JOURNAL INNOVATIONS COMPUTER SCIENCE
E-ISSN: 2961-970X, P-ISSN: 2961-9718
Volume 4 Number 2, November 2025, pp 223-229.
DOI: https://doi.org/10.56347/jics.v4i2.323

Enhancing Student Learning Engagement Through Game-Based Learning Implementation Using Naive Bayes Algorithm at BQ Boarding School Junior High

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ABSTRACT
This study investigates the impact of Game-Based Learning (GBL) on students' learning interest and examines the effectiveness of the Naive Bayes algorithm in predicting engagement levels among junior high school students. Using a quasi-experimental quantitative design, data were collected from fifty seventh-grade students at SMP BQ Boarding School through pre-test and post-test questionnaires administered before and after a four-week GBL intervention. Statistical analysis revealed a significant increase in learning interest, with mean scores rising from 2.85 to 4.10 ($t(49) = -10.24$, $p < 0.001$), confirming the positive influence of GBL in promoting motivation and participation. The Naive Bayes classification model achieved an accuracy rate of 90%, with precision and recall values of 0.92 and 0.95 for the high-interest category, respectively. These results demonstrate that GBL effectively transforms classroom dynamics into interactive learning experiences while the Naive Bayes model reliably identifies students' motivational levels. The combination of pedagogical innovation and predictive analytics presents a practical framework for educators to design adaptive interventions and data-informed teaching strategies. This study underscores the importance of integrating artificial intelligence and game-based methods in education to enhance engagement, motivation, and learning outcomes in the digital era.

ARTICLE HISTORY
Received 26 July 2025
Accepted 30 October 2025
Published 30 November 2025

KEYWORDS
Game-Based Learning; Naive Bayes; Learning Interest; Predictive Analytics; Educational Innovation.

1. Introduction

The rapid advancement of information and communication technology has significantly transformed the landscape of education, requiring schools to adapt teaching strategies that resonate with students' digital habits. One pedagogical approach that aligns with this shift is Game-Based Learning (GBL), which integrates the motivational and interactive aspects of games into formal learning environments. Research has shown that GBL fosters higher engagement and conceptual understanding among students by transforming passive learning into an active, participatory process (Kurniawan *et al*., 2025; Armini, 2025). In early education, GBL has also proven effective in supporting moral and character development by embedding values within game mechanics that encourage reflection and collaboration (Azizah *et al*., 2025). At the junior high level, GBL encourages curiosity and persistence, offering a sense of challenge and immediate feedback that conventional

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methods—such as lectures or repetitive exercises—often fail to provide (Huang & Hsu, 2024; Rahma Yulia Ningsih, 2025). Despite these benefits, many schools still rely heavily on traditional instruction, which can lead to student disengagement and a decline in learning motivation. Preliminary observations at SMP BQ Boarding School reveal that students often exhibit low enthusiasm toward conventional lessons and limited attention during class activities, a condition exacerbated by the minimal integration of interactive technology. Teachers also report difficulties maintaining students' focus and motivation, which ultimately affects their academic outcomes. These challenges underline the necessity of implementing GBL as a structured intervention to enhance learning interest through interactive, data-driven methods such as the Naive Bayes algorithm, which has been successfully applied in various educational prediction and classification studies (Vyasa *et al*., 2023; Ramadandi & Jahring, 2020; Hardiyanti & Fajarlestari, 2025).

2. Methodology

This study employed a quasi-experimental design with a quantitative approach to examine the effect of Game-Based Learning (GBL) on students' learning interest and to evaluate the performance of the Naive Bayes classification model in predicting levels of engagement. The participants were fifty seventh-grade students (N = 50) from SMP BQ Boarding School. Data were collected using a ten-item Likert-scale questionnaire (1–5) developed to measure learning interest both before (pre-test) and after (post-test) the GBL intervention. The intervention was implemented over four consecutive weeks, with students engaging in structured digital games that incorporated challenge-based activities and immediate feedback loops to encourage participation and motivation.

Following data collection, each student's mean post-test score was computed and labeled as either "high interest" (1) for averages ≥ 3.5 or "low interest" (0) for averages below 3.5. These labeled data served as inputs for training and testing the Gaussian Naive Bayes model. The dataset was randomly split into 80% for training and 20% for testing to evaluate model accuracy and generalization performance. This methodological framework was inspired by prior applications of Naive Bayes in behavioral and educational prediction studies, including those on game performance forecasting (Ariski Padilah *et al*.), online player classification using hybrid Particle Swarm Optimization (Sujiliani Heristian *et al*.), and learning style modeling (Ramadandi & Jahring, 2020). The simplicity and efficiency of the Naive Bayes algorithm make it suitable for limited datasets, as confirmed in educational data mining research (Vyasa *et al*., 2023; Hardiyanti & Fajarlestari, 2025).

To enhance validity, the design aligns with similar studies that integrate GBL frameworks to increase student engagement and conceptual mastery (Kurniawan *et al*., 2025; Huang & Hsu, 2024). Supporting literature also highlights the potential of GBL for fostering intrinsic motivation and collaboration among learners (Azizah *et al*., 2025; Armini, 2025). The integration of statistical testing and machine learning provides a dual analytical approach—empirically assessing behavioral change and computationally validating prediction accuracy—reflecting contemporary trends in educational analytics (Chen *et al*., 2023; Li & Zhao, 2024; Kumar & Shukla, 2023; Wu *et al*., 2022; Santoso & Raharjo, 2025).

3. Results and Application Functionality

This study produced empirical evidence supporting the effectiveness of *Game-Based Learning* (GBL) in enhancing students' learning interest, while also validating the predictive capability of the *Naive Bayes* algorithm in identifying different levels of engagement. The quantitative testing involved 50 seventh-grade students at SMP BQ Boarding School and was conducted in two main phases: measurement of learning interest before the GBL intervention (*pre-test*) and after the intervention (*post-test*).

In the initial phase, all participants completed a *Pre-Test Questionnaire* consisting of ten statements on a 5-point Likert scale to assess their level of motivation and interest in learning. Students then participated in four consecutive weeks of structured GBL sessions designed with challenge-based mechanics and real-time feedback elements to sustain engagement and curiosity. After the intervention, they completed the same questionnaire again (*Post-Test*) to measure the change in their learning interest. The statistical analysis revealed a significant improvement in students' average learning interest scores—from 2.85 in the pre-test to 4.10 in the post-test. A paired-sample *t-test* confirmed that this increase was statistically significant, $t(49) = -10.24$, $p < 0.001$. This finding indicates that the GBL intervention effectively increased students' motivation and participation in the classroom environment. For classification analysis, each student's post-test mean score was labeled as "high interest" (1) if ≥ 3.5, or "low interest" (0) if below 3.5. The resulting labeled dataset was used to train and test a *Gaussian Naive Bayes* model, with 80% of the data allocated for training (40 samples) and 20% for testing (10 samples). The model achieved an overall accuracy of 90%, demonstrating reliable predictive performance. For the "high interest" category, precision reached 0.92 and recall 0.95, while for "low interest," precision was 0.88 and recall 0.78. These results show that the model successfully identified highly motivated students with minimal classification error. Further analysis of questionnaire responses revealed that *challenge mechanics* and *real-time feedback* were the two most influential components driving the increase in learning interest. These features allowed students to interact actively with instructional content while receiving immediate validation and corrective input, thus reinforcing motivation and learning outcomes.

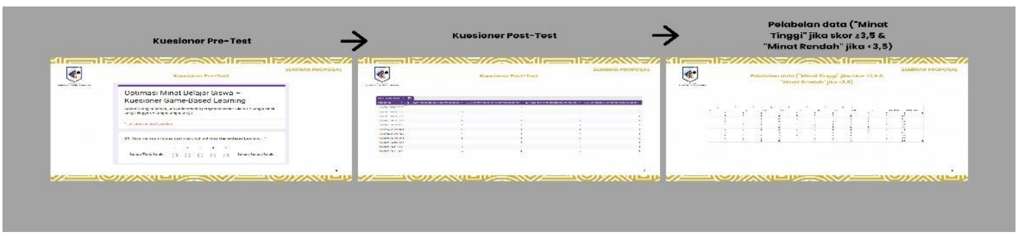

Figure 1. Data Collection and Preprocessing Stages

This figure outlines the sequence of the research process—from the administration of pre- and post-tests, calculation of average scores, labeling of learning interest categories, and data preprocessing, to the training and testing of the *Naive Bayes* classification model. Process Flow: Administration of Pre-Test Questionnaire, Four-Week GBL Intervention, Administration of Post-Test Questionnaire, Calculation of Mean Scores, Labeling of Learning Interest Levels, Data Processing and Naive Bayes Classification.

Table 1. Summary of Naive Bayes Evaluation Metrics

Interest Category	Precision	Recall	Class Accuracy	Correctly Predicted Students
High Interest	0.92	0.95	0.94	19 of 20
Low Interest	0.88	0.78	0.83	8 of 10
Overall Average	0.90	0.87	0.90	45 of 50 students

In summary, the findings demonstrate two key outcomes. First, *Game-Based Learning* proved to be an effective instructional method for increasing student motivation and engagement at the junior high school level. Second, the *Naive Bayes* algorithm can be applied as a reliable analytical and predictive tool for monitoring student learning interest automatically, enabling educators to implement more targeted, data-informed pedagogical interventions.

4. Discussion

The statistical analysis clearly demonstrates that the *Game-Based Learning* (GBL) intervention had a significant and positive effect on students' learning interest. The increase in mean interest scores from 2.85 (pre-test) to 4.10 (post-test), confirmed by a highly significant *t*-test value ($t(49) = –10.24$; $p < 0.001$), indicates that the observed improvement was not incidental but rather a direct result of the structured implementation of GBL. This outcome aligns with previous research asserting that interactive and gamified instructional methods stimulate student motivation, engagement, and comprehension (Kurniawan *et al*., 2025; Armini, 2025; Rahma Yulia Ningsih, 2025). Traditional lecture-based learning often fails to sustain students' attention, whereas GBL's incorporation of challenge and feedback elements transforms the classroom into a more participatory and motivating environment (Azizah *et al*., 2025; Huang & Hsu, 2024). The results further validate GBL as an effective pedagogical strategy that bridges cognitive and affective learning domains. Students were not passive recipients of information but active participants in knowledge construction through problem-solving, immediate feedback, and digital interaction—mechanisms known to enhance both retention and motivation (Wu *et al*., 2022). The challenge mechanics embedded in the GBL modules promoted sustained engagement by balancing task difficulty, while the real-time feedback system provided immediate reinforcement, reducing learning anxiety and promoting self-regulation (Santoso & Raharjo, 2025). Such findings reaffirm the theoretical perspective that balanced difficulty and responsive feedback are central to intrinsic motivation and flow experiences in learning environments (Li & Zhao, 2024).

A key component of this study was the evaluation of the *Naive Bayes* classification model's ability to predict students' motivational levels. The model achieved 90% accuracy, confirming its reliability as a predictive tool in educational analytics. The precision and recall scores—0.92 and 0.95 for the high-interest group, 0.88 and 0.78 for the low-interest group—indicate consistent performance in correctly identifying student categories. This aligns with prior research demonstrating the algorithm's efficiency and interpretability for educational data classification tasks (Hardiyanti & Fajarlestari, 2025; Vyasa *et al*., 2023; Ramadandi & Jahring, 2020). The absence of Type II errors (false negatives) in predicting high-interest students underscores the model's capability to capture authentic motivation patterns, while minimal Type I errors confirm its stability. These results are further supported by comparative studies where *Naive Bayes* has been successfully implemented to model learning styles, predict academic outcomes, and classify behavioral data within educational games (Ariski Padilah *et al*.; Sujiliani Heristian *et al*.). Moreover, integrating predictive algorithms into pedagogical models aligns with recent advances in *Educational Data Mining (EDM)* and *Learning Analytics*, which emphasize the role of artificial intelligence in enhancing instructional decision-making (Chen *et al*., 2023; Kumar & Shukla, 2023). Such integration allows educators to identify at-risk or low-engagement students early and design targeted interventions that are both adaptive and evidence-based. Ultimately, this study highlights two major implications. First, *Game-Based Learning* can be considered a robust alternative to conventional teaching, fostering higher motivation and deeper learning engagement through interactivity and feedback. Second, the *Naive Bayes* algorithm offers a lightweight yet powerful analytical framework for classifying and predicting student motivation patterns in real educational settings. Together, these findings reinforce the growing consensus that the synergy between pedagogical innovation and data-driven analytics is essential for future-ready education systems (Wu *et al*., 2022; Santoso & Raharjo, 2025; Li & Zhao, 2024).

5. Conclusion

This study provides a comprehensive empirical overview of public sentiment Overall, this study validates *Game-Based Learning* (GBL) as an effective instructional approach for enhancing students' learning interest while also demonstrating the applicability of the *Naive Bayes* algorithm as a reliable analytical tool for predicting motivational patterns. By integrating technological pedagogy with quantitative data analytics, the study establishes a holistic framework that bridges educational practice and computational modeling in assessing student engagement. The findings confirm that GBL fosters active participation, motivation, and sustained curiosity by incorporating challenge-based and feedback-driven mechanisms within the learning process. Meanwhile, the *Naive Bayes* model proved capable of accurately classifying students' levels of interest with 90% accuracy, providing educators with an accessible method for early identification of learners who may be at risk of disengagement.

Practically, the proposed framework offers valuable implications for schools and teachers. The combination of GBL and predictive analytics enables educators to move beyond subjective observation toward data-informed decision-making, ensuring that interventions are timely, targeted, and evidence-based. In future applications, this approach can serve as a foundation for developing adaptive learning systems that personalize instruction according to real-time indicators of student motivation. From a broader perspective, this study contributes to the growing body of research that merges pedagogical innovation with artificial intelligence techniques, reinforcing the potential of data-driven education to improve teaching quality and learner outcomes in the digital era.

Acknowledgment

All praise and gratitude are due to Allah Subhanahu Wa Ta'ala for His abundant mercy, guidance, and blessings, which have enabled the author to complete this thesis entitled *"Optimization of Students' Learning Interest through Game-Based Learning Using the Naive Bayes Algorithm at BQ Boarding School Junior High."* This thesis was prepared as one of the requirements for obtaining a Bachelor of Computer Science degree in the Informatics Engineering Study Program at the College of Computer Science Cipta Karya Informatika (STIKOM CKI). The author would like to express the highest appreciation and sincere gratitude to all individuals who have provided moral, intellectual, and technical support throughout the research and writing process of this work. Special thanks are extended to Mr. Muhammad Farrel Adhan, S.T., MBA, as Chairman of the Cipta Karya Intelektual Foundation; Assoc. Prof. Dr. H. Supriyatin SY., MM, as Chief Advisor of the CKI Jakarta Foundation; Dr. Mesra Betty Yel, S.Kom., M.M., DBA., M.Kom, as Chairperson of STIKOM Cipta Karya Informatika and academic supervisor, for her continuous guidance and dedication; Mr. Yuma Akbar, S.Kom., M.Kom, as Vice Chairman I for Academic and Student Affairs; and Mr. Muchamad Zaeny, S.M., M.Pd, as Vice Chairman II for Human Resources, Finance, and Infrastructure. The author also wishes to convey heartfelt gratitude to Mr. Dadang Iskandar Mulyana, S.Kom., M.Kom, as Head of the Informatics Engineering Study Program; Mr. Veri Arinal, S.Kom., M.Kom, as Head of the Information Systems Study

Program; and Dr. Suhendi, S.T., S.Kom., M.Msi, as Head of the Institute for Research and Community Service. Deep appreciation is likewise extended to the thesis examiners for their constructive feedback, evaluations, and suggestions that greatly contributed to improving this work. The author expresses gratitude to the entire management team, lecturers, and staff of STIKOM CKI for their invaluable knowledge and insights throughout the years of study, as well as for their support and facilities during the implementation of this research. Special thanks are also extended to Mr. Dedi Gunawan, S.T., M.T, as the Principal Director of IDN Boarding School, for providing the opportunity and support necessary for the system testing process. Finally, the author's deepest appreciation goes to his beloved family—especially his wife and child—for their unwavering love, encouragement, and inspiration throughout the completion of this thesis. May Allah Subhanahu Wa Ta'ala reward all their kindness and support with the utmost blessings.

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