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THE EFFECT OF USING BAAMBOOZLE EDUCATIONAL GAMES IN IMPROVING MATHEMATICS LEARNING OUTCOMES OF HIGH SCHOOL STUDENTS

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ABSTRACT
This research is motivated by the low achievement of students in mathematics even though PBL (Problem Based Learning) has been widely applied. Previous studies have generally placed PBL as a single model, with limited attention to its integration with interactive digital media as well as evaluations that include cognitive and affective aspects. This study develops an approach by integrating PBL and digital competition-based educational games (Baamboozle) which are applied systematically and evaluated through N-gain analysis and student response. The study aimed to compare the mathematics learning outcomes between students taught using Baamboozle-assisted PBL and conventional PBL. The method used was a quasi-experiment with a non-equivalent control group pretest-posttest design at SMAIT Raudhatul Jannah Cilegon, with samples selected through cluster random sampling. Data was collected through pretest, posttest, N-gain analysis, and student response questionnaires. The results showed that the experimental group obtained a higher improvement in learning outcomes than the control group, accompanied by a more positive student response. These findings confirm that the integration of PBL with interactive digital game media is effective in improving learning outcomes as well as student engagement. This research contributes in the form of strengthening gamification-enriched problem-based learning strategies and a more comprehensive evaluation approach in mathematics learning.
Keywords: baamboozle educational game; mathematics learning outcomes; problem-based learning.

ABSTRAK
Penelitian ini dilatarbelakangi oleh rendahnya prestasi siswa dalam matematika meskipun PBL (Problem Based Learning) telah banyak diterapkan. Studi sebelumnya umumnya menempatkan PBL sebagai model tunggal, dengan perhatian terbatas pada integrasinya dengan media digital interaktif serta evaluasi yang mencakup aspek kognitif dan afektif. Penelitian ini mengembangkan pendekatan dengan mengintegrasikan PBL dan game edukasi berbasis kompetisi digital (Baamboozle) yang diterapkan secara sistematis serta dievaluasi melalui analisis N-gain dan respons siswa. Penelitian bertujuan membandingkan hasil belajar matematika antara siswa yang diajar menggunakan PBL berbantuan Baamboozle dan PBL konvensional. Metode yang digunakan adalah kuasi-eksperimen dengan desain non-equivalent control group pretest-posttest di SMAIT Raudhatul Jannah Cilegon, dengan sampel yang dipilih melalui cluster random sampling. Data dikumpulkan melalui pretest, posttest, analisis N-gain, dan angket respons siswa. Hasil penelitian menunjukkan bahwa kelompok eksperimen memperoleh peningkatan hasil belajar yang lebih tinggi dibandingkan kelompok kontrol, disertai respons siswa yang lebih positif. Temuan ini menegaskan bahwa integrasi PBL dengan media game digital interaktif efektif dalam meningkatkan hasil belajar sekaligus keterlibatan siswa. Penelitian ini memberikan kontribusi berupa penguatan strategi pembelajaran berbasis masalah yang diperkaya gamifikasi serta pendekatan evaluasi yang lebih komprehensif dalam pembelajaran matematika.
Kata kunci: g*ame* edukasi b*aamboozle;*hasil belajar matematika;p*roblem-based learning.*

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Introduction

Mathematics is an essential discipline to hone students' competencies in logical, analytical, and critical thinking. Although its role is important, the fact is that many students, especially at the high school level, still face serious obstacles in mastering the basic concepts. Rahayu et al. (2022) underline that despite compulsory, math subjects are often considered difficult by the majority of students, which ultimately negatively impacts their interests and achievement of learning outcomes.

The achievement of learning outcomes is basically a reflection of the transformation that occurs in students, including the dimensions of knowledge, skills, and behavior, after going through a series of learning activities (Suswati, 2021) However, in general, the mathematical ability of Indonesian students raises great concerns. For example, *the* Programme for International Student Assessment (PISA) in 2018 recorded that Indonesia was ranked 73rd out of a total of 79 participating countries, with an average score of 379. This figure is far below the average standard of the Organisation for Economic Co-operation and Development (OECD) member countries of 489 (Sudiana et al., 2023) This concern was reinforced by the 2022 PISA results which recorded a decrease in math scores to 366, despite an increase in rankings of around 5–6 positions (OECD, 2023) These data indicate that the numeracy (mathematics) skills of students in Indonesia still need serious intervention.

According to Rofi'ah et al. (2019) one of the main difficulties students have is in solving story problems, while Rofi'ah et al. (2019) argue that student mistakes can be an indicator of mastery of the material that is not optimal. The factor of low student learning outcomes is influenced by internal aspects, such as motivation and interest in learning, as well as external aspects, such as learning methods and media (Nabillah & Abadi, 2020; Sari et al., 2025) Several studies, such as those stated by Ihsanudin et al. (2022), show that the lack of innovation in learning media makes the learning process feel monotonous, negatively impacting students' mathematical communication skills. On the other hand, the use of interactive learning media can increase the effectiveness and involvement of students (Iskandar et al. 2022).

One of the strategies relevant to the learning needs of the 21st century is the PBL (Problem Based Learning) model, which encourages students to actively solve real problems collaboratively (Hakim et al. 2023). To make it more interesting, this model can be combined with technology-based educational games, one of which is Baamboozle, an interactive platform that presents educational quizzes in the form of games (Iffada & Efendi, 2024; Febryanti et al., 2026), Baamboozle is considered to be able to increase student motivation, participation, and learning outcomes because it presents more lively, fun, and accessible learning (Sari & Ramadan, 2025).

Educators and students are increasingly using technology, especially educational games, as a popular approach to boost students' motivation to learn and academic achievement in mathematics subjects. Therefore, through the support of appropriate learning media, teachers can manage the learning process as a whole, from planning, implementation, to evaluation (Syarifudin, 2020) In the context of

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21st century education, choosing an effective learning model is very important considering the variety of options available (Kartini et al. 2022). This decision is crucial because it aims to develop students' basic skills, namely critical thinking, collaboration, communication, and creativity. One relevant approach is the PBL model, which focuses on the teamwork of students with heterogeneous abilities to solve real (contextual) problems (Safitri et al. 2023). Preliminary analysis shows that the implementation of Baamboozle educational games within the framework of the PBL Model has not fully resulted in a meaningful impact on improving the learning outcomes of mathematics subjects. These findings are in line with the research of Habsah et al. (2025), Hilda & Prasetyaningtyas (2024) and Sari & Ramadan (2025) which affirm that the learning models and methods used have not been optimal in supporting the improvement of student achievement.

Based on the background description and research gaps that have been presented, the integration of the PBL model with *the* Baamboozle educational game still requires stronger empirical proof, especially in improving students' mathematics learning outcomes. Therefore, this study is focused on testing the effectiveness of the combination of the two approaches compared to the use of conventional PBL models.

The formulation of the problem in this study is: Is the improvement in mathematics learning outcomes of students who learn with the PBL (*Problem Based Learning*) model assisted by the Baamboozle educational *game* better than students who learn with the PBL (*Problem Based Learning*) model without the help of the media? Based on the formulation of the problem, the research hypothesis is formulated as follows:

H_0 (null hypothesis): There was no difference in the improvement of mathematics learning outcomes between students who obtained learning with the PBL model assisted by the Baamboozle educational *game* and students who obtained learning with the conventional PBL model.

H_1 (alternative hypothesis): There is a difference in the improvement of mathematics learning outcomes between students who learn with the PBL model assisted by the Baamboozle educational game and students who learn with the conventional PBL model.

Operationally, the alternative hypothesis in this study leads to the suspicion that the increase in learning outcomes of students who obtain learning with the PBL model assisted by the Baamboozle educational game is higher than that of students who obtain learning with the conventional PBL model.

Research Methods

This study uses a numerical (quantitative) approach by choosing an impure experimental design or known as a quasi-experiment. The design used is the Nonequivalent Pretest-Posttest Control Group Design (Sugiyono, 2013). The data analysis in this study was carried out in stages by integrating inferential statistical approaches and theoretical interpretations to obtain a more comprehensive understanding of the effectiveness of the treatment given.

The initial stage of analysis was carried out through descriptive statistics to describe the general trend of the data, including mean values, standard deviations, minimum scores, and maximums in both *pretest* and *posttest* in both groups.

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However, the analysis does not stop at this stage, but is continued with assumption testing as a prerequisite for inferential analysis, namely the normality test and the variance homogeneity test. The normality test aims to ensure that the distribution of data follows a normal distribution pattern, while the homogeneity test is carried out to determine the similarity of variance between groups. After the prerequisites were met, the analysis was followed by a difference test using a parametric statistical test, which is an independent sample t-test to compare the posttest results between the experimental group and the control group. In addition, a paired sample t-test was also carried out to analyze the improvement in learning outcomes in each group from pretest to posttest. The use of these two tests was intended to not only identify differences in end-of-life outcomes, but also to evaluate the dynamics of improved learning ability that occurred as a result of treatment.

To strengthen the interpretation, this study also calculates the value of the gain score or improvement in learning outcomes which is then analyzed using the average difference test. This approach is based on a theoretical framework of learning that emphasizes the importance of viewing change in ability as an indicator of the success of an intervention, rather than just an end result. Furthermore, the interpretation of statistical results is not carried out mechanically based on the value of significance alone ($p - value$), but is also associated with the relevant theoretical foundation. If a significant difference is found between the experimental and control groups, it is interpreted as empirical evidence that the integration of the PBL model with Baamboozle's educational game media is able to improve learning outcomes more effectively. Theoretically, these findings can be explained through the perspective of constructivism, which states that learning that involves problem-solving activities and active interaction with the learning environment will strengthen the process of knowledge construction.

In addition, the gamification element in Baamboozle is understood as a factor that increases intrinsic motivation and student engagement. This higher engagement contributes to improved deep learning, which ultimately leads to improved learning outcomes. Thus, the data analysis in this study not only serves to test the hypothesis statistically, but also to explain the relationship between learning strategies, students' cognitive processes, and the learning outcomes achieved. This approach is expected to be able to produce a more meaningful interpretation and is not limited to mere descriptions of numbers, so as to meet the standards of scientific analysis expected in journal publications. The design of this research can be illustrated as follows in Table 1.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Description:
O_1 = experimental group before treatment
O_2 = experimental group after treatment
O_3 = control group before treatment

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O_4 = control group after treatment
X = Treatment (implementing the PBL (Problem Based Learning) model assisted by the educational game Baamboozle)

Based on Table 1, the two research groups were given a pretest to identify the initial ability, then received different treatments, and ended with a posttest to measure the final learning outcomes. Comparisons between pre- and post-treatment scores in each group, as well as differences in posttest results between groups, were used as a basis for assessing the effectiveness of interventions more objectively.

Conceptually, this design allows testing the effect of the integration of the PBL model with the Baamboozle educational *game* on improving students' mathematics learning outcomes. Therefore, the hypothesis proposed in this study is that there is a significant difference between the learning outcomes of students who participate in Baamboozle-assisted PBL learning and students who participate in PBL learning without the help of the media.

Results and Discussion

Results

This study has two main objectives: first, to evaluate and compare the degree of improvement in mathematics learning outcomes between students who were given PBL (Problem Based Learning) model interventions combined with *the* Baamboozle educational *game* with a control group that only applied; second, to examine students' views (perceptions) related to the teaching-learning process that combines the two components, namely PBL and the Baamboozle educational game.

In order to achieve this goal, all numerical information is processed and statistically analyzed using Microsoft Excel and IBM SPSS Statistics 27th edition. The total subjects involved in data collection were 68 students, consisting of 34 students in the treatment group (experiment) and 34 students in the comparison group (control).

Data collection instruments consist of two main types: (1) Descriptive questions designed based on relevant cognitive domain indicators, used to obtain pretest, posttest, and n-gain scores. (2) Questionnaire, which functions to record student perception and response data to the implementation of the PBL model assisted by the Baamboozle educational game in Table 2.

Table 2. Description of Pretest Data Learning Outcomes Based on Study Group

Class	N	Min	Max	Mean	Std. Deviation
Experiment	34	0	30.5	15.64	7.884
Control	34	0	28.5	12.70	6.889

The average initial *pretest* scores presented in table 2 for the experimental group and the control group showed the numbers were 15.64 and 12.70, respectively. These figures collectively indicate that the level of initial mastery (math learning outcomes) in both subject groups is still relatively low and requires

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improvement efforts through intervention. To validate the differences in initial abilities and corroborate these findings, the next step will be an inferential statistical test in Table 3.

Table 3. Description of Posttest Data Learning Outcomes by Study Group

Class	N	Min	Max	Mean	Std. Deviation
Experiment	34	40.5	100	67.4	13.630
Control	34	30	94	54.8	15.260

Based on table 3, the average posttest score (final learning outcome) showed that the treatment group recorded a score of 67.4, while the comparison group reached 54.8. This data confirms that the level of mastery of the final math material of students in the experimental group far exceeded that of the control group, whose achievement was at the intermediate level. This apparent numerical gap provides a strong indication of the presence of substantial differences in final mathematics learning outcomes between the two study groups. To ensure the validity and methodologically reinforce these disparity findings, the next step taken is to conduct inferential statistical testing.

Normality Test

Because the number of participants in this study was less than 50 subjects, the Shapiro-Wilk Test was used to evaluate the normality of data distribution (Sugiyono, 2017). In this statistical procedure, the Null Hypothesis (H_0) regarding the normality of the data distribution, it will be confirmed if the probability value ($p - value$) or significance ($Sig.$) calculated, is above 0.05 ($Sig. > 0.05$). The results of the calculation showed that the pretest scores of the treatment group and the comparison group had significance values of 0.275 and 0.166, respectively. Posttest scores from both groups resulted in a Sig value. by 0.508 and 0.076. Since all significance values obtained exceeded the critical value of 0.05, it can be concluded that both the pretest and posttest data from the experimental group and the control group met the normal distribution assumptions.

Homogeneity Test

To evaluate the similarity of variance between data groups, this study used the Levene Test. In homogeneity testing, the Null Hypothesis (H_0) which states that the variance between groups is the same (homogeneous) will be accepted if the significance value ($p - value$) obtained is greater than the threshold of 0.05 ($Sig. > 0.05$). The results of the Levene Test show that the pretest data has a significance value ($Sig.$) of 0.917. The posttest data has a significance value ($Sig.$) of 0.553. Because the two significance values exceeded 0.05, it was concluded that the pretest and posttest data came from a population with homogeneous variance. This condition meets one of the important prerequisites for the implementation of further comparative parametric statistical tests.

Test Difference to Average

To identify whether or not there is a striking average disparity between the two data groups, this research uses the Independent Sample t-test. This test

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centered on a hypothesis about the possibility of significant differences in mathematics learning outcomes between the treatment group and the comparison group. The rules of decision-making stipulate that Hypothesis Zero (H_0) will be granted (no substantial difference) if the probability value ($p - value$) or significance ($Sig.$) is measured, exceeding the number 0.05 ($Sig. > 0.05$). Pre-intervention testing yielded a $Sig\ value. = 0.163$. Since the value of 0.163 far exceeds 0.05, it can be concluded that no significant differences were identified in the initial mastery of math material between the two classes. This situation confirms that the basic abilities of the two groups are equal before the intervention (treatment) is carried out.

Hypothesis Test

To test the alleged research in the research, the One-Tailed Independent Sample t-test is used. This procedure is focused on testing the Alternative Hypothesis (H_1), which is a proposition that states that the achievement of mathematics learning outcomes of students who use the PBL combined with the Baamboozle educational game will be better than students who only apply the PBL model. The decision principle for this hypothesis test stipulates that Hypothesis Zero (H_0) will be rejected (and H_1 accepted) if the probability value ($p - value$), or significance ($Sig.$) obtained, is less than the threshold of 0.05 ($Sig. < 0.05$). Furthermore, Table 4 is presented below, which contains a summary of the results of hypothesis testing to prove the main conjecture of this study in Table 4.

Table 4. Hypothesis Test Results

Data	***Independent sample t-test***	Description
Posttest	$\frac{1}{2}$ ***Sig. (2-tailed)*** 0.0005	H_0 = rejected

Based on the results presented (refer to table 4), the significance value ($p - value\ Sig.$) obtained was below 0.05 ($Sig. < 0.05$). This condition causes the Null Hypothesis (H_0) to be rejected. Rejection H_0 This provides strong empirical evidence, which shows that the mathematics learning outcomes of students in the experimental group that applied the PBL model supported by the Baamboozle educational game, were significantly superior compared to the control group that implemented learning with the PBL model. This conclusion validates the study's initial conjecture.

Test N-Gain Data

To determine the effectiveness or improvement of learning, it was analyzed using *the N-Gain value*, which is a measure that compares student learning outcomes in the *pretest* and *posttest* (Wahyuni et al., 2020) The calculation of *the n-gain* score refers to the formula proposed by Volunteer et al. (2024) to assess the change in the value of students' mathematics learning outcomes quantitatively, namely:

$$N_{Gain} = \frac{\text{Skor Posttest} - \text{Skor Pretest}}{\text{Skor Ideal} - \text{Skor Pretest}}$$

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The following results of the n-gain data are presented in the table below in Table 5:

Table 5. Quantitative Descriptive Results of N-Gain Data

Class	N	Min	Max	Mean	Std. Deviation
Experiment	34	0.25	1.00	0.616	0.161
Control	34	0.18	0.93	0.484	0.168

The results of the descriptive analysis of the N-Gain index showed that the average level of material mastery in all study participants (treatment and comparison groups) was classified as a moderate criterion. However, in terms of variability statistics, the standard deviation value (N-Gain*) of the* experimental group was smaller than that of the control group. This fact confirms that the distribution of increased learning outcomes in the experimental classroom is much denser around the group's average number, reflecting the existence of better and superior homogeneity and consistency of results in Table 6.

Table 6. N-Gain Data Normality Test

Data	Class	Statistic	Shapiro-Wilk df	*Sig.*
N-Gain	Experiment	0.956	34	0.183
	Control	0.959	34	0.235

Based on the results of the N-Gain calculation in table 7, the significance value obtained for the experimental class was 0.183 and for the control class 0.235. Since both are greater than 0.05, it can be concluded that the *N-Gain data* in both classes is normally distributed in Table 7.

Table 7. N-Gain Data Homogeneity Test

Data	Statistic	df1	df2	Sig.	Description
N-Gain	0.288	1	66	0.593	Homogeneity

Referring to the results of the N-Gain calculation (presented in table 7), the significance value ($p - value$) for both the experimental group and the control group exceeded the threshold of 0.05 ($Sig. > 0.05$). Therefore, the conclusion that can be drawn is that the variance of the data on learning outcome improvement ($N - Gain$) in the two groups has a homogeneous nature. To complement these quantitative findings, an in-depth analysis of student perception questionnaires was carried out based on student learning outcome indicators that include affective taxonomy A1 to A5 (considering its compatibility with the implementation of the PBL model assisted by the educational game Baamboozle). The following table is presented related to student perception questionnaire data on each indicator of affective domain learning outcomes in Table 8.

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Table 8. Percentage of Student Perception Questionnaire Data for Each Indicator

Indicator	Ideal Score	Actual Score	Percentage
A1 (Receiving)	1360	874	64,26%
A2 (Responding)	1360	887	65,22%
A3 (Appreciating)	1360	878	64,55%
A4 (Organizing)	1360	906	66,61%
A5 (Internalization of Values)	1360	896	65,88%
Average Percentage		65, 30%	

Based on Table 8, it shows that indicator A1 obtained a percentage of 64.26%, indicator A2 of 65.22%, indicator A3 of 64.55%, indicator A4 of 66.61%, and indicator A5 of 65.88%. All of these results are in the good category. Overall, the average percentage of student response questionnaires reached 65.30%, which shows that the application of the PBL model assisted by the Baamboozle educational *game* received a positive response with a good category.

Discussion

The application of the PBL (Problem Based Learning) model fostered by Baamboozle's educational game is carried out through five main stages, namely problem orientation, learning organization, investigation, presentation of results, and evaluation in four meetings. Baamboozle is used as a supporting medium in various phases, such as breaking the ice, working on Student Worksheets (LKPD), to individual quizzes. This integration creates an interactive learning atmosphere, builds positive attitudes such as confidence, cooperation, and learning motivation, while encouraging students' active involvement in the problem-solving process. This is in line with Dienes' view that the presentation of material through various activities and representations can increase students' interaction with concepts and foster interest in mathematics (Hasanah et al. 2022).

The results showed a significant improvement in the cognitive aspect. The average posttest score of the experimental group was higher by 12.6 points compared to the control group, and was supported by a significance value of 0.0005 (< 0.05). Smaller standard deviations in the experimental group also showed an even distribution of student comprehension. However, this increase is not solely due to the use of Baamboozle, but also due to the synergy between the PBL model, group dynamics, and student learning motivation.

These findings are consistent with previous research showing that PBL is effective in improving conceptual understanding and problem-solving skills, especially when supported by interactive media (Darman et al. 2024). In addition, dynamic learning has been shown to encourage active student participation (Setyowati et al. 2023). In the affective aspect, the results of the study also showed a positive response of 65.30% of students with a good category, which was

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characterized by an increase in confidence, cooperation, and involvement in learning. This is in line with the theory of constructivism which emphasizes that understanding is built through active learning experiences, and is reinforced by the view of Dienes and Bruner that the presentation of concepts in concrete terms facilitates mathematical understanding (Hasanah et al. 2022). Rizqiyani et al. (2024), who stated that the integration of PBL with game media is able to increase student involvement and positive attitudes in learning.

However, this study has some limitations. First, the limited sample covers only one class context, so generalizations of the results are still limited. Second, the use of cluster sampling has the potential to cause bias due to differences in initial ability between groups that are not fully controlled. Third, the use of Baamboozle depends on technology facilities and has the potential to shift students' focus to the gaming aspect if it is not managed properly. In addition, these media are more optimal for reinforcing material than in-depth conceptual learning. Thus, although the results of the study showed significant effectiveness, the interpretation of the findings needed to consider these factors. Further research is recommended to involve a broader sample and combine various learning strategies to obtain more comprehensive results.

Conclusions and Suggestions

Based on the results of the study, the application of PBL (Problem Based Learning) assisted by Baamboozle was proven to be effective in improving the learning outcomes and involvement of high school students, which was shown by the N-Gain value of 0.616 (medium category) and the student's affective response of 65.30% (good category). Theoretically, these findings reinforce the constructivist perspective put forward by Tohari & Rahman (2024) and Vygotsky (1978), that problem-based learning supported by active interaction plays a role in building more meaningful understanding. In addition, the results of this study are also in line with the theory of learning motivation and gamification which emphasizes that the provision of challenges, direct feedback, and active student involvement are important factors in improving participation and the quality of the learning process (Sanatang et al. 2023).

This research offers a new contribution through the application of the PBL model combined with competition-based digital game media (Baamboozle) in an integrated manner at each stage of learning in the Integrated Islamic High School. This approach not only presents a variety of methods, but shows that a blend of problem-based learning and gamification elements can be optimized as a strategy that encourages active engagement while supporting equitable student understanding. However, these findings need to be understood by considering several limitations, including the scope of samples from only one school, the relatively short duration of the study, and the reliance on technological support in its implementation. Therefore, the interpretation of the results of this study still requires caution, especially in the context of wider application.

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Based on this, teachers are advised to use Baamboozle in a targeted manner by providing an initial introduction and ensuring that each stage of PBL remains focused on the learning objectives. The next research is recommended to expand the sample, extend the duration of the research, and adjust the use of media to the conditions of students and learning facilities in order to obtain more comprehensive results.

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