

Enhancing Learning Interest in Mathematics: Integrating Problem-Based Learning with a Kinesthetic Game and Music

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Abstract: This study was motivated by the low level of learning interest in mathematics among tenth-grade students and aimed to analyze the effect of integrating Problem-Based Learning (PBL) with the kinesthetic game Walking Marker, accompanied by music, on students' interest in learning mathematics. The research employed a quasi-experimental design with a non-equivalent control group design. The participants consisted of 64 tenth-grade students from SMA Negeri 1 Bintan Timur, who were divided into an experimental group (n = 32) and a control group (n = 32). The experimental group received PBL instruction integrated with a kinesthetic game and music, while the control group was taught using conventional PBL. Students' learning interest was measured using a validated learning interest questionnaire administered before and after the intervention. Data analysis included tests of normality, homogeneity, and an independent samples t-test. The results indicated that integrating the Problem-Based Learning (PBL) model with the kinesthetic game Walking Marker, accompanied by music, significantly enhanced students' interest in learning mathematics. This finding was supported by the results of the independent samples t-test, which revealed a significant difference between the experimental and control groups, $t(62) = 9.920$, $p < .001$, with a mean difference of 11.03 points and a large effect size (Cohen's $d = 1.18$). This study offers novelty through the integration of PBL, a kinesthetic game, and music as an effective multimodal approach to increasing students' interest in learning mathematics and provides practical implications for teachers in designing more engaging and meaningful learning experiences. Furthermore, this study contributes empirical evidence regarding the effectiveness and magnitude of the impact of a multimodal PBL approach on students' learning interest in mathematics education.

Keywords: Accompanied by Music, Learning Interest, Problem-Based Learning, Walking Marker Game

A. Introduction

Education plays a strategic role in developing students' intellectual, social, and character competencies, enabling them to respond effectively to the diverse challenges

of the global era (Hidayat et al., 2019). However, student disengagement or low levels of participation in STEM (Science, Technology, Engineering, and Mathematics) subjects have emerged as a significant global issue, which is also evident in the Indonesian context (Rahmania, 2021). At SMA Negeri 1 Bintan Timur, for instance, the average score of Grade X students on the Final Semester Examination in the odd semester of the 2024/2025 academic year was only 55.3, below the Minimum Learning Achievement Criteria (KKTP) of 60. Specifically, in the topic of statistics, students' levels of understanding in three classes reached only 64.1%, 28.2%, and 56.4%, with two classes failing to meet the KKTP. Most students perceive mathematics as difficult and insufficiently relevant to everyday life, which negatively affects their motivation, learning interest, and self-confidence (Nugroho, 2021; Putra et al., 2023; Rizky et al., 2017). This condition highlights the urgent need for innovative instructional strategies capable of enhancing active participation and cognitive engagement among students.

Problem-Based Learning (PBL) is one instructional approach that addresses these challenges. Theoretically, PBL fosters students' intrinsic motivation by fulfilling basic psychological needs, namely autonomy, competence, and relatedness (Deci & Ryan, 2000). Rather than passively receiving information, students actively seek solutions to contextual problems, thereby developing critical thinking, collaboration, and problem-solving skills (Hmelo-Silver & Barrows, 2021). Furthermore, the integration of game elements into instruction can create enjoyable learning experiences and facilitate a state of "flow," in which students are fully immersed in learning activities (Csikszentmihalyi, 1997). Music also plays a significant role in supporting the learning process, as it can reduce affective barriers and assist in managing cognitive load, thus enhancing students' attention, retention, and creativity (Krashen, 1982; Roffiq et al., 2017; Sweller et al., 2019).

Previous studies have demonstrated the effectiveness of PBL in improving students' motivation and learning interest compared to conventional instructional methods (Bara & Xhomara, 2020; Ramadhani & Pasaribu, 2022; Xu & Ke, 2016). In addition, game-based learning has been shown to increase student engagement and interaction, while music has been found to stimulate creativity and foster a positive learning atmosphere (Hafizah et al., 2024; Roffiq et al., 2017). Nevertheless, research that systematically integrates these three elements PBL, games, and music—remains limited, particularly in the context of mathematics instruction at the senior high school level in Indonesia, including at SMA Negeri 1 Bintan Timur.

Based on these problems and the literature review, this study aims to address the existing research gap by examining the effect of PBL integrated with the kinesthetic game "Walking Marker" accompanied by music on the learning interest of Grade X students. This research is expected to provide empirical contributions to the development of innovative instructional models that enhance student engagement, motivation, and learning outcomes in mathematics. The proposed hypothesis is that there is a significant effect of Problem-Based Learning combined with the "Walking

Marker” game accompanied by music on the mathematics learning interest of Grade X students at SMA Negeri 1 Bintan Timur.

B. Methods

Research Design

This study employed a quasi-experimental design, specifically the non-equivalent control group design. The design involved two groups of students who were not randomly assigned but were selected based on the equivalence of their characteristics (Creswell, 2012). The purpose was to compare the effects of Problem-Based Learning (PBL) integrated with the Walking Marker kinesthetic game and music on students’ interest in learning Mathematics.

Population and Sample

The research population comprised all students of SMA Negeri 1 Bintan Timur in the odd semester of the 2025/2026 academic year, consisting of 30 classes with an average of 30 students per class. The research sample was drawn from two Grade X classes, each consisting of 32 students. The experimental class received PBL instruction integrated with the Walking Marker game and music, whereas the control class was taught using conventional PBL without games and music (Sugiyono, 2017).

Table 1. Participant Characteristics

Class	Number of Students	Gender (M/F)
Experimental	32	16/16
Control	32	15/17

Sampling Procedure

The sample was selected using purposive sampling, taking into account the equivalence of the number of students, similarity of lesson schedules, and relatively balanced mathematical ability (Creswell, 2012). Sample selection was conducted in coordination with the school to ensure that both classes had nearly identical average mathematics scores and comparable distributions of academic achievement. Each class was treated as a complete group to allow for comprehensive implementation of the treatment and to ensure the validity of between-group comparisons.

Research Procedure

The study was conducted over 16 meetings across eight weeks. The initial phase began with the administration of a pre-test in the form of a questionnaire to measure students’ interest in learning before the treatment. Subsequently, instructional activities were implemented in both classes. The experimental class received PBL integrated with the Walking Marker game and music. The PBL stages included

problem orientation, organizing students for learning, exploration and investigation, presentation of solutions, and reflection and evaluation. The Walking Marker game required students to write answers on the board while walking along a designated path, guided by cues from other group members. Music was used as background accompaniment to create an enjoyable learning atmosphere and enhance student motivation. Each game round lasted approximately five minutes. Meanwhile, the control class followed conventional PBL without games and music, employing the same PBL stages, but with more static interactions at group tables and turn-based presentations. Throughout the instructional process, the teacher conducted systematic observations to monitor the implementation of PBL steps, the use of instructional media, teacher-student interactions, and student engagement. After the completion of all treatments, a post-test questionnaire was administered to assess changes in students' interest in learning.

Research Instruments

The primary research instrument was a student learning interest questionnaire using a four-point Likert scale, consisting of 16 items measuring three sub-dimensions of learning interest: feelings toward mathematics, the perceived value or importance of mathematics, and engagement in learning activities. Sample items included "I enjoy learning mathematics," "Learning mathematics is important for my daily life," and "I actively participate in mathematics class discussions." The instrument was validated through expert judgment and its reliability was tested using Cronbach's Alpha, yielding a coefficient of 0.820, indicating that the instrument was reliable for use in this study. In addition to the questionnaire, teacher observation sheets and audio media were employed to support the implementation of PBL with games and music.

Data Analysis

The research data were analyzed quantitatively using SPSS software. The initial stage of analysis involved testing data normality using the Kolmogorov-Smirnov or Shapiro-Wilk tests, followed by a homogeneity test using Levene's Test to ensure the equality of variances between groups. Subsequently, an independent samples t-test was conducted to examine differences in learning interest between the experimental and control classes. This analysis aimed to determine the effect of PBL integrated with a kinesthetic game and music on students' interest in learning mathematics. All analyses were carried out systematically to ensure the validity and accuracy of the research findings (Sugiyono, 2017).

C. Results And Discussion

Results

This section presents the research findings concerning the effect of implementing Problem-Based Learning (PBL) integrated with the kinesthetic game “Walking Marker” accompanied by music on the mathematics learning interest of tenth-grade students at SMA Negeri 1 Bintan Timur. The study aims to examine the extent to which the integration of PBL with kinesthetic activities and music can enhance students’ interest in learning mathematics. Before analyzing the effects of the instructional treatment, statistical assumption tests were conducted to ensure the validity of the data analysis. Normality and homogeneity tests were performed to confirm that the research data met the required assumptions, thereby allowing the results to be analyzed accurately and reliably.

Table 2. Normality Test

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Learning_Interest	.083	64	.200*	.974	64	.185

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

Based on the normality tests conducted using the Kolmogorov–Smirnov and Shapiro–Wilk methods, the significance values obtained for the learning interest variable were 0.200 and 0.185, respectively. These results indicate that the residual data of students’ learning interest in both the experimental and control groups are normally distributed. In other words, the data distribution does not deviate significantly from a normal distribution, thereby fulfilling the normality assumption required for subsequent statistical analyses. Accordingly, the data used in this study satisfy the normality assumption, allowing further analyses to be conducted. After the normality assumption was met, the next step was to perform a homogeneity test to determine whether the variance of the data between the control and experimental groups was equal before testing the main research hypothesis. The homogeneity test in this study was carried out using Levene’s Test by examining the equality of variances between the two groups. The decision-making criterion states that if the significance value (Sig.) is greater than 0.05, the variances of the two groups are considered homogeneous or equal.

Table 3. Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Learning Interest	Based on Mean	.605	1	62	.440
	Based on Median	.603	1	62	.440
	Based on Median and with adjusted df	.603	1	61.019	.441
	Based on trimmed mean	.604	1	62	.440

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Learning_Method

Based on the results of Levene's test presented in the table above, the significance value for the learning interest variable is 0.440, which is greater than 0.05. This finding indicates that the variance of students' learning interest data between the experimental class and the control class is relatively equal or homogeneous. In other words, there is no significant difference in score variability between the two groups, indicating that they are comparable and suitable for fair statistical analysis. Furthermore, the results of the study demonstrate a significant effect of Problem-Based Learning (PBL) integrated with the kinesthetic game "Walking Marker" accompanied by music on students' interest in learning mathematics. The complete results of the hypothesis testing are presented in the following table.

Table 4. Hypothesis Testing Results

		Levene's Test for Equality of Variances		t-test for Equality of Means			95% Confidence Interval of the Difference			
		F	Sig.	T	Df	Sig. (2- tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Learning Interest	Equal variances assumed	.605	.440	-	62	.000	-11.031	1.112	-13.254	-8.808
	Equal variances not assumed			-	61.017	.000	-11.031	1.112	-13.255	-8.808

Based on the independent samples t-test, the significance value was 0.000, which is lower than the 0.05 threshold, with a mean difference of 11.031 points in learning interest between the experimental and control groups. These findings confirm that the integration of a kinesthetic game and music within the Problem-Based Learning (PBL) framework significantly enhances students' interest in learning mathematics compared to conventional PBL. Therefore, the research hypothesis stating that "there is a significant effect of Problem-Based Learning combined with the 'Walking Marker' kinesthetic game accompanied by music on the mathematics learning interest of Grade X students at SMA Negeri 1 Bintan Timur" is accepted.

Discussion

This study found that integrating Problem-Based Learning (PBL) with a kinesthetic game and music resulted in a significantly greater increase in students' interest in learning mathematics compared to conventional PBL. This finding was evidenced by the independent samples t-test, which yielded a significance value of $0.000 < 0.05$, as well as a mean difference in learning interest scores of 11.031 points between the experimental and control groups. These results strongly support the research hypothesis that the combination of PBL with a kinesthetic game and music

significantly enhances students' interest in learning mathematics compared to PBL alone; therefore, the hypothesis was accepted. This indicates that learning approaches incorporating physical activity and music can strengthen students' emotional and cognitive engagement in mathematics learning.

The observed increase in learning interest can be explained through the synergy of several psychological and pedagogical factors. The PBL framework provides students with opportunities to experience autonomy and competence, two essential components of Self-Determination Theory (Deci & Ryan, 2017). Through this autonomy, students do not merely follow instructions but are intrinsically motivated to understand mathematical concepts. The Walking Marker game facilitates the emergence of a state of flow, in which students become fully engaged cognitively and emotionally in challenges that are well balanced with their abilities (Csikszentmihalyi, 1997). The accompanying music produces affective effects that enhance positive mood, reduce anxiety, and create rhythm within kinesthetic activities, thereby making learning more enjoyable and multisensorially meaningful (Parong & Mayer, 2018). Such multisensory learning experiences allow students to process information simultaneously through visual, kinesthetic, and auditory channels, which may enhance retention and deepen conceptual understanding of mathematics.

Beyond individual factors, social interaction and collaboration also play a crucial role. Within the PBL approach, students work in groups to solve problems, discuss solutions, and pose critical questions. These collaborative experiences not only enhance conceptual understanding but also foster social skills such as communication, tolerance, and leadership (Bara & Xhomara, 2020). The addition of a kinesthetic game and music further enriches the social dimension, as students must engage in physical and coordinative interactions, resulting in higher affective engagement and learning motivation compared to conventional PBL.

From a cognitive perspective, the integration of kinesthetic activities and music supports mathematics learning through the lens of embodied cognition, which posits that abstract knowledge is more easily understood through physical experience. Physical activities such as walking while marking answers help students internalize abstract concepts by making them more concrete. Music contributes rhythmic repetition effects that support both short-term and long-term memory, thereby increasing the likelihood that students remember problem-solving steps (Xu & Ke, 2016). Vankúš (2021) also emphasizes that game-based learning has a positive impact on affect and learning motivation, suggesting that multisensory experiences strengthen students' engagement and interest in subject matter.

The findings demonstrating a significant effect of implementing Problem-Based Learning (PBL) integrated with the Walking Marker game accompanied by music on students' learning interest indicate that learning models positioning students as active subjects can foster more meaningful learning interest. These data suggest both

consistency with and expansion of relevant findings in the existing literature. The results align with studies showing that PBL consistently contributes positively to increased motivation and learning interest by emphasizing meaningful and experience-based learning (Savery, 2015).

More deeply, the increase in learning interest observed in this study can be interpreted as a result of heightened student autonomy and perceived competence throughout the learning process. In PBL, students are given opportunities to explore problems, formulate solutions, and make independent decisions. This condition aligns with the Self-Determination Theory framework, which asserts that fulfilling the needs for autonomy and competence promotes intrinsic motivation. Empirical studies across educational contexts have demonstrated that autonomy-supportive learning environments are strongly associated with students' interest and engagement in learning (Howard et al., 2021).

The integration of the Walking Marker game into instruction reinforces kinesthetic and collaborative aspects that contribute to increased learning interest. Game-based activities allow students to learn through movement, social interaction, and direct experience, thereby reducing boredom often associated with conventional instruction. Research on game-based learning indicates that educational games enhance students' interest and engagement by presenting enjoyable challenges and clear goals (Subhash & Cudney, 2018). Thus, the game employed in this study is not merely recreational but functions as a pedagogical medium that enriches the learning experience.

The use of music as an accompaniment to learning activities also plays an important role in explaining the study's results. Music contributes to the creation of a positive emotional atmosphere, enhances learning comfort, and helps students maintain focus during activities. Cross-disciplinary studies suggest that appropriate background music can improve mood and learning motivation, particularly when combined with collaborative and kinesthetic activities. Recent research confirms that music can serve as an affective stimulus that supports students' engagement and interest in learning tasks (Schaefer et al., 2023).

When viewed in relation to meta-analytic findings, the results of this study reinforce evidence that problem-based and game-based learning approaches tend to exert stronger effects on affective-motivational aspects than on cognitive outcomes alone. Meta-analyses indicate that although effects on academic achievement may vary, impacts on students' interest and engagement are consistently positive, particularly when instructional designs are structured and contextualized (Barz et al., 2024). Therefore, the findings of this study align with the mainstream of research on innovative learning approaches.

Overall, the findings confirm that the combination of PBL, kinesthetic games, and music constitutes an effective multimodal approach to enhancing students' learning

interest. These results also contribute empirical evidence to the development of more humanistic and student-centered instructional practices. Previous research emphasizes that learning integrating cognitive, affective, and social dimensions is more capable of sustaining students' learning interest over the long term (Lohmeyer & Taylor, 2020). Accordingly, the findings are not only contextually relevant but also possess theoretical and practical significance for the development of innovative instructional models.

Furthermore, the results indicate that multimodal learning—combining problem-solving, physical activity, and auditory stimulation—is more effective in capturing students' attention than monomodal approaches. The increased learning interest data suggest that students respond positively to instruction engaging multiple sensory channels simultaneously. Previous research demonstrates that multimodal learning enhances attention and interest by providing varied learning experiences that accommodate diverse learning styles (Mayer, 2020). Thus, these findings support the view that modality-rich instructional designs can strengthen classroom learning appeal.

In addition, the significant increase in learning interest can be understood as a reflection of heightened cognitive and emotional engagement during the PBL process. When students actively engage in collaborative problem-solving, they are more likely to perceive learning as purposeful and challenging. Empirical studies show that high levels of cognitive engagement are closely associated with sustained learning interest, particularly in problem-based learning that emphasizes higher-order thinking (Fredricks et al., 2016). This reinforces the interpretation that the PBL implementation in this study successfully created an environment conducive to deep engagement.

The Walking Marker game may also be interpreted as a form of embodied learning, in which the body is actively involved in cognitive processes. The increased learning interest data indicate that students' physical engagement does not hinder learning but rather enhances their interest in the subject matter. Recent research in embodied cognition confirms that physical activities integrated with conceptual learning can improve students' interest and understanding by linking abstract concepts with concrete experiences (Skulmowski & Rey, 2018). Accordingly, the kinesthetic game in this study contributed to increased learning interest through body-based cognitive mechanisms.

From the perspective of educational psychology, the findings can also be associated with the theory of situational interest, which refers to interest that emerges in response to specific learning conditions. Games, music, and contextual problems within PBL function as triggers of situational interest, which may develop into individual interest when implemented consistently. Longitudinal research indicates that instruction capable of stimulating situational interest has substantial potential to foster long-term

learning interest (Renninger & Hidi, 2016). Thus, the findings are relevant not only for immediate effects but also for the development of sustained learning interest.

Moreover, the results strengthen evidence that collaborative learning within the PBL framework contributes significantly to students' affective outcomes, including interest and positive learning attitudes. Group-based game activities promote social interaction, a sense of belonging, and shared responsibility in problem-solving. Previous research shows that well-structured collaborative learning enhances learning interest because students feel socially and emotionally supported (Gillies, 2016). This highlights the importance of the social dimension in increasing students' learning interest.

The findings also provide additional empirical evidence that creatively and contextually designed instructional innovations can address the issue of low student learning interest across educational levels. Recent studies emphasize that teachers need to integrate innovative pedagogical strategies to align instruction with the characteristics of contemporary learners. Previous research confirms that innovative, problem-based, and active learning approaches positively influence students' interest and engagement more broadly (OECD, 2018). Consequently, the results have broad relevance within the context of 21st-century instructional practice development.

Finally, these findings carry significant practical implications for teachers and curriculum developers in designing instruction that goes beyond mere knowledge transmission toward the creation of interactive, meaningful, and enjoyable learning experiences. The integration of Problem-Based Learning (PBL) with educational games and music can serve as an innovative instructional model in schools, as it balances cognitive, affective, and social aspects of learning. Music and games are not positioned merely as entertainment or instructional variation, but as pedagogical strategies that enrich classroom dynamics, stimulate curiosity, and strengthen students' emotional engagement. By designing game-based activities that promote healthy competition and collaborative problem-solving, and by utilizing appropriate background music to create a positive learning atmosphere, teachers can foster intrinsic motivation, group cooperation, and sustained student interest in learning.

D. Conclusion

Based on the results of the study conducted with tenth-grade students at SMA Negeri 1 Bintan Timur, it can be concluded that the integration of the Problem-Based Learning (PBL) model with the kinesthetic game "Walking Marker", accompanied by music, significantly enhances students' interest in learning mathematics. In line with these findings, mathematics teachers are encouraged to implement PBL enriched with kinesthetic games and music as an alternative instructional strategy to foster students' learning interest. Schools are expected to support the implementation of this innovative approach by providing adequate facilities and infrastructure, as well as

professional development opportunities that enable teachers to manage learning activities creatively and effectively. Future researchers are advised to extend this study by involving larger samples, different educational levels, or additional variables such as motivation, creativity, and learning outcomes. Furthermore, stakeholders including education authorities, school committees, and parents are expected to offer policy support, facilities, and a conducive learning environment to ensure that the sustainable implementation of innovative PBL-based instruction integrated with kinesthetic games and music yields broader and more positive educational impacts.

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