mathematics significantly affect students' intrinsic motivation. The study outcomes can offer valuable insights into the factors contributing to students' engagement and enthusiasm in mathematics-related subjects. By comprehending these factors, educators can tailor interventions to enhance students' motivation, potentially leading to improved academic achievements.

2 Methodology

This section describes the conceptual model, target population and study design, sampling design, research instrument, data collection method, and method of data analysis employed for this research.

A Conceptual Model

The primary goal of this study is to investigate whether mathematics self-efficacy and mathematics anxiety significantly affect students' intrinsic motivation in learning mathematics-related subjects. The conceptual model, as presented in Figure 1, portrays the interconnection between the independent variables and dependent variable involved in this study. There are two research hypotheses derived from the conceptual model shown in Figure 1. The required research hypotheses need to be tested in this study are listed as follows:

H_{11}:Mathematics self-efficacy significantly affects students' intrinsic motivation in learning mathematics-related subjects.
H_{12}:Mathematics anxiety significantly affects students' intrinsic motivation in learning mathematics-related subjects.

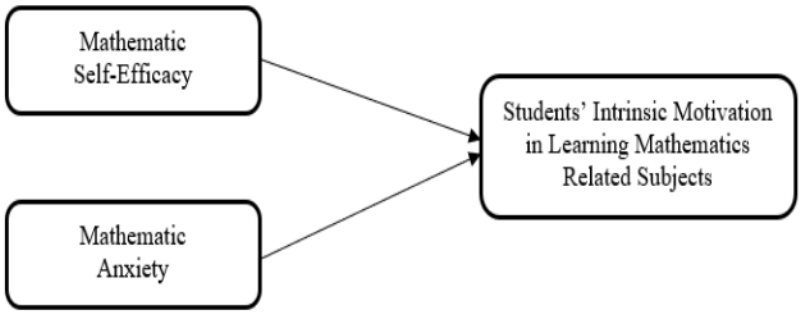


Figure 1: Conceptual Model

B Target Population and Study Design

The target population for this study was students from Universiti Teknologi MARA (UiTM) Kelantan Branch, Kota Bharu campus, covering from semester 3 to semester 7. Only two different programs were involved in this study – Bachelor of Science (Hons.) Statistics (CS241) and Bachelor of Entrepreneurship (Logistics and Distributive Trade) with Honours (CS291). A cross-sectional study was used in this study which allows researchers to investigate whether mathematics self-efficacy and mathematics anxiety significantly affect students' intrinsic motivation in learning mathematics-related subjects at a single point in time.

C Sampling Design

A total of 137 students (45 male and 92 female) from two different courses mentioned earlier participated in this study. The sample size in this study was determined using Raosoft software, with a 5% margin of error and a 95% confidence interval. The selection of participants to be involved in this study was carried out employing the simple random sampling technique to ensure that each student have an equal chance of being chosen. The sampling frame for this study was obtained from the Academic Affairs Department of UiTM Kelantan Branch's Kota Bharu Campus.

D Research Instrument and Data Collection Method

A semi-structured questionnaire was used as a research instrument in this study. This questionnaire consisted of four sections covering demographic profile, mathematics self-efficacy, mathematics anxiety, and intrinsic motivation in learning mathematics-related subjects. The participants were asked to rate every item for each section on a 10-point scale. The detailed number of items and the scale employed for each section are summarized in Table 2.

Table 2: Summary of the Number of Items for each Section

Section	Number of Items	Scale
A: Demographic	2	Not Applicable
B: Mathematics Self-Efficacy	7	A 10-point Likert response range from strongly disagree to strongly agree
C: Mathematics Anxiety	5	
D: Intrinsic Motivation in Learning Mathematics-Related Subjects	6	

The data for this study was collected based on self-administered questionnaire which was constructed using Google Forms platform. The online questionniare was distributed to selected participants through WhatsApp. The WhatsApp application was chosen to distribute the questionnaire as it was a medium that is mostly used by students. The questionnaire will take about 10-15 minutes to complete. The participation of the selected respondents in this study was fully voluntary, and they can complete the questionnaire at their own convenient time and place.

E Method of Data Analysis

i. Descriptive Analysis

Descriptive statistics were used to provide quantitative descriptions of the demographic profile of respondents who took part in this study including gender and course enrolment.

ii. Reliability Analysis

The reliability analysis was utilized to evaluate the internal consistency of a set of scales employed in this study. Researchers commonly use the Cronbach's alpha coefficient as a statistics tool to assess reliability of the scales. A Cronbach's alpha value below 0.6, indicates inadequate internal consistency while values in the range of 0.6-0.7 are considered acceptable and those exceeding 0.8 are considered good.

iii. Multiple Linear Regression Analysis

The multiple linear regression analysis was used to identify which factors (mathematics self-efficacy and mathematics anxiety), if any, significantly affect students' intrinsic motivation in learning mathematics-related subjects. The multiple linear regression model involved in this study is written as equation 1.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \quad (1)$$

Where

Y: Intrinsic Motivation
X_1: Mathematics Self-Efficacy
X_2: Mathematics Anxiety

The R-square, which is known as coefficients of determination, was used to assess the goodness of fit of the regression model. The R-square values range from 0 to 1, in which the closer the value to 1 suggesting a more accurate fit of the regression line to the data points. In general, a higher R-square indicates a better fit of the model to the dataset.

Following the assessment of the model fitness, the subsequent step involved in regression analysis is to examine the model adequacy. These include normality assumption, homoscedasticity assumption and multicollinearity, where they must be met before the model can be used to predict dependent variable. The normality assumption was examined using the normal probability plot and histogram. Meanwhile, the scatterplot of residual versus predicted was employed to check homoscedasticity assumption. If the scatter plot does not show any obvious pattern among data points, it can be concluded that the homoscedasticity assumption is satisfied, indicating a consistent error variance.

The multiple linear regression involved several independent variables. The presence of more than one independent variable often leads to a strong correlation among these variables, which can result in multicollinearity issues in the dataset. This condition can be accessed through the coefficients known as variance inflation factor (VIF). The dataset is considered to have a multicollinearity problem when the VIF exceeds 10.

After all the above requirements are fulfilled, the subsequent step involves examining the overall F-test. The overall F-test signifies the significance of the model by assessing the p-value provided in the ANOVA. The model is said to be significant if the p-value is less than 0.05. Once the model is confirmed to be significant, the result of individual t-test is examined to identify specific

predictor variables (mathematics self-efficacy and mathematics anxiety) that significantly impact the response variable (students' intrinsic motivation in learning mathematics-related subjects).

3 Finding

A Descriptive Analysis

Figure 2 illustrates the distribution of respondents based on gender and course enrolment. According to the presented pie chart, majority of participants of this study were female, constituting 92% of the total. The pie chart also indicates that most participants came from CS241 course, accounting for 96%.

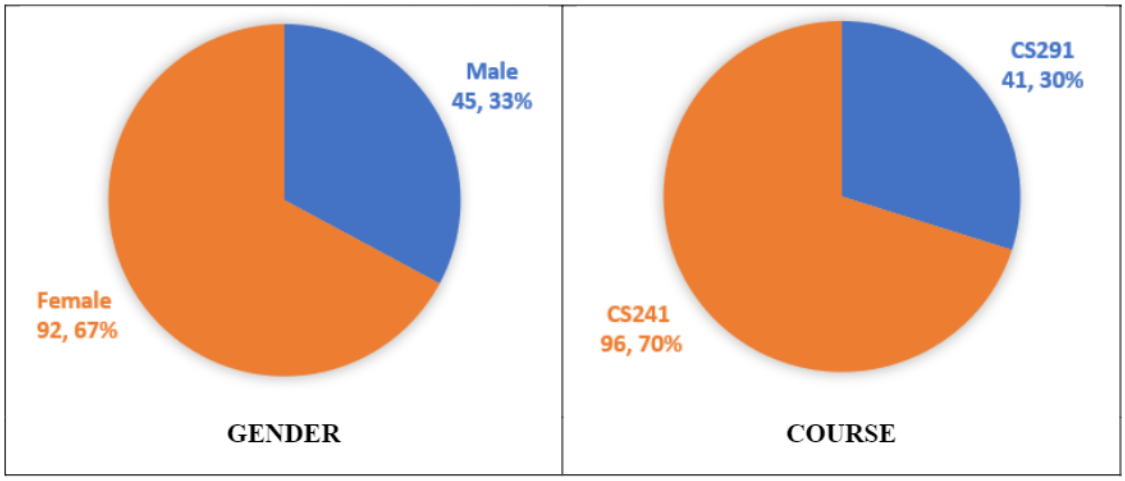


Figure 2: Distribution of Respondents

B Reliability Analysis

Table 3 presents the Cronbach's alpha values associated with each construct involved in this study. As all the Cronbach's Alpha Coefficient exceeded the established minimum value of 0.6, therefore, it can be inferred that the set of items within the construct exhibits high internal consistency. This suggests that these items effectively measure the same underlying concept.

Table 3: Summary of Reliability Analysis for each Construct

Construct	Number of Items	Cronbach's Alpha Coefficient
Mathematics Self-Efficacy	7	0.889
Mathematics Anxiety	5	0.894
Intrinsic Motivation in Learning Mathematics-Related Subjects	6	0.851

C Multiple Linear Regression Analysis

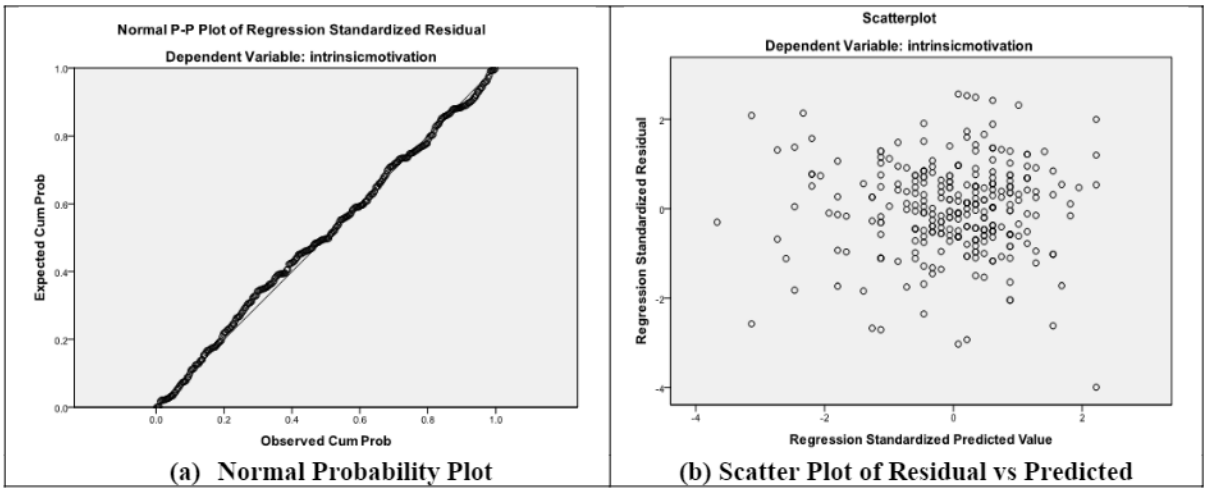
The R-square was 0.549, signifying that 54.9% of the total variation in students' intrinsic motivation in learning Mathematics-related subject is explained by mathematics self-efficacy and mathematics anxiety. Meanwhile, the remaining 46.1% of total variation is explained by other contributing factors.

Table 4: Goodness of Fit

R-Square
0.549

Figure 3(a) and Figure 3(b) provide visual inspection of the normality and homoscedasticity assumption, respectively. The normal probability plot of regression standardized residuals shows a close alignment of the data points with the fitted line, suggesting that the error terms exhibit normal

distribution. Thus, it is reasonable to conclude that the assumption of normality holds. The scatterplot of residual versus predicted portrays a random and evenly scattered distribution without any systematic pattern. Thus, this indicates the error terms have constant variance.



(a) Normal Probability Plot **(b) Scatter Plot of Residual vs Predicted**

Figure 3: Normality and Homoscedasticity Assumptions

Table 5 provides the variance inflation factor (VIF) for each construct. Since none of the VIF values exceed 10, it can be concluded that all independent variables are uncorrelated among themselves. Consequently, the absence of multicollinearity between mathematics self-efficacy and mathematics anxiety can be affirmed.

Table 5: Multicollinearity Assumption

Construct	VIF
Mathematics Self-Efficacy	1.357
Mathematics Anxiety	1.062

As shown in Table 6, the calculated p-value was <.000 which is less than significance level, 0.05. This result leads to the conclusion that the multiple linear regression model is statistically significant. This implies that at least one of the predictor variables (mathematics self-efficacy and mathematics anxiety), if any, significantly influences the response variable (students' intrinsic motivation in learning mathematics-related subjects).

Table 6: Test for Significance of Regression Model

Model	Sum of Square	DF	Mean Square	F Statistics	Sig.
Regression	114.267	1	114.267	89.858	<.000
Residual	172.943	136	1.272		
Total	287.210	137			

From the estimated regression function reported in Table 7, the p-value was below the level of significance, 0.05, indicating that both mathematics self-efficacy and mathematics anxiety exert a significant influence on students' intrinsic motivation in learning mathematics-related subjects. The coefficient values reveal that the most influential contributor to students' intrinsic motivation in this context is identified. In this case, among the two factors, mathematics self-efficacy (β_1=0.286) is the most impactful factor as it produces the highest beta coefficient. This coefficient signifies that for every one-unit increase in mathematics self-efficacy, there is an associated increase of 0.286 in students' intrinsic motivation in learning mathematics-related subjects.

Table 7: Test for Significance of Individual Predictor Variable

Variable	Coefficient Value	Standard Error	T Statistics	Sig.
Constant	2.251	.470	4.787	<.000
Mathematics Self-Efficacy	0.286	0.056	5.147	<.000
Mathematics Anxiety	-0.131	0.042	-3.130	.002

The fitted regression model is as follows:

$$\hat{Y} = 2.251 + 0.286X_1 - 0.131X_2 \quad (2)$$

4 Conclusion

The study has provided valuable insights into the factors influencing students' intrinsic motivation in learning mathematics-related subjects. The findings of the multiple linear regression model demonstrated that both mathematics self-efficacy and mathematics anxiety significantly contributed to students' intrinsic motivation, with mathematics self-efficacy showing a stronger influence (β_1=0.286) compared to mathematics anxiety. The outcomes of this study suggest that interventions at enhancing students' confidence in their mathematical abilities could potentially have a more pronounced effect in fostering intrinsic motivation in learning mathematics-related subjects. Future studies could expand the scope by including additional predictor variables that might contribute to intrinsic motivation, such as students' attitude, teaching methods, parents' involvement, peer influence or technological interventions. By considering these variables, future studies can contribute to better understanding of the significance factors influencing students' intrinsic motivation in learning mathematics-related subjects and provide actionable insights for educational practitioners.

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