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THE EFFECT OF PROBLEM-BASED LEARNING SUPPORTED BY MATH PLAYGROUND ON THIRD-GRADE STUDENTS' LEARNING ENGAGEMENT

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ABSTRACT

The low level of student participation in third-grade mathematics at SDN 1 Pejambon underscores the urgent need to strengthen learning engagement, as active involvement is essential for fostering mathematical reasoning and sustaining student interest. This study sought to examine how the application of the Problem-Based Learning (PBL) model, assisted by the Math Playground platform, influences students' engagement during learning activities. A quantitative approach with a pre-experimental one-group pretest-posttest design was applied, involving 20 third-grade students chosen through purposive sampling. Questionnaires and classroom observation sheets measuring cognitive, affective, and behavioral engagement served as the instruments for gathering data, which were subsequently examined using the Wilcoxon Signed-Rank Test and N-Gain test. Findings from the Wilcoxon signed-rank test revealed a Z-statistic of -3.854 with an Asymp. Sig. (2-tailed) value of $p < 0.001$, pointing to a statistically significant difference in students' engagement prior to and following the intervention. Meanwhile, the N-Gain analysis produced an average score of 0.4998 (49.98%), placing it in the moderate range and suggesting that this instructional model holds reasonable efficacy in boosting student engagement. Overall, the empirical data revealed a substantial increase in participation, demonstrating that embedding digital game-based tools within a Problem-Based Learning framework significantly boosts elementary school students' active engagement in mathematics instruction.

Keywords: Problem-Based Learning, Math Playground, Learning Engagement.

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PRELIMINARY

Fostering active student engagement in elementary classrooms is foundational to achieving meaningful learning outcomes. Through the integration of the Merdeka Curriculum, learning in elementary school is designed to encourage students to think analytically, innovatively, and cooperatively, as well as to play an active role in constructing their own knowledge. Therefore, learning engagement is considered an

important indicator of successful learning because it reflects students'physical, mental, and emotional involvement throughout the learning process.

Learning engagement refers to students' active participation in various instructional activities, such as paying attention to explanations, asking questions, expressing opinions, engaging in discussions, collaborating with peers, and completing tasks independently. According to Prasetyo (2021) learning engagement represents students' conscious effort to develop their potential through these interactive learning processes to achieve optimal academic outcomes. Meanwhile, Novitasari et al. (2018) explain that active students are characterized by their involvement in carrying out learning tasks, solving problems, seeking information, participating in discussions, and expressing their opinions during the learning process. Therefore, the higher the level of student involvement in learning activities, the greater the opportunity for learning objectives to be achieved optimally.

Classroom conditions indicate that students' level of activeness in mathematics learning is still relatively low. As evidenced by data gathered from classroom monitoring and field inquiries with the third-grade educator at SDN 1 Pejambon, it was found that most students remained passive during the learning process. Student participation in learning activities reached only approximately 20%. Students tended to be less active in asking questions, participating in discussions, and completing tasks independently. In addition, the learning process was still dominated by the teacher, limiting students' opportunities to explore knowledge and construct their own understanding. Furthermore, the learning materials used were insufficiently varied, making them less effective in attracting students' attention and encouraging their active participation throughout the learning experience. This ongoing issue is further reflected in the fact that several students have not yet achieved the school's minimum criteria for learning objective attainment (KKTP), which is set at 75.

One alternative that can be implemented to address this issue is the application of the Problem-Based Learning (PBL) framework. This strategy centers around real-world issues as the foundational baseline for the curriculum, prompting learners to apply analytical reasoning. Problem-Based Learning constitutes an instructional approach that engages learners dynamically in addressing practical issues, allowing them to foster critical reasoning, analytical competence, and autonomous knowledge acquisition (Anugraheni, 2018). Based on these characteristics, Problem-Based Learning is believed to foster meaningful learning and enhance students' engagement in the learning process.

The Problem-Based Learning (PBL) model is closely related to students' real-life experiences, allowing them to gain direct experience with the problems they study, while the knowledge they acquire is not solely dependent on the teacher (Arifin & Arifin, 2026). In this model, the teacher serves as a facilitator who guides the learning process without providing direct answers. The teacher assists students in organizing problems, gathering information, and evaluating the outcomes of their discussions (Husna et al., 2025). In addition to the learning model, the use of instructional media during the learning process also plays an important role. Educational games are learning media employed to incorporate interactive elements that align with educational values (Andari, 2020).

The use of educational games in learning can help students gain the confidence they need to learn and give them a sense of accomplishment from the problems or challenges they have overcome in the game (Sarumaha et al., 2024). The great potential of interactive educational games to boost students' interest, motivation, and understanding of mathematics has attracted the attention of many educators and curriculum developers (Muhtarom, 2022).

The impact of implementing the PBL strategy can be enhanced through the support of engaging instructional media that are appropriate for the characteristics of elementary school students. One such medium is Math Playground, an educational game-based learning platform that provides a variety of interactive activities to help students understand mathematical concepts through game-based learning. The platform offers a wide range of mathematics games designed according to the developmental level of primary school students, consequently encouraging motivation to learn and increasing students' engagement in the learning activities. In addition, the use of technology-based instructional media has been shown to enhance students' interest, motivation, and participation throughout the learning process (Rochmah et al., 2019).

Earlier studies have consistently shown the beneficial effects of integrating the PBL approach featuring digital learning media in mathematics instruction. For instance, Margarita et al. (2018) demonstrated that incorporating PBL-based interactive media into fourth-grade fraction topics was highly valid in terms of content and design, significantly enhancing students' conceptual understanding and academic performance compared to conventional instruction. Beyond improving concept mastery, their interactive tool successfully fostered a dynamic classroom atmosphere while encouraging active engagement and autonomous learning. However, their study was limited by a small sample

size restricted to a few elementary schools, as well as initial technical issues regarding text legibility and audio clarity.

Building upon similar principles, Wedayanti and Wiarta (2022) engineered PBL-infused interactive multimedia tailored for fourth-grade students to master the concepts of perimeter and area. Their findings similarly revealed that the interactive tool was highly viable in creating a conducive learning environment, boosting enthusiasm, and facilitating independent learning when grasping abstract mathematical principles. Nevertheless, their research encountered implementation constraints, as large-scale classroom deployment could not be executed optimally due to the COVID-19 pandemic, thereby restricting feasibility evaluations to individual and small-group trials.

Extending this line of inquiry to division word problems, Sukmarani et al. (2025) successfully developed PBL-anchored interactive PowerPoint media for Phase B/fourth-grade elementary students. Their results further reinforce the efficacy of this approach, showing that the tool was exceptionally feasible and effective in elevating students' motivation, conceptual understanding, and problem-solving capabilities. Nonetheless, a key limitation of their study lies in its implementation scope, as product trials were restricted to a single student participant. Collectively, these studies underscore the consistent capacity of PBL-integrated media to enhance engagement and mathematical competencies, while also pointing to a shared need for broader, large-scale empirical validation.

Previous studies have made significant contributions to the advancement of education, particularly improving learning outcomes, enhancing problem-solving skills, and developing instructional media. However, research integrating the Problem-Based Learning (PBL) model with the Math Playground platform to teach whole number multiplication to third-grade elementary students remains absent. This empirical absence highlights a critical research gap regarding how this specific technology-assisted framework influences student learning engagement.

This study evaluates the implementation of the Problem-Based Learning (PBL) model supported by the Math Playground platform among third-grade students at SDN 1 Pejambon. Specifically, this research aims to: (1) determine the effect of the Math Playground-assisted PBL model on students' learning engagement, and (2) measure the extent to which their engagement increases following the intervention. Ultimately, the findings are expected to serve as an innovative instructional alternative in elementary mathematics education and provide a useful reference for technology-integrated teaching.

METHODS

A quantitative approach utilizing a pre-experimental framework, specifically a one-group pretest-posttest design, was adopted for this research. This design was selected due to practical constraints in school scheduling that precluded the establishment of an equivalent control group without disrupting regular instruction. Experimental research serves as a robust method for evaluating the direct influence of an intervention on subsequent outcomes by establishing cause-and-effect relationships between variables (Putra et al., 2025). Within this framework, a specific treatment is applied to the independent variable, the Problem-Based Learning (PBL) strategy integrated with the Math Playground platform, to measure its effect on the dependent variable, student learning engagement, under controlled conditions.

A purposive sampling technique was employed to select 20 third-grade students from a single-classroom population of 47 students. Rather than utilizing the entire class, this targeted sample size was chosen to maintain high fidelity during the digital intervention and to ensure manageable monitoring during computer-supported learning sessions. The inclusion criteria for the sample were: (1) full attendance during both the baseline assessment and the entire intervention sequence, and (2) completion of the orientation session on navigating the digital platform.

Data on student learning engagement were collected using a structured questionnaire adapted from the multidimensional engagement framework developed by Fredricks et al. (2025). The instrument measures three distinct dimensions of engagement: behavioral engagement (2 items), emotional engagement (2 items), and cognitive engagement (2 items), yielding a total of 6 indicators. Each item was assessed using a 4-point Likert scale, and the adapted instrument was statistically validated for internal consistency and construct validity before data collection.

Table 1. Methodological Framework
Pre-Experimental Approach Using a One Group Pretest-Posttest Layout

Research group (experimental)	Pretest	Treatment	Posttest
Third Grade class at SDN 1 Pejambon	O_1	X	O_2

Description:

O_1 = Initial assessment (pretest)

X = Treatment involving a Problem-Based Learning model Supported by Math Playground

O_2 = Final assessment (posttest)

This research was conducted at SDN 1 Pejambon in Cirebon Regency. The study population consisted of all 47 third-grade students. Sampling in this experiment used the purposive sampling technique, where 20 students were deliberately selected based on specific considerations to meet the needs of the study. Data on learning engagement were collected using instruments such as questionnaires and observation sheets. Before implementation, the instruments underwent rigorous validation and reliability testing. Content validity was established through expert judgment by two validators specializing in elementary education and instructional technology, who evaluated the alignment of the items with engagement indicators. Construct validity was subsequently confirmed using Pearson's product-moment correlation analysis, ensuring that the items accurately measured the underlying dimensions of learning engagement. Additionally, internal consistency reliability was verified using Cronbach's alpha, confirming that the instruments were highly reliable and suitable for data collection.

The validity test results indicated that all items had calculated r values ranging from 0.417 to 0.652. Since all these values are greater than the critical r-value of 0.361 at a 5% significance threshold, each item is deemed statistically valid. This means that this instrument can be used for research.

Table 2. Reliability Analysis Outcomes For the Questionnaire

Results of Instrument Reliability Test	N of Item
0.70	10

The results of the reliability analysis in Table 2 show that the students' learning engagement questionnaire achieved a Cronbach's alpha value of 0.70 for the 10 items. Because this value meets the standard acceptable threshold of 0.70, this measurement scale is classified as having acceptable reliability. This proves that the measurement tool used is consistent and reliable for research data collection.

The research procedure began with the development of instructional materials and research instruments, followed by evaluating the instruments' validity and consistency. Following this, the implementation of the research began with a pretest using a learning engagement questionnaire to assess students' initial levels of learning engagement. Subsequently, students participated in mathematics lessons on the multiplication of whole numbers using a PBL model supported by the Math Playground platform.

This model was implemented through five stages (Rosidah, 2018):

1. Introducing the problem to learners: The instructor presented a contextual word problem on the interactive smartboard (e.g., calculating the total number of books distributed across multiple shelves in a library), framing the concept of equal groups before introducing the Math Playground platform.
2. Getting students ready to learn: Learners were arranged into small collaborative clusters and instructed on the gameplay mechanics and navigational procedures for the *Space Race Multiplication* module displayed on the smartboard.

Figure 1. Space Race Multiplication

3. Assisting pupils during their inquiries, both independently and in groups: Student teams engaged in iterative 1- to 2-minute rounds of *Space Race Multiplication*, capitalizing on real-time visual feedback from the platform to refine their numerical fluency and problem-solving tactics.
4. Presenting their work: Teams documented their operational strategies and performance metrics, subsequently presenting their step-by-step mathematical reasoning at the interactive smartboard.
5. Evaluating the problem-solving process: The instructor facilitated a post-activity synthesis to review multiplication concepts, deconstruct computational errors, and reflect on collective learning outcomes.

After all learning stages were completed, students took a posttest and completed a learning engagement questionnaire, followed by an observation of their learning engagement throughout the instructional process.

Data interpretation in this project incorporated descriptive alongside inferential statistical methods. The descriptive analysis aimed to illustrate the average, peak score, lowest score, and percentage of student learning engagement. Furthermore, as a prerequisite for hypothesis testing, the data distribution was first checked using a Shapiro-Wilk normality test. Then, the study performed a Wilcoxon Signed-Rank Test to observe any marked shifts in the learning engagement levels pre- and post- application of the implementation of the PBL model supported by Math Playground media. Meanwhile, to measure the extent of this increase in engagement, the analysis was conducted using the

normalized Gain (N-Gain). The entire statistical evaluation was executed via the IBM SPSS Statistics application, version 27.

RESULT AND DISCUSSION

The research was conducted to evaluate the impact of implementing the PBL strategy, supported by the Math Playground media, on the learning engagement of third-grade students at SDN 1 Pejambon. Using a One-Group pretest-posttest design, this study involved 20 students as the sample. Students' levels of learning engagement were measured using questionnaires administered before (pretest) and after (posttest) the implementation of the learning model.

To obtain a clearer picture of the data on students' learning engagement, the results analyzed using descriptive statistics are presented in the form of mean, minimum score, maximum score, and standard deviation. Evaluation was performed to illustrate the degree of student academic involvement prior to and following the execution of the PBL approach aided by the Math Playground platform. The detailed descriptive statistical findings are presented in Table 4.

Table 3. Descriptive Statistic Results

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	20	2.00	8.00	5.5000	1.87785
Posttest	20	6.00	9.00	7.8500	0.81273

Based on the descriptive statistical analysis above, the research sample consisted of 20 students. Students' learning engagement before the execution of the PBL approach aided by the Math Playground platform (pretest) had a mean score of 5.50, with a minimum score of 2.00, a maximum score of 8.00, and a standard deviation of 1.87785. Following the introduction of the PBL framework utilizing the Math Playground platform (posttest), the recorded average value was 7.85, a minimum score of 6.00, a maximum score of 9.00, and a standard deviation of 0.81273. The outputs indicate a growth in the mean level of student academic involvement following the intervention. The homogeneity of the distribution of students' learning engagement scores after the intervention is indicated by a decrease in the standard deviation of the posttest scores compared to the pretest scores. This suggests that the levels of student participation and engagement in the classroom are now much more evenly distributed.

Table 4. Results of Observations

	Percentage	Category
Pretest	20%	Good
Posttest	80%	Very Good

The results of observations on learning engagement also showed positive changes. Before the intervention, only 4 students (20%) were in the "good" category. Conversely, after implementing the PBL model supported by Math Playground, this number increased to 16 students (80%) who achieved the "good" and "very good" categories. This improvement was evident in critical thinking, collaboration, and independence. Students became highly active in asking questions, sharing their insights, cooperating within teams, and completing tasks independently.

To satisfy the classical assumptions of data analysis, a normality test was conducted as an initial step before testing the research hypotheses. This study relied on the Shapiro-Wilk test to assess the normality of data. The complete data are presented in Table 5.

Table 5. Normality Test Results

Variable	(Sig.)	Distribution
Pretest	0.033	Non-Normal
Posttest	0.009	Non-Normal

Based on the normality test results, the p-values for the pretest and posttest were 0.033 and 0.009, respectively. Since both values are below the 0.05 significance threshold, the data deviate from a normal distribution. Consequently, the non-parametric statistical analysis, the Wilcoxon Signed-Rank Test, was used for hypothesis testing.

Table 6. Hypothesis Testing Results of Wilcoxon Signed Rank Test

Test Statistics	
	Posttest-Pretest
Z	-3.854[b]
Asymp. Sig. (2-tailed)	.001
a. Wilcoxon Signed-Rank Test	
b. Based on Negative Ranks	

As shown in Table 6, the Asymp. Sig. (2-tailed) value is < 0.001. This value is lower than 0.05, which is the significance level set for this study. These analytical outcomes verify a substantial variation in students' academic focus pre- and post-integration of the Math Playground-assisted Problem-Based Learning framework, thereby demonstrating the model's positive impact.

Table 7. Normalized Gain Analysis

N	Mean N-Gain	Percentage	Category
20	0.4998	49.98%	Medium

The empirical outcomes of this research demonstrate that executing the PBL approach, supported by the Math Playground platform, significantly increased the learning engagement of third-grade students. This is evidenced by the increase in the students' average learning engagement score, from 5.50 on the pretest to 7.85 on the posttest. Supported by hypothesis testing, a significance value (Sig. 2-tailed) < 0.001 was obtained, verifying a substantial shift in students' academic involvement pre- and post-intervention. Furthermore, the N-Gain analysis yielded a mean value of 0.4998 (49.98%), indicating that the growth in learners' engagement falls into the moderate category.

The empirical alignment between this study and the findings of Sheptia et al. (2026) stems from a shared pedagogical foundation: both frameworks leverage Problem-Based Learning (PBL) to transition elementary classrooms from passive instruction toward active, student-directed inquiry. However, a critical divergence lies in the operational variables and instructional media employed. While the baseline study targeted fourth-graders' cognitive problem-solving abilities using physical puzzle tools, the present inquiry explicitly examines third-grade learners' affective-behavioral dimension, specifically their learning engagement through the gamified digital environment of Math Playground. Consequently, this research extends the current literature by establishing that integrating interactive, technology-assisted platforms within a PBL structure significantly amplifies non-cognitive academic participation, proving that PBL's efficacy is not restricted to traditional manipulative tools or cognitive-only outcomes.

Learning engagement refers to students' physical, mental, intellectual, and emotional involvement in the learning process (Aresty, 2023). Through the use of the PBL model, students not only absorb data from the educator but also proactively participate in recognizing issues, debating them, gathering data, and formulating resolutions. This engagement encourages students to participate more actively throughout the learning process, thereby increasing their learning engagement (Hutama & Satria, 2024).

Active learning is demonstrated not only through physical activities but also through mental activities, such as thinking, analyzing, expressing opinions, and problem-solving (Palittin, 2019). The primary strength of the PBL approach lies in the use of learning materials created by the teachers that draw on real-life contexts, particularly problems relevant to the students' own lives. This aims to stimulate students' interest and enthusiasm in understanding and solving the problems they face, whether through worksheets or assessment questions (Sandi et al., 2024).

This study states that active learning is an interactive process requiring teachers to create a learning environment in which students actively ask questions, express their opinions, and seek information to solve problems. Active learning is also evident in students' participation in discussions, asking questions of teachers and peers, and taking part in completing learning tasks. Active learning is one of the key factors determining the success of learning (Halik & Aini, 2020).

Enhancements in learners' problem-solving capabilities alongside their focus within math instruction were effectively attained via incorporating the PBL framework (Siswanto & Rahayu, 2025). Furthermore, Math Playground plays a role in increasing student engagement in learning. According to Math Playground, students can strengthen their basic math skills in a fun way, since it aligns with their age-appropriate tendency to enjoy playing. Game-based learning such as Math Playground can boost student motivation, where students' interactions within the game and their enthusiasm for answering questions make the experience more fun and engaging (Salimah et al., 2024).

This research demonstrates that integrating the Problem-Based Learning framework with the Math Playground platform effectively enhances student engagement in primary mathematics instruction. This heightened engagement occurs because Math Playground offers real-time, immediate feedback, allowing students to independently reflect on and correct their errors during problem-solving. Additionally, the interactive visual gamification captures students' attention and sustains their focus during complex tasks. These dynamics foster a collaborative and stimulating environment that simultaneously cultivates critical thinking and peer cooperation. Nevertheless, several limitations of this study should be acknowledged. First, the investigation was conducted with a relatively small sample size (N = 20) within a single school setting, which restricts the generalizability of the findings to broader populations. Second, the research design relied on a One-Group Pretest-Posttest structure without a dedicated control group, making it challenging to completely isolate external confounding variables. Finally, the intervention was implemented over a short duration, suggesting that long-term retention of student engagement and academic gains warrants further longitudinal exploration.

CONCLUSION

The integration of Math Playground into the Problem-Based Learning (PBL) framework was effective in improving third-grade students' classroom engagement.

Specifically, the implementation yielded an improvement in student engagement falling into the moderate category, demonstrating that pairing gamified digital tools with structured inquiry effectively heightens learner focus in primary mathematics instruction. Empirically, these findings confirm that game-based media can optimize active student participation during problem-solving activities, offering elementary school educators a practical instructional strategy to create more dynamic and interactive learning environments. However, the scope of this study remains limited to a single institutional setting at SDN 1 Pejambon and a specific age cohort. To build upon these insights, future research should evaluate the longitudinal impact of this integrated approach across larger student demographics and broader mathematical domains.

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