Jurnal Gantang IX (2) (2024): 147-154

JURNAL GANTANG

e-ISSN: 2548-5547
p-ISSN: 2503-0671

http://ojs.umrah.ac.id/index.php/gantang/index

The impact of high school students' enthusiasm for game-based learning (GBL) on their enthusiasm for mathematics learning

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Submission: November 1st, 2024; Accepted: December 24th, 2024; Published: December 31st, 2024
DOI: https://doi.org/10.31629/jg.v9i2.6923

Abstract

The low interest of students in mathematics learning can negatively impact their academic performance. Game-based learning has been implemented to increase students' interest and enthusiasm for studying mathematics. This study aims to analyze the impact of high school students' enthusiasm for game-based learning on their enthusiasm for mathematics learning. The research uses a quantitative method through an online questionnaire distributed to 216 West Sumatra and North Sumatra high school students. Data were analyzed using binary logistic regression to understand the effect of game-based learning on students' enthusiasm for mathematics. The results show that students' enthusiasm for game-based learning through traditional and online games significantly influences their interest in mathematics learning, with a model accuracy rate of 90.7%. Additionally, the game-based learning approach boosts students' interest and facilitates collaboration and critical thinking skills. This study concludes that game-based learning is an effective method for enhancing students' enthusiasm for mathematics, and it is recommended that teachers integrate this approach into high school mathematics curricula.

Keywords: students' enthusiasm; game-based learning; binary logistic regression.

How to cite: Panjaitan, M. A., & Dasari, D. The impact of high school students' enthusiasm for game-based learning (GBL) on their enthusiasm for mathematics learning. *Jurnal Gantang, 9*(2), 147 – 154. https://doi.org/10.31629/jg.v9i2.6923

I. Introduction

Mathematics is a subject encountered by students from various backgrounds, from elementary school (SD) to senior high school (SMA). Despite studying mathematics for nine years, many high school students still perceive it as difficult. They often express a lack of interest, anxiety, and a loss of enthusiasm for learning mathematics. This finding aligns with what Fitriana and Aprilia (2021) found, who noted that students' initial attitudes toward mathematics are frequently negative. Internal and external factors contribute to students' negative perceptions of the subject. Internal factors include students' interest, motivation, and physical state, while external factors encompass the role of teachers, the abstract nature of mathematics, and traditional teaching methods (Kholil & Zulfiani, 2020). High school students' low interest and enthusiasm in mathematics can lead to suboptimal learning outcomes, making it essential to incorporate alternative teaching methods.

Game-Based Learning (GBL) is designed motivation during the learning process. GBL can boost students' enthusiasm for mathematics, enhance their critical thinking, and promote problem-solving and collaboration, especially in the digital age (Untari, 2022). GBL platforms, including traditional games and web-based online games like Kahoot, Quizizz, and Wordwall, can be applied in high school mathematics instruction (Rincon-Flores et al., 2023). These platforms make the learning process enjoyable, as students are challenged through game activities tailored to mathematics, ultimately leading to greater enthusiasm and more effective learning outcomes (Novian, 2013; Syaikhu et al., 2022). Although GBL has been widely implemented in various educational contexts, few studies have explored its direct impact on students' enthusiasm for mathematics.

The purpose of this study is to analyze the effect of high school students' enthusiasm for Game-Based Learning (GBL) on high school students' enthusiasm for learning mathematics using the logistic regression analysis method. The type of logistic regression used is binary logistic regression because the dependent variable is in a binary category, namely measuring students' enthusiasm or unenthusiasm in learning math using games (Hosmer Jr et al., 2013). This research will gain further insight into the effectiveness of the Game-Based Learning (GBL) method in increasing enthusiasm and interest in learning mathematics. Thus, 3 hypotheses can be formulated in this study, namely:

1. The frequency of learning mathematics using Game-Based Learning significantly affects high school students' enthusiasm for learning mathematics.
2. Learning mathematics using traditional Game-Based Learning significantly affects high school student's enthusiasm for learning mathematics.
3. Learning mathematics using online Game-Based Learning significantly affects high school student's enthusiasm for learning mathematics.

Regression methods are crucial in data analysis to test these hypotheses and visualize the relationship between a dependent variable and one or more independent variables. This study employs binary logistic regression, a method suitable for analyzing the effects of multiple independent variables on a dichotomous dependent variable (Agresti, 2012; Hosmer Jr et al., 2013). Further details on the steps of logistic regression are elaborated in the *Methodology* section.

II. Research Method

This study adopts a quantitative research approach that utilizes primary data collected through an online survey via Google Forms. The primary data was gathered by distributing questionnaires to high school students in Indonesia who are studying mathematics in the 2024/2025 academic year. The sample for this research consists of students from a public high school in West Sumatra and a private high school in North Sumatra. This research aims to analyze the effect of student enthusiasm for Game-Based Learning (GBL) on their enthusiasm for learning mathematics. The process involved designing survey instruments, collecting data via Google Forms, analyzing the data, drawing conclusions, and preparing the research report (Cresswell, 2013).

The study uses both dependent and independent variables. The dependent variable (Y) in this study is students' enthusiasm for learning mathematics with game-based learning, categorized as 1 (unenthusiastic) and 2 (enthusiastic). The independent variables (X) are measured using a Likert scale: 1 (very unenthusiastic), 2 (unenthusiastic), 3 (enthusiastic), and 4 (very enthusiastic). The independent variables include (X_1) frequency of game-based learning in mathematics, (X_2 enthusiasm for traditional games in mathematics, and (X_3) enthusiasm for online games in mathematics.

Regression analysis plays a critical role in data analysis as it helps to visualize the relationship between the dependent and independent variables. The dependent variable is discrete, meaning it can take two or more distinct values. Regression analysis aims to find a simple yet effective model that can explain the relationship between the dependent and independent variables (Agresti, 2012). Logistic regression, in particular, is commonly used when the dependent variable is categorical. It can be classified into binary, multinomial, or ordinal logistic regression. In this case, binary logistic regression analyzes the relationship between one dependent variable and several independent variables. The dependent variable is dichotomous, with values 1 (indicating the presence of a characteristic) and 0 (indicating the absence of a characteristic) (Hosmer Jr et al., 2013; Park, 2013; Sepang et al., 2012)

The steps involved in binary logistic regression are as follows (Agresti, 2012; Hosmer Jr et al., 2013):

1. Logistic Regression Model

The general form of a logistic regression model with one predictor is:

$$\frac{\pi}{1-\pi} = \exp(\beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k)$$

2. The goodness of fit test

This test assesses whether the chosen model adequately explains the relationship between student enthusiasm for Game-Based Learning and enthusiasm for mathematics. The formula for the Goodness of Fit test is:

$$\hat{C} = \sum_{r=1}^{g} \frac{(O_r - n_r\bar{\pi}_r)^2}{n_r \pi r(1-\bar{\pi}_r)}$$

3. Parameter test

This test evaluates the influence of independent variables on the dependent variable in the model using the G test statistic, which is calculated as follows:

$$G = -2\ln\left[\frac{\left(\frac{n_1}{n}\right)^{n_1}\left(\frac{n_0}{n}\right)^{n_0}}{\Pi_{i=1}^{n}\hat{\pi}_l^{y_i}(1-\hat{\pi}_l)^{1-y_i}}\right]$$

4. Partial test

This test assesses the influence of each individual independent variable on the dependent variable, calculated as follows:

$$w = \frac{\hat{\beta}i}{SE(\hat{\beta}i)}$$

5. Odds ratio

The odds ratio measures how much an independent variable influences the dependent variable. It is computed as:

$$\theta = \frac{\left(\frac{\pi}{1-\pi}\right) \mid x = x_{(1)}}{\left(\frac{\pi}{1-\pi}\right) \mid x = x_{(2)}}$$

The hypotheses in this study will be tested using logistic regression analysis in SPSS software. This is consistent with the research question, which seeks to examine the influence of multiple independent variables on the dependent variable. The analysis will include collecting data through the questionnaires, selecting the logistic regression model, conducting an overall model fit test, and validating the model using the Hosmer and Lemeshow Test. In hypothesis testing, the Wald test will be used to assess the significance of each independent variable. A significance level of 5% will be used for decision-making. If the p-value is more significant than 0.05, the null hypothesis (H_0) is accepted, suggesting that the independent variable does not significantly affect the dependent variable. If the p-value is less than 0.05, H_0 is rejected, indicating that the independent variable has a significant effect on the dependent variable (Ghozali, 2016).

III. Results and Discussion

Based on the respondents' data results through g-form, 216 high school students will be studying math in 2024/2025. The data contains students' enthusiasm for game-based learning towards students' enthusiasm for learning math. Then, the data is analyzed using binary logistic regression using the statistical software SPSS. The output results are as follows:

1. Case Processing Summary

Table 1. Case Processing Summary

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	216	100.0
	Missing Cases	0	.0
	Total	216	100.0
Unselected Cases		0	.0
Total		216	100.0

a. If weight is in effect, see classification table for the total number of cases.

The study has 216 data, and Table 1 does not contain missing cases so that all data can be processed to the next steps.

2. Classification Table

Table 2. Classification Table[a,b]

Classification Table[a,b]

Observed			Predicted: Antusias PBM MTK dengan GBL: Antusias	Predicted: Antusias PBM MTK dengan GBL: Tidak An	Percentage Correct
Step 0	Antusias PBM MTK dengan GBL	Antusias	190	0	100.0
		Tidak An	26	0	.0
	Overall Percentage				88.0

a. Constant is included in the model.

b. The cut value is .500

The overall percentage result before including the independent variable is 88%, as seen in Table 2. The table explains that 88% (190) of students are enthusiastic about learning math with game-based learning, and 12% (26) are not enthusiastic.

3. Iteration History

Table 3. Iteration History[a,b,c,d]

Iteration History[a,b,c,d]

Iteration		-2 Log likelihood	Coefficients: Constant	Frekuensi PBM MTK dengan GBL	Antusias PBM MTK dengan Game Tradisional	Antusias PBM MTK dengan Game Online
Step 1	1	123.357	2.428	.040	-.425	-.906
	2	92.805	5.490	-.031	-.835	-1.735
	3	82.410	8.867	-.214	-1.285	-2.542
	4	80.110	11.339	-.399	-1.619	-3.100
	5	79.948	12.189	-.471	-1.735	-3.290
	6	79.947	12.265	-.478	-1.745	-3.307
	7	79.947	12.266	-.478	-1.745	-3.307

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 158.830

d. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

The -2 Log Likelihood value is 158.830, as shown in table 3. This iteration history table does not include the independent variables if we compare it with the Chi-Square value when the degree of freedom DF=N-Number of Independent Variables = 213 and probability P=0.05, then the -2 Log Likelihood value: 158.830 < Chi-Square value: 251.286 indicating that after including independent variables, the model fits the data.

4. Omnibus Test

Table 4. Omnibus tests of model coefficients

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	78.884	3	.000
	Block	78.884	3	.000
	Model	78.884	3	.000

The significance value contained in Table 4 is sig <0.05. Based on this value, the model is declared fit, or in another sense, adding independent variables has a real influence on the model.

5. Hosmer and Lemeshow Test

Table 5. Hosmer and Lemeshow Test

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	4.057	5	.541

The Chi-Square Hosmer and Lemeshow test values are less than the Chi-Square table, namely 4.057 < 11.070 (when df 5 and probability P = 0.05) or can be reviewed from the significance value in the table 0.541 > 0.05, which means there is no significant difference between the model and its observations so that hypothesis testing can be done (see table 5).

6. Classification Results

Table 6. Classification Results

Classification Table[a]

Observed			Predicted: Antusias PBM MTK dengan GBL: Antusias	Predicted: Antusias PBM MTK dengan GBL: Tidak An	Percentage Correct
Step 1	Antusias PBM MTK dengan GBL	Antusias	185	5	97.4
		Tidak An	15	11	42.3
	Overall Percentage				90.7

a. The cut value is .500

Table 6 shows the results of students who are not enthusiastic about learning mathematics with game-based learning, 26 students with a classification of 11 students who are not enthusiastic, and 15 students who should not be enthusiastic but are enthusiastic after the independent variable is included. After that, students who were enthusiastic about learning math with Game-Based Learning were 190, with a classification of 185 enthusiastic students and five students who should be enthusiastic but were not enthusiastic. Thus, table 6 also obtained the accuracy of the research model of 90.7%.

7. Logistic Regression Model and Hypothesis Test

The results of the SPSS output in Table 7, which contains the coefficient, are as follows:

Table 7. Variable in the Equation

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Frekuensi PBM MTK dengan GBL	-.478	.459	1.085	1	.298	.620	.252	1.525
	Antusias PBM MTK dengan Game Tradisional	-1.745	.470	13.817	1	.000	.175	.070	.438
	Antusias PBM MTK dengan Game Online	-3.307	.613	29.130	1	.000	.037	.011	.122
	Constant	12.266	2.622	21.876	1	.000	212269.987		

a. Variable(s) entered on step 1: Frekuensi PBM MTK dengan GBL, Antusias PBM MTK dengan Game Tradisional, Antusias PBM MTK dengan Game Online.

Table 7 will answer the hypotheses that have been formulated in this study as follows:

1. The first hypothesis on X_1 (frequency of math learning with Game-Based Learning)

H_0: There is no effect of the frequency of learning mathematics with Game-Based Learning on high school students' enthusiasm for learning mathematics.

H_1: There is an effect of the frequency of learning mathematics with Game-Based Learning on high school students' enthusiasm for learning mathematics.

Table 7 shows that the p-value > 0.05, so H_0 is accepted. This means that there is no effect of the frequency of learning mathematics with Game-Based Learning on high school students' enthusiasm for learning mathematics. This contradicts some research results, which state that consistently applying game-based learning in mathematics learning can increase motivation, learning outcomes, and competence in learning mathematics (Himmawan & Juandi, 2023; Mahmud Muhammad Sofwan, 2023; Yulita Dwi Lestari et al., 2023).

2. The second hypothesis on X_2 (traditional Game-Based Learning in math learning)

H_0: Traditional Game-Based Learning has no effect on high school students' enthusiasm for learning mathematics.

H_1: There is an effect of student enthusiasm with traditional Game-Based Learning on high school students' enthusiasm for learning mathematics.

The effect of student enthusiasm with traditional Game-Based Learning on high school students' enthusiasm for learning mathematics. According to Tiarawati dan Surakarta (2024), traditional games that are applied to math learning foster interest and enthusiasm among students. This strongly supports the hypothesis in point two.

3. The third hypothesis on X_3 (Online Game-Based Learning in math learning)

H_0: Online Game-Based Learning has no effect on high school students' enthusiasm for learning mathematics.

H_1: There is an effect of student enthusiasm with online Game-Based Learning on high school students' enthusiasm in learning mathematics.

Table 7 shows that the p-value <0.05 so that H_0 is rejected, which means that there is an effect of student enthusiasm with online Game-Based Learning on high school students' enthusiasm for learning mathematics. This is in line with Che Mansor dan Rosly (2024), who stated that digital-based games that have been applied in mathematics learning significantly improve students' mathematical achievement and provide positive perceptions of mathematics learning. Through digital-based games, students' skills and activeness in learning mathematics are involved (Wardani & Kiptiyah, 2024). On the other hand, through Table 7, a logistic regression model can be obtained in terms of independent variables that have a significant effect, namely:

$$Logit\left(\frac{\pi}{1-\pi}\right) = 12{,}266 - 1{,}745X_2 - 3{,}307X_3$$

The findings of this study align with previous research, such as Adinda et al. (2024), Yustina & Yahfizham (2023), and Rosarian & Dirgantoro (2020), which highlight the positive impact of Game-Based Learning (GBL) on student engagement and enthusiasm in mathematics education. Adinda et al. (2024) showed that interactive, game-based methods significantly boost student motivation compared to traditional approaches. Yustina and Yahfizham (2023) found that digital games tailored for mathematics enhance cognitive and emotional engagement. Rosarian and Dirgantoro (2020) further emphasized the role of gamification elements, such as points and challenges, in maintaining student interest. However, this study builds upon these insights by introducing a quantitative analysis through a binary logistic regression model, achieving a 90.7% predictive accuracy, which offers a more systematic way of understanding student enthusiasm as a predictor of learning outcomes.

The integration of traditional and online GBL formats in this research provides a broader perspective on GBL strategies, surpassing the scope of previous studies that focused solely on gamification elements or digital tools. The logistic regression analysis provides robust empirical evidence demonstrating how enthusiasm for specific learning tasks directly influences the effectiveness of GBL approaches. This method complements the qualitative insights from earlier studies and offers educators a practical tool to predict and address areas where student engagement might be lacking.

These results highlight the potential for more targeted instructional strategies in mathematics education. Educators can use the predictive model to design interventions that address specific motivational gaps, choosing appropriate GBL strategies, whether collaborative c, classroom settings, or individualized online environments, according to the context. Future research should explore additional variables, such as peer interactions, self-efficacy, and collaborative dynamics, to build an even more comprehensive understanding of factors that drive engagement and learning outcomes in mathematics education through GBL.

IV. Conclusion

The findings of this study highlight the significant role of Game-Based Learning (GBL) in influencing high school students' enthusiasm for learning mathematics. While the frequency of using GBL did not show a significant effect, both traditional and online GBL approaches positively impacted students' enthusiasm for mathematics learning. The binary logistic regression model, with an accuracy of 90.7%, demonstrated that GBL effectively predicts and enhances enthusiasm for learning mathematics.

The partial test analysis revealed that traditional Game-Based Learning significantly enhances student engagement, supporting research emphasizing traditional games' role in fostering interest. Similarly, online game-based learning significantly affects enthusiasm, which aligns with studies showing that digital games improve mathematical achievement and positive perceptions of learning. These results are summarized in the logistic regression equation:

$$Logit\left(\frac{\pi}{1-\pi}\right) = 12{,}266 - 1{,}745X_2 - 3{,}307X_3$$

This research provides valuable insights for high school teachers to adopt Game-Based

Learning as an innovative approach to their teaching practices. Teachers can create a more engaging and motivating learning environment by integrating traditional and online games into the mathematics curriculum. Such methods increase students' interest and foster collaboration, critical thinking, and overall academic performance.

Ultimately, Game-Based Learning offers a promising pathway to address students' declining interest in mathematics and enhance the overall quality of mathematics education in high schools. Future research could explore the long-term impact of GBL and investigate optimal strategies for its implementation in diverse educational contexts.

Acknowledgment

I want to thank the Indonesia Endowment Fund for Education (LPDP) from the Ministry of Finance Republic Indonesia for granting the scholarship and supporting this research through the doctoral degree program in 2024.

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