The effect of game-based learning model with STEM approach in reducing learning anxiety and enhancing science learning motivation among students

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ABSTRACT

Students' anxiety in science learning can affect their overall abilities. Thus, schools must create a supportive environment to reduce anxiety and foster learning motivation. This study examines the influence of game-based learning models with STEM approaches to decrease learning anxiety and enhance students' learning motivation. The study was conducted at the junior high school level, specifically at SMPN 1 Mlarak Ponorogo. The method employed was quantitative descriptive with questionnaire surveys for 34 students. The research findings, analyzed through MANOVA tests, revealed that the game-based learning model with STEM approaches did not significantly affect students' learning anxiety and motivation. Still, it did influence students' learning outcomes. Consequently, this study suggests that employing game-based learning models enhances students' learning outcomes more effectively than conventional teaching methods. The implications of this study underscore the importance of considering non-academic factors in adopting innovative learning models to support effective teaching and learning practices.

Pengaruh model pembelajaran berbasis permainan berbasis STEM untuk mengurangi kecemasan belajar dan meningkatkan motivasi belajar IPA siswa

ABSTRAK

Kata Kunci:

Teknologi pendidikan
Pembelajaran berbasis permainan
Motivasi belajar
Kecemasan belajar IPA
STEM

Kecemasan siswa dalam belajar IPA dapat mempengaruhi kemampuan mereka secara keseluruhan, sehingga penting bagi sekolah untuk menciptakan lingkungan yang mendukung untuk mengurangi kecemasan dan membangun motivasi belajar. Penelitian ini bertujuan untuk menguji pengaruh model pembelajaran berbasis permainan dengan pendekatan STEM untuk menurunkan kecemasan belajar dan meningkatkan motivasi belajar siswa. Penelitian dilaksanakan di tingkat sekolah menengah pertama lebih tepatnya di SMPN 1 Mlarak Ponorogo. Metode yang digunakan dalam penelitian ini adalah deskriptif kuantitatif dengan menggunakan angket kuesioner untuk siswa dengan jumlah 34 siswa. Hasil penelitian yang dilakukan dengan analisis uji MANOVA diketahui bahwa model pembelajaran berbasis permainan dengan pendekatan STEM tidak berpengaruh terhadap kecemasan belajar dan motivasi belajar siswa tetapi berpengaruh terhadap hasil belajar siswa, maka penelitian ini menunjukkan bahwa cara untuk meningkatkan hasil belajar siswa lebih baik menggunakan model pembelajaran game based learning

dibandingkan dengan pembelajaran konvensional. Implikasi penelitian ini menekankan pentingnya mempertimbangkan faktor-faktor non-akademis dalam mengadopsi model pembelajaran inovatif untuk mendukung pengajaran dan pembelajaran yang efektif.

1. INTRODUCTION

The results of research conducted by the Program for International Student Assessment (PISA) in 2022 showed a decrease in learning outcomes in the international scope caused by the COVID-19 pandemic. Indonesia's ranking in 2022 has increased by 5-6 compared to 2018. Even so, regarding science literacy, Indonesia's score dropped 13 points, almost the same as the international average drop of 12 points. Indonesia's low ranking in science literacy is because science learning still needs to be centered on solving science literacy problems and focusing only on factual problems. Low interest in science literacy is a problem that Indonesia needs to face. Science literacy is the ability to coordinate science, solve problems in science, and understand science. Improving science literacy can be done by motivating students and implementing innovative learning strategies that provide direct experience and application of science in everyday life [1]. Science literacy can also be addressed by shifting from conventional or traditional learning to student-centered learning [2].

A two-way interaction in learning activities, namely from teachers to students, is bridged by learning resources or media in the learning activity environment [3]. Teachers need concentration and innovation in learning activities to motivate students and be more enthusiastic about learning. Learning motivation is the development of a person's soul, which is influenced by psychological and physiological factors [4]. Students who do not have learning motivation or interest in learning will become indifferent to learning and underestimate what teachers explain. As a result, their learning outcomes decrease and are not complete [5]. The school environment should provide comfort and opportunities for students to share learning barriers and anxiety experienced to overcome psychological problems, especially anxiety in learning, and build their learning motivation. Many studies have shown that the environment affects learning anxiety problems. The school environment is one factor that influences adolescents as a process of maturation and individual development related to the future [6]. On the other hand, student learning motivation will affect learning achievement [7], and learning interest is very influential in learning [8].

In arousing student learning motivation, it is necessary to pay attention to several aspects: clarify the objectives to be achieved, increase and build student interest, form a pleasant atmosphere in learning, reward every student's success, provide an assessment that satisfies students, comment on every student's work, and create cooperation and competition between groups [9]. Suppose there is a material or subject that students do not like. In that case, students will learn less in that subject. Therefore, learning motivation is helpful as a driving force in students' efforts to achieve successful learning because if someone has high learning motivation, he has a desire to try to achieve something he wants [10].

Each student responds differently to understanding learning; some immediately understand when explained, and some take a long time to understand, especially in science subjects that require more understanding than other subjects [11]. Students' liking for science is strongly related to learning achievement, class selection, career selection, and lifelong learning [12]. On the other hand, increasing students' learning time from tutoring

and other activities can improve their understanding of science or subject matter [13]. The application of science learning in daily life is important. Students' ability to apply science in everyday life dramatically affects their affective attitudes [14].

Science learning can correlate the situation directly with objective conditions because science studies everything in the universe [15]. A fun learning model will increase students' interest in learning and will make them better understand the learning material. Game-based learning (GBL) is a breakthrough learning model that uses game methods. GBL is a form of game-centered learning that aims to achieve learning objectives [16]. The benefits of a GBL model include motivating and involving all students in the learning, training students in literacy, and counting from the material used in the game as one way to overcome students' cognitive problems [17]. GBL dramatically increases students' motivation to learn, creates a sense of enthusiasm, and produces fun learning. Otherwise, a sense of kinship and cooperation between friends will also be created [18].

With the learning media, learning activities with games will run well. The learning media in the research was conducted using the STEM (Science, Technology, Engineering, and Mathematics) approach. STEM is a learning approach developed in the 21st century that connects academic knowledge or concepts with the natural world or life in nature by adhering to the principles of science, technology, engineering, and mathematics [19]. Applying learning with the STEM approach makes STEM principles the students' main goal [20]. Implementing STEM learning will improve skills and understanding, create a good standard of technological literacy, and improve student learning outcomes [21], [22].

Based on the results of the initial study through observations and interviews with science teachers, the learning anxiety was still high at SMPN 1 Mlarak. The students were less interested in monotonous learning, and most thought science learning was complicated to understand. On the other hand, learning outcomes and achievement did not meet the minimum completeness criteria standards. The literature states that learning motivation and students' learning anxiety will affect their achievement and learning outcomes. The GBL model is a learning model that is thought to be used to attract students' interest in learning research, which states that learning with games will hone students' thinking and logic and make learning material more exciting and easy to accept [23].

In contrast, learning media is needed to support the implementation of the GBL model. Learning media is made with a STEM approach because the STEM approach is expected to improve science literacy, according to research that states that learning with STEM methods will affect mathematical literacy [24]. Therefore, to overcome the problems at SMPN 1 Mlarak, this study examined the innovations used in science learning, namely the STEM-based GBL model, which is thought to reduce science learning anxiety and increase student learning motivation, increasing student science literacy.

Many studies have been conducted on the GBL model, such as game-based learning for early childhood [16], the effect of the GBL model on argumentation skills [25], game-based learning as an innovation and solution to accelerate learning adaptation [26], and game-based learning on students' learning interest [27]. However, the previous studies only discussed the effect of the GBL learning model on argumentation skills. In contrast, the uniqueness and differentiation of this study was to examine learning anxiety and student learning motivation during science learning, with the help of learning media made with the STEM approach.

This study aims to determine the influence of a game-based learning model with STEM on reducing learning anxiety. The difference or renewal of this study with previous ones was the existence of learning media that supports the implementation of the GBL

model. This study also tested the effect on student learning anxiety and increased learning motivation.

Contribution to the Literature

This study contributes to:

- Enriching the understanding of the impact of GBL with the STEM approach.
- Providing empirical evidence regarding the effectiveness of GBL with a STEM approach in enhancing student learning outcomes.
- Adding to the literature on the importance of supportive learning environments in addressing learning anxiety and enhancing student learning motivation.

2. METHOD

This study took place at SMPN 1 Mlarak with randomly selected subjects, namely 34 students of class VII D. In this study, a series of GBL activities with a STEM approach were carried out for four weeks in seven meetings, each for two lesson hours. This study was conducted from August to September 2023. An observer observed each student during science learning. Learning activities began with introductions, and then direct learning was carried out with concept understanding first. The GBL was carried out in the middle and end of the learning sessions at meetings four and seven. The study's data collection instrument was a Likert scale questionnaire. The instrument that had been made was validated by a validator who was a science expert. After the instrument was approved and could be used, the next stage was for all subjects to fill out the questionnaire provided by the researcher. The research subject filled in honestly according to the circumstances, and there was no coercion. The questionnaire consisted of two aspects related to learning anxiety and learning motivation. Then, after the research data from the questionnaire was obtained and was already in the form of a Likert scale, the next stage was to analyze the data obtained to determine the effect given by the GBL model with a STEM approach to learning anxiety and learning motivation. The data analysis was carried out using SPSS 25 software to perform the validity and reliability tests, the normality test, the homogeneity test, the multivariate test (MANOVA), and the MANOVA univariate test. After performing the MANOVA analysis, a comparison of learning outcomes was conducted between class VII D using the GBL learning model STEM approach and class VII C using the conventional learning model.

Figure 1. Research procedure

3. RESULTS AND DISCUSSION

Learning using the GBL model with a STEM approach started with making learning tools or GBL teaching modules with the STEM approach, then making learning media tailored to the learning tools made and applying STEM elements in it. After the learning media had been made, the next stage was the application stage in the field and data collection. The collected data was then analyzed with the help of SPSS 25 software.

3.1 The GBL Implementation

The implementation of the learning was carried out and adjusted to the syntax in the GBL model [27]. The syntax description is listed in Table 1.

Table 1. Learning activities

Syntax	Description
Choose a game that is adapted to the topic	- The teacher plans the correct game, adapted to the material being studied. - Teachers adjust the facilities and infrastructure to support the games applied in learning.
Explanation of concept	- Before the game is applied, the teacher explains the material or learning concept to the students.
Rules	- The teacher explains the rules of the game to be used and the scoring agreement. - Students must obey the rules that have been agreed upon.
Playing games	- Students play the game with classmates. - The teacher monitors the learning activity.
Summarizing knowledge	- Students summarize the material obtained from the game activities and evaluate their understanding of the material discussed.
Reflecting	- The teacher conducts reflection activities on the learning activities that have been carried out. - The teacher evaluates the course of learning activities. - The teacher provides feedback and discusses game questions if any deviate from the subject matter.

In the GBL model, the researchers used games that utilize STEM card media with the concept of quizzing. Card media itself can improve student learning outcomes [28]. In its implementation, student representatives take one randomized card, and the teacher reads the question. If anyone wants to answer, students are welcome to raise their hands first, and if the student answers correctly, the student will get a reward and points from the game. Giving rewards is a form of appreciation for the efforts made while also providing reinforcement of learning to students [29].

Each syntax is measured with an implementation instrument that the observer assesses. The observer is tasked with observing and recording, overseeing the learning course [30]. Observers assess learning activities without interfering with them.

3.2 STEM-based Learning Media

The learning media used to support the implementation of the GBL model was card media with the STEM approach. The card media used in learning is shown in Figure 2. From the card, the STEM approach was applied in learning, among others:

Science : The science learning materials in the cards are substances and their changes.

Technology : Technology contained in learning is a card made as media played for the implementation of learning because technology is a means that helps humans achieve goals. Therefore, technology is not defined as a tool but rather a medium that can help achieve the goals [31]. Science and technology in the current era are very developed and create a lot of media and technology. Even in learning activities, technology dramatically affects effectiveness. Technology is a medium for student learning [32].

Engineering : Engineering is a game technique or strategy used to implement learning. Choosing suitable learning media and techniques or steps will create effective learning [33].

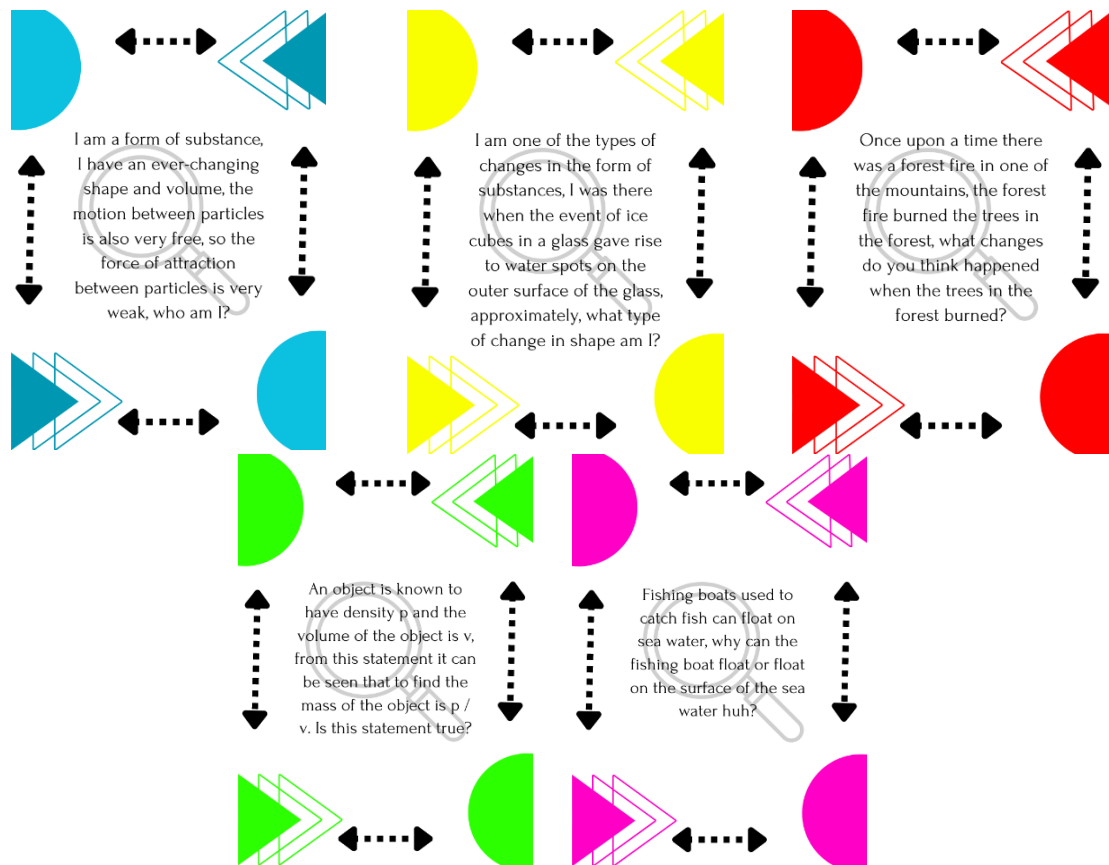Mathematics : The mathematics included in learning is students' points when playing the game with the card.

Figure 2. STEM card learning media

3.3 Data Analysis Results
3.3.1 The Normality Test

The normality test determined whether the research data was normally distributed. Normally distributed data will minimize the possibility of bias. The normality test in this study used the Shapiro-Wilk test in the SPSS 25 application. The Shapiro-Wilk normality test has the best consistency among the Lilliefors and Kolmogrov-Smirmov tests [34]. The error rate in data collection was set at α of 5% or 0.05. The Shapiro-Wilk test suggests that the significance value (P-value) of research results is more than 0.05, so the data is normally distributed [35]. Table 2 displays the results of the normality test.

Table 2. Data normality test

Variable Dependent	Kolmogorov-Smirnov			Saphiro-Wilk		
	Statistic	Df	Sig	Statistic	Df	Sig
Science learning anxiety	0.168	6	0.200*	0.932	6	0.595
Learning motivation	0.246	6	0.200*	0.879	6	0.264

a. Lilliefors Significance Correction
*. This is a lower bound of the true significance

Table 2 shows that in the Shapiro-Wilk test obtained from the data processing results through SPSS software, the significance value is 0.595 for learning anxiety and 0.264 for learning motivation. With this significance value, it is known that the significance value based on the Shapiro-Wilk test is greater than 0.05 (sig α > 0.05). Therefore, it can be said

that the results of the learning anxiety and learning motivation questionnaires are normally distributed [36].

3.3.2 The Homogeneity Test

This homogeneity test is carried out to determine whether the data obtained is identical [37]. The homogeneity test is carried out if the data in a group has a normal distribution. In this study, the Levene statistics of the homogeneity test were carried out using SPSS 25. The Levene statistics have homogeneous variants if the significant level of α is higher than 0.05 [38]. The results of the homogeneity test can be seen in Table 3.

Table 3. The homogeneity test

	Levene Statistic	dfl	df1	Df2	Sig
Science learning anxiety	0.408	9		14.044	0.910
Learning motivation	0.421	9		13.853	0.903

Table 3 shows that the significance value processed through SPSS software with the Levene test is 0.910 for learning anxiety and 0.903 for learning motivation. Both significance values are higher than 0.05. Therefore, learning anxiety and motivation have homogeneous or equal variants. If the sig value of α is more than 0.05, then the data will be homogeneous or the same [39].

3.3.3 MANOVA Multivariate Test

Analysis with one independent variable and two dependent variables determines the effect given to class VIID SMPN 1 Mlarak students in reducing science learning anxiety and increasing student learning motivation. Multivariate analysis is a method with statistical calculations used to understand the data structure [40]. Many multivariate techniques are extensions of univariate procedures. Historically, most applications of multivariate techniques arose in the behavioral and biological sciences. However, interest in multivariate methods has now spread to other fields such as education, chemistry, physics, geology, engineering, law, business, literature, religion, public television broadcasting, nursing, mining, linguistics, psychology, and other fields. These techniques are popular because they are considered capable of modeling the complexity of natural systems, although they are challenging to implement. Therefore, this study used MANOVA to analyze the results. MANOVA is a statistical technique used to calculate the significance of the test of simultaneous mean differences between groups for two or more dependent variables. MANOVA is a generalization of ANOVA for situations with many dependent variables [41]. In MANOVA testing, the significance level is 5% or 0.05; if the significance value of α is less than 0.05, there is an influence given by the variable significantly [42]. The multivariate test on the data was carried out with the help of SPSS software; the multivariate test results can be seen in Table 4.

Table 4. Multivariate MANOVA test

	Multivariate Test	Value	F	Hypothesis df	Error df	Sig
GBL	Pillai's Trace	0.956	2.015	20.000	44.000	0.027
	Wilks' Lambda	0.258	2.036[b]	20.000	42.000	0.026
	Hotelling's Trace	2.049	2.049	20.000	40.000	0.026
	Roy's Largest Root	1.493	3.285[c]	10.000	22.000	0.010

Table 4 shows that the p-value results are different. For the multivariate Pillai's Trace test, the p-value of 0.956 indicates that the value is more than 0.05. It can be said that the independent variable does not affect the dependent variable. For the multivariate Wilks

Lambda test, the p-value of 0.258 indicates that the value is higher than 0.05. It can be said that the independent variable does not affect the dependent variable. For the Hotelling's Trace multivariate test, the p-value of 2.049 indicates that the value is more than 0.05. The independent variable does not affect the dependent variable. Then, Roy's Largest Root has a p-value of 1.493, indicating that the value is more than 0.05. It can be said that the independent variable does not affect the dependent variable.

3.3.4 Univariate Test on MANOVA

Univariate tests after MANOVA testing aim to determine which variables are more effectively used [43]. The univariate test on MANOVA was carried out using SPSS software. The results of the univariate test on MANOVA can be seen in Table 5.

Table 5. Univariate test results on MANOVA

Independent Variable	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig
Intercept	Science learning anxiety	22668.568	1	22668.568	1428.623	0.000
	Learning motivation	27538.090	1	27538.090	4540.947	0.000
GBL	Science learning anxiety	197.098	10	19.710	1.242	0.320
	Learning motivation	118.462	10	11.846	1.953	0.092

Table 5 shows the results of the effect of one independent variable, namely the GBL learning model, on the dependent variable, namely learning anxiety and learning motivation. Univariate test after MAANOVA testing concerning Bonferroni and with the decision of the significance level of 5% or 0.05, if the significance value of α is less than 0.05, there is an influence between the independent and dependent variables [43]. Based on Table 5, the sig value for learning anxiety is 0.320, which is more than 0.05. Therefore, the GBL learning model with a STEM approach does not affect learning anxiety. Then, the significance value on learning motivation is 0.092, less than 0.05, meaning that the GBL learning model with the STEM approach does not affect learning motivation.

Based on the data analysis, the independent variable does not affect the dependent variable. There is no influence between the STEM-based GBL model and decreased learning anxiety and increased student learning motivation when studying science subjects. According to research, several factors affect emotional intelligence or learning anxiety, starting from the family environment, internal factors, or non-family or external factors. Both factors can affect students' emotional intelligence, and it is known that students' backgrounds also vary [44]. With this statement, many aspects affect a person's learning anxiety. Reducing student learning anxiety in science subjects must also look at the internal aspects of students, which come from family and living environment. Therefore, the research conducted is not enough to affect student learning anxiety because the internal problems of the students themselves should be considered. Increasing student learning motivation is also a problem that teachers often experience during learning. There are many ways to increase student learning motivation, such as paying attention to students' intrinsic motivation. Research states that student learning motivation is divided into intrinsic and extrinsic. Intrinsic motivation arises from the students themselves. In contrast, extrinsic motivation arises because of external influences [45]. Therefore, teachers must pay attention to students from various points of view so that existing problems can be resolved.

3.3.5 Learning Outcome

The research data obtained outside the questionnaire is the student learning outcomes obtained from the summative assessment at the end of the study. To compare the results of student learning achievement, this study grouped students into two classes. The

experimental class implemented the GBL model and the STEM approach. In contrast, the control class implemented a conventional learning model. The data can be seen in Table 6.

Table 6. Student learning outcomes

Group	Mean	Max	Min	Low	Medium	High	STDEV	d (Cohen Effect)
Experiment Group (N = 31)	68.03	90	33	22.6% (N=7)	32.3% (N=10)	45.2% (N=14)	17.5	0.787
Control Group (N = 33)	53.66	94	17	39.4% (N=13)	48.5% (N=16)	12.1% (N=4)	18.8	

Table 6 shows that the average learning outcomes of students using the conventional model are 53.66, while the learning outcomes using the GBL model are 68.03. Therefore, the GBL learning model can improve student learning outcomes. Table 6 also states that the maximum value in the experimental class was 90, while in the control class was 94. The minimum value in the experimental class was 33, while in the control class was 17. In the experimental class, seven students (22.6%) were grouped in the lower class based on the scores obtained, and 13 students (39.4%) were in the upper class. Cohen's effect on the learning outcomes of the experimental and control classes is 0.787, which means that it has a moderate influence. With Cohen's of 0.79, 78.4% of the experimental group will be above the average of the control group (Cohen's U3), and 69.4% of the two groups will overlap. There is a 71.1% chance that a person randomly selected from the experimental group will have a higher score than one from the control group. Based on student learning outcomes as evidenced by summative scores and stated in Table 6, teachers must have innovations in learning so that learning achievement or student learning outcomes can be maximized. Teachers must understand and apply innovations in education so that learning can be more conducive and create a pleasant learning atmosphere to improve student learning outcomes [46].

The analysis revealed that the GBL learning model with the STEM approach did not significantly affect students' learning anxiety and motivation. In previous research, GBL positively influences students' critical thinking [47], and other studies have indicated that GBL can enhance the learning experience [48]. The sample size of the dependent variables used becomes a factor influencing the results of this study compared to previous studies. Nevertheless, these findings are intriguing as they suggest that this instructional model did not directly address anxiety or learning motivation despite improvements in learning outcomes.

Both the previous studies and this study examined the effect of the GBL model. Still, the dependent variable is different, namely measuring the effect of GBL on students' critical thinking ability. In addition, previous research related to STEM states that STEM learning media can improve students' mathematical spatial abilities [49]. The similarity with this study is the utilization of STEM learning media. However, this study measures the effect on learning anxiety and student learning motivation, while the previous studies measured students' mathematical spatial abilities. However, in this study, student learning outcomes and the Cohen value obtained was 0.787, and learning with the GBL model of the STEM approach can improve student learning outcomes. When teachers have problems with student learning outcomes, the GBL learning model supported by STEM learning media can overcome these problems because it can improve student learning outcomes. Teachers and curriculum developers must continue developing learning innovations so that student learning outcomes are better and continue to improve.

The significant contribution of this study lies in highlighting the necessity of integrating psychological approaches and supportive learning environments alongside implementing innovative learning models. The implication is that schools and teachers should consider non-academic factors when adopting new approaches to teaching and learning. Limitations of this study include a limited sample size and a focus on a specific school context, which may impact the generalizability of the findings. Future research could explore the influence of GBL models with the STEM approach in various educational contexts and with larger samples to bolster these findings. Recommendations for further research include further investigation into how specific elements of GBL and STEM influence students' psychological aspects and learning outcomes, as well as the development of intervention strategies to enhance the effectiveness of these learning models in reducing learning anxiety and increasing motivation.

4.   CONCLUSION

This study explored the influence of the STEM-based GBL model on science learning at SMPN 1 Mlarak Ponorogo and found that although this model did not significantly reduce learning anxiety or increase student motivation, there was a significant improvement in student learning outcomes. These findings indicate that while the STEM-based GBL model may not directly affect psychological factors, such as anxiety and motivation, it effectively enhances students' academic achievement in science learning. Therefore, this innovative teaching method can be considered a beneficial strategy to enrich the learning process and improve learning outcomes, emphasizing the importance of integrating pedagogical approaches that support innovation in the educational environment.

AUTHOR CONTRIBUTION STATEMENT

INA contributed to conceptualizing research, developing instruments, and collecting data. SA contributed to analyzing data and making research reports.

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