

Enhancing Learning Outcomes in Vocational Animation Education: A Quasi-Experimental Study of Kahoot-Assisted Game-Based Learning in Indonesia

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ABSTRACT

Student disengagement during theory-based instruction in vocational high schools remains a critical pedagogical challenge. Game-based learning (GBL) has emerged as an innovative approach to improve student engagement and achievement, particularly in vocational education. This study aimed to examine differences in learning outcomes and the effectiveness of the Kahoot-assisted GBL model compared with conventional learning in the 2D Animation subject. A quasi-experimental pretest-posttest control group design was employed. Sixty-one grade XI Multimedia students at a vocational high school in Surakarta were selected through cluster random sampling (experimental n=30, control n=31). Data were collected via validated achievement tests and analyzed using an independent-samples t-test and the normalized gain index. Results showed a significant difference in learning outcomes ($t=5.548$, $p=0.000<0.05$). The normalized gain score of the experimental class ($g=0.52$, medium category) was significantly higher than the control class ($g=0.20$, low category). Kahoot-assisted GBL is more effective than conventional learning in improving student learning outcomes in 2D Animation. These findings offer evidence-based guidance for vocational educators seeking to enhance theory-based learning through gamified digital tools. This study contributes to the limited body of evidence on gamified learning in vocational multimedia education within the developing country context.

Keywords: *Game-Based Learning, Kahoot, Learning Outcomes, Vocational Education, 2D Animation.*

1. INTRODUCTION

The rapid advancement of information and communication technologies (ICT) in the 21st century has fundamentally transformed educational landscapes worldwide. Students today are increasingly required to master a broad range of competencies, including critical thinking, problem-solving, collaboration, communication, and digital literacy, to thrive in an ever-evolving global workforce (Bambang Purwanto et al., 2023; Birru, 2024). These demands place significant pressure on educational institutions, particularly vocational high schools, to innovate their pedagogical approaches and ensure that graduates possess both technical skills and adaptable learning competencies (Kalyani, 2024).

In vocational education contexts, student engagement during theoretical instruction presents a persistent challenge. Many students in vocational settings tend to disengage during theory-based lessons, preferring hands-on practical activities instead. This disengagement often undermines their foundational understanding of subject matter, which in turn affects their performance during practical tasks (Setiawan, 2023). Addressing this challenge requires innovative instructional models that bridge the gap between student interest and academic content delivery. The integration of digital technology into classroom instruction has therefore become not merely optional but essential in creating dynamic, interactive, and student-centered learning environments (Delello et al., 2025).

One of the most promising innovations in contemporary pedagogy is Game-Based Learning (GBL). GBL is an instructional approach that integrates game mechanics, such as rules, feedback, incentives, and interactive challenges, into the learning process (Adipat et al., 2021). Rooted in constructivist and experiential learning

theories, GBL actively engages learners in building knowledge through exploration, social interaction, and iterative problem-solving, rather than through passive reception of information (Alotaibi, 2024). Research has consistently demonstrated that GBL yields significant improvements in student motivation, engagement, and academic achievement across various educational levels and subject areas (Alotaibi, 2024; Zeng et al., 2024). A systematic review conducted by Abdissalam et al (2025), confirmed that GBL has a positive impact on learning motivation, student involvement, and learning outcomes in vocational education contexts in Indonesia.

Among the various GBL platforms available, Kahoot! has emerged as one of the most widely adopted and empirically validated tools in educational settings. Kahoot! is a free, web-based game-based learning platform designed to be accessible across diverse classroom environments worldwide. It enables educators to create interactive quizzes, surveys, and discussion activities, which students can participate in using any internet-enabled device (Wang & Tahir, 2020). The platform incorporates key gamification elements, including leaderboards, time-limited responses, instant feedback, and point-based rewards, which collectively stimulate student motivation and competition in the classrooms (Özdemir, 2025). A comprehensive meta-analysis by Özdemir (2025), covering multiple controlled studies, confirmed that Kahoot! has a significant positive effect on academic achievement, knowledge retention, student motivation, and engagement. Similarly, (Ramaila, 2024) conducted a systematic review confirming that Kahoot! consistently fosters meaningful teaching and learning experiences across educational settings. Although Özdemir (2025) confirmed Kahoot!'s positive effect on achievement, the meta-analysis was predominantly based on higher education samples, limiting its direct applicability to vocational secondary contexts in developing nations such as Indonesia.

Prior studies have documented the effectiveness of Kahoot! across diverse educational contexts. Alsswey and Malak (2024) found that gamified learning via Kahoot! reduced students' stress and anxiety while improving self-efficacy and academic achievement among university students. Rayan and Watted (2024) demonstrated that Kahoot! significantly enhanced students' engagement and learning processes in elementary school settings. Aibar-Almazán et al (2024) reported improvements in attention, concentration, self-regulation, and adaptability skills among students using Kahoot! in university classrooms. Furthermore, (Wirani et al., 2022) specifically highlighted Kahoot!'s role in monitoring learning performance and fostering active learning during both in-person and online instruction. In the Indonesian context, the continued use of Kahoot! among Indonesian students was evaluated and confirmed its positive reception as a gamification-based learning platform.

This study is grounded in constructivist learning theory (Piaget, 1954; Vygotsky, 1978), which posits that learners actively construct knowledge through experience and social interaction. GBL operationalises this principle by replacing passive content reception with active, game-mediated knowledge construction. Despite this growing body of evidence, research on Kahoot-assisted GBL in Indonesian vocational high school settings, particularly within creative and multimedia subjects such as 2D Animation, remains limited. Most existing studies have focused on general or higher education contexts, with fewer investigations addressing the specific pedagogical challenges of vocational students. This study contributes empirically by providing robust quasi-experimental evidence on the effectiveness of Kahoot-assisted game-based learning in vocational multimedia education, and theoretically by extending constructivist learning principles into gamified instructional contexts within secondary vocational settings. This research gap underscores the need for empirical investigation in this context. Therefore, this study aims to (1) examine whether there is a significant difference in learning outcomes between students taught using the Kahoot-assisted GBL model and those taught using conventional learning in the 2D Animation subject; and (2) determine which learning model is more effective in improving student learning outcomes.

2. RESEARCH METHOD

2. A. Research Design

This study employed a quantitative, quasi-experimental design. Full random assignment was not feasible due to the school's pre-existing fixed class scheduling system, necessitating the quasi-experimental approach (Denny et al., 2023). Quasi-experimental designs are widely used in educational research settings where full randomization is not feasible or ethically possible, yet the researcher still seeks to establish causal relationships between instructional interventions and learning outcomes (Denny et al., 2023). Specifically, this study adopted a Pretest-Posttest Control Group Design, which involves two non-randomly assigned groups — an experimental class and a control class — both of which were measured pretest and posttest, and the instructional treatment (Creswell & Creswell, 2023). The research design is presented in Table 1.

Table 1 Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental (R)	O ₁	X	O ₂
Control (R)	O ₃	—	O ₄

Note: O₁, O₃ = pretest scores; O₂, O₄ = posttest scores; X = Kahoot-assisted Game-Based Learning treatment

Before administering the treatment, both classes were given a pretest to establish their initial learning abilities and confirm that both groups had equivalent baseline competencies. The experimental class then received learning using the Kahoot-assisted Game-Based Learning model, while the control class received conventional learning. At the conclusion of the study, both classes were administered a post-test to measure final learning outcomes.

2. B. Population and Sample

The population of this study consisted of 90 eleventh-grade students enrolled in the Multimedia programme at State Vocational High School 9 Surakarta, distributed across three parallel classes: XI MM A (n=30), XI MM B (n=31), and XI MM C (n=29). The sampling technique employed was cluster random sampling, a probability sampling method appropriate when the population is naturally organised into pre-existing groups or clusters rather than as a list of individuals (Creswell & Creswell, 2023). This technique ensures that each cluster has an equal opportunity to be selected, thereby maintaining the representativeness of the sample (Creswell & Creswell, 2023). Two classes were randomly selected from the three available clusters: XI MM A served as the experimental group (n=30), and XI MM B served as the control group (n=31), yielding a total sample of 61 students.

2. C. Data Collection

Data was collected using a learning achievement test (LAT) comprising multiple-choice questions on the basic competency of creating simple objects in 2D Animation using Adobe Flash. Two sets of tests were developed: a pretest administered before the treatment to assess students' initial ability, and a posttest administered after the treatment to measure changes in learning outcomes. Before use in the study, all instruments underwent a tryout process with 29 students from class XI MM C to examine the quality of the items.

2. D. Instrument Validity and Reliability

Before use in the main study, the research instrument was subjected to a tryout (*uji coba*) involving 29 students from class XI MM C. The instrument consisted of 60 items in total — 30 pretest items and 30 posttest items. The critical value of r-table used was $r_{\text{tabel}} = 0.367$ ($df = n - 2 = 27$, $\alpha = 5\%$). Item validity was assessed using the Pearson Product-Moment. An item was declared valid if $r > r_{\text{tabel}}$ (0.367). Based on the tryout results, 37 items passed the validity test — comprising 18 pretest items (items: 2, 4, 5, 6, 9, 10, 11, 12, 13, 16, 17, 19, 20, 21, 24, 25, 26, 29) and 19 post-test items (items: 1, 4, 6, 8, 9, 10, 12, 13, 15, 16, 19, 20, 21, 22, 23, 25, 27, 29, 30). The remaining 23 items were discarded as they did not meet the validity threshold. The reliability of the valid items was measured using Cronbach's Alpha; only the 37 valid items were included in the reliability calculation. The results are presented in Table 2.

Table 2 Reliability Test Results

Test	Cronbach's Alpha	Category
Pretest	0.841	Very High
Posttest	0.852	Very High

Based on the reliability criteria (Hair et al., 2019), both the pretest and posttest instruments were categorised as having very high reliability (0.80–1.00), confirming that both instruments were consistent and dependable for use in data collection. The difficulty level of each item was analysed. Items were classified based on the criteria: $P < 0.30$ (difficult), $0.30 \leq P \leq 0.70$ (moderate), and $P > 0.70$ (easy). The distribution of item difficulty for all 60 tryout items is presented in Table 3.

Table 3 Distribution of Item Difficulty

Category	Pretest Items	Posttest Items
Difficult ($P < 0.30$)	3 items (8, 15, 30)	3 items (7, 17, 29)
Moderate (0.30–0.70)	22 items	22 items
Easy ($P > 0.70$)	5 items (3, 6, 7, 20, 23)	5 items (1, 4, 5, 6, 18)

Most items fell within the moderate difficulty category, indicating that the instrument was appropriately calibrated for the target student population. Based on the combined results of all five psychometric analyses, a final selection of items was made as presented in Table 4.

Table 4 Final Instrument Decision Summary

Instrument	Items Used (Pakai)	Items Discarded (Drop)	Cronbach's Alpha
Pretest	18 items (2, 4, 5, 6, 9, 10, 11, 12, 13, 16, 17, 19, 20, 21, 24, 25, 26, 29)	12 items (1, 3, 7, 8, 14, 15, 18, 22, 23, 27, 28, 30)	0.841 (Very High)
Posttest	19 items (1, 4, 6, 8, 9, 10, 12, 13, 15, 16, 19, 20, 21, 22, 23, 25, 27, 29, 30)	11 items (2, 3, 5, 7, 11, 14, 17, 18, 24, 26, 28)	0.852 (Very High)

The final instrument of 18 pretest items and 19 posttest items was therefore used for data collection in the main study, having satisfied the requirements for validity, reliability, appropriate difficulty level, adequate discriminating power, and functional distractors.

2. E. Treatment Procedures

The Kahoot-assisted GBL treatment was delivered across four 90-minute theory sessions over two consecutive weeks. Each session included 10–15 quiz items aligned with lesson objectives, with a 20-second individual response window per item. Questions were projected on the classroom screen while students submitted responses via personal devices. No additional teacher training was required, as the platform is designed for intuitive use. The control class received identical content through conventional lecture-discussion without any gamification component.

2. F. Ethical Considerations.

This study was conducted in accordance with institutional ethical research standards. Before data collection, written permission was obtained from the principal of State Vocational High School. All student participants were informed of the study's purpose, and written parental or guardian consent was obtained. Participation was entirely voluntary, and students were free to withdraw at any time without academic consequence. All collected data were anonymized and used exclusively for the purposes of this research.

2. G. Data Analysis Technique

Data was analysed using two complementary statistical techniques, each selected to address a specific research objective. To address the first research objective — determining whether a significant difference in learning outcomes existed between the two groups — the Independent Sample T-Test was employed at a significance level of $\alpha = 0.05$. This parametric test was selected because it is appropriate for comparing the means of two independent groups when the data meet the assumptions of normality and homogeneity of variance, both of which were confirmed through prerequisite testing. To address the second research objective — determining which instructional model was more effective — the Normalized Gain (N-Gain) index was used. The N-Gain formula (Hake, 1998) measures the relative magnitude of learning improvement from pretest to posttest, calculated as $g = (\text{posttest score} - \text{pretest score}) / (\text{maximum score} - \text{pretest score})$. This index was selected because it accounts for differences in students' initial ability levels, providing a more equitable comparison of learning gains across the experimental and control groups. All statistical computations were performed using SPSS version 21.

3. RESULT AND ANALYSIS

3. A. Prerequisite Tests

Before hypothesis testing, three prerequisite tests were conducted to ensure the data met the assumptions required for parametric statistical analysis. A balance test was performed on the pretest data using the Independent Sample T-Test at a significance level of $\alpha = 0.05$ to verify that both the experimental and control classes possessed equivalent initial learning abilities before treatment was administered. The result yielded a significant value of $0.710 > 0.05$, indicating that there was no statistically significant difference between the two groups' initial abilities. It was therefore concluded that both classes were balanced and comparable before the intervention, satisfying a key prerequisite for a valid experimental comparison (Creswell & Creswell, 2023). The normality of the data distribution was examined using the Kolmogorov-Smirnov test in SPSS version 21. Data are considered normally distributed if the significance value (sig.) > 0.05 (Field, 2024). The results are presented in Table 5.

Table 5 Normality Test Results for Experimental and Control Classes

Data	Class	Sig.	α	Conclusion
Pretest	Experimental	0.069	0.05	Normal
Pretest	Control	0.2	0.05	Normal
Posttest	Experimental	0.161	0.05	Normal
Posttest	Control	0.085	0.05	Normal

All significance values exceeded the threshold of 0.05, confirming that both the pretest and posttest data from both the experimental and control classes were normally distributed. This result justified the subsequent use of parametric statistical tests. The homogeneity of variance between the two groups was tested using Levene's Test in SPSS 21 at an error level of 0.05. The results are presented in Table 6.

Table 6 Homogeneity Test Results for Experimental and Control Classes

Data	Levene's Statistic	Sig.	α
Pretest	0.048	0.815	0.05
Posttest	0.365	0.548	0.05

Both the pretest and posttest significance values (0.815 and 0.548, respectively) exceeded the 0.05 error level. It was therefore concluded that the sample data originated from populations with homogeneous variances, fulfilling the homogeneity assumption for independent sample t-testing (Creswell & Creswell, 2023). Table 7 presents descriptive statistics for both classes. The pretest mean scores were comparable between the experimental class ($M = 63.57$) and the control class ($M = 64.68$), confirming balanced initial conditions. Following the intervention, the experimental class demonstrated a notably higher posttest mean ($M = 79.97$) compared to the control class ($M = 68.71$), suggesting a positive effect of the Kahoot-assisted GBL treatment on student learning outcomes.

Table 7 Descriptive Statistics for Experimental and Control Classes

Class	Test	N	M	SD	Min
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Experimental	Pretest	30	63.57	11.69	44
Experimental	Posttest	30	79.97	7.56	63
Control	Pretest	31	64.68	11.53	44
Control	Posttest	31	68.71	8.26	53

3. B. Hypothesis Testing

1) First Hypothesis — Difference in Learning Outcomes

H_0 : There is no significant difference in learning outcomes between students taught using the Kahoot-assisted GBL model and those taught using conventional learning in the 2D Animation subject.

H_a : There is a significant difference in learning outcomes between students taught using the Kahoot-assisted GBL model and those taught using conventional learning in the 2D Animation subject.

To address the first hypothesis — whether a significant difference in learning outcomes existed between the two groups — the Independent Sample T-Test was applied to the Normalized Gain (N-Gain) scores of both groups rather than to the raw posttest scores. Applying the t-test to N-Gain values is appropriate for a Pretest-Posttest Control Group Design because the N-Gain index accounts for each student's initial ability level, thereby controlling for pretest differences between groups and yielding a more equitable comparison of learning improvement (Hake, 1998). This approach is consistent with the recommendation to integrate N-Gain with inferential testing in quasi-experimental educational research. The significance level was set at $\alpha = 0.05$, and H_0 was rejected if Sig. (2-tailed) < 0.05 . The results are presented in Table 8.

Table 8 Results of the First Hypothesis Test (Independent Sample T-Test)

Class	N	Sig. (2-tailed)	α
Experimental	30	0	0.05
Control	31	—	—

The t-test on the N-Gain scores yielded Sig. (2-tailed) = 0.000 < 0.05 , with $t_{\text{count}} = 5.548$ exceeding $t_{\text{table}} = 2.001$, confirming a statistically significant difference in learning improvement between the two groups. The effect size was calculated as Cohen's $d = 1.42$, representing a large effect according to established criteria (Cohen, 2013; $d > 0.80$). This indicates that the Kahoot-assisted GBL intervention produced not only a statistically significant but also a practically substantial improvement in student learning outcomes. Consequently, H_0 was rejected, and H_a was accepted, leading to the conclusion that there is a statistically significant difference in learning outcomes between students in the experimental class (Kahoot-assisted GBL) and those in the control class (conventional learning) on the 2D Animation subject.

2) Second Hypothesis — Effectiveness of Learning Model

H_0 : The Kahoot-assisted GBL model is not effective in improving student learning outcomes in the 2D Animation subject, as reflected by a low N-Gain score ($g < 0.30$).

H_a : The Kahoot-assisted GBL model is effective in improving student learning outcomes in the 2D Animation subject, as reflected by a medium or high N-Gain score ($g \geq 0.30$).

The second hypothesis was evaluated using the normalized Gain (N-Gain) index, which measures the magnitude of learning improvement relative to the maximum possible improvement (Hake, 1998). The results are presented in Table 9.

Table 9 Results of the Second Hypothesis Test (N-Gain Analysis)

Class	Pretest Mean	Posttest Mean	N-Gain (g)	Category
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Experimental	63.57	79.97	0.52	Medium
Control	64.68	68.71	0.2	Low

The N-Gain interpretation categories are as follows (Hake, 1998):

Table 10 N-Gain Interpretation Categories

N-Gain Value	Interpretation
$-1.00 \leq g < 0.00$	Decreased
$g = 0.00$	No change
$0.00 < g < 0.30$	Low
$0.30 \leq g < 0.70$	Medium
$0.70 \leq g < 1.00$	High

The experimental class achieved a gain score of $g = 0.52$ (medium category), while the control class achieved $g = 0.20$ (low category). Since $g_{\text{experimental}} (0.52) > g_{\text{control}} (0.20)$, H_0 was rejected and H_a was accepted. This confirms that the Kahoot-assisted GBL model is significantly more effective than conventional learning in improving student learning outcomes in the 2D Animation subject.

4. DISCUSSION

Addressing the first research objective, the independent samples t-test confirmed a significant difference in learning outcomes ($t = 5.548$, $p = 0.000$). In response to the second objective, the N-Gain analysis demonstrated that the GBL model ($g = 0.52$) was more effective than conventional learning ($g = 0.20$). The large effect size observed ($d = 1.42$) exceeds the typical effect sizes reported in the meta-analytic literature on Kahoot! (Özdemir, 2025), underscoring the effectiveness of this approach in the vocational secondary context. Taking together, these findings provide empirical support for both hypotheses and confirm the educational value of Kahoot-assisted GBL in this context.

These results are consistent with the growing body of evidence on game-based learning and Kahoot! in educational contexts. A comprehensive meta-analysis by Özdemir (2025) confirmed that Kahoot! has a significant positive effect on academic achievement and student motivation across various educational levels. Similarly, Wang and Tahir (2020), in their literature review, found consistent evidence that Kahoot! enhances learning outcomes through its interactive and feedback-driven mechanisms. The competitive and gamified elements of Kahoot! — including leaderboards, time-limited responses, and instant feedback — are known to stimulate intrinsic motivation and sustain student engagement during learning activities (Aibar-Almazán et al., 2024; Rayan & Watted, 2024).

From a theoretical perspective, the superiority of the GBL approach in this study can be explained through constructivist learning theory (Piaget, 1954; Vygotsky, 1978), which posits that learners construct knowledge most effectively through active, experience-based engagement rather than passive reception of information (Alotaibi, 2024). The Kahoot-assisted GBL model operationalised this principle by placing students at the centre of the learning process, actively responding to questions, receiving immediate corrective feedback, and competing with peers — all of which are recognised as cognitively activating processes (Adipat et al., 2021; Zeng et al., 2024). These findings also resonate with Self-Determination Theory (Deci & Ryan, 1985), which posits that intrinsic motivation is sustained when competence, autonomy, and related needs are met — precisely what Kahoot!'s leaderboard, response interface, and competitive dynamic collectively address.

In the Indonesian vocational education context specifically, the results align with findings from Muin et al. (2025), who demonstrated that Kahoot!-based gamification improved learning activity, motivation, and achievement in a vocational school setting. Furthermore, Wirani et al. (2022) confirmed positive reception of Kahoot! among Indonesian students as a continued gamification-based learning platform. The present study extends these findings to the specific domain of 2D Animation instruction at the vocational high school level, a context that has received limited empirical attention in the literature.

It is worth noting, however, that the N-Gain value of 0.52 falls within the **medium** category, suggesting that while the Kahoot-assisted GBL model was meaningfully more effective than conventional instruction, there remains room for optimisation. Future studies may consider combining GBL with cooperative learning

structures, such as the Team Games Tournament (TGT) model, to further enhance the collaborative dimensions of game-based instruction (Aibar-Almazán et al., 2024). Additionally, the relatively small sample size ($n = 61$) and single-school context of this study constitute limitations that should be acknowledged when generalising these findings.

5. CONCLUSION

This study provides empirical evidence that Kahoot-assisted GBL significantly outperforms conventional instruction in improving 2D Animation learning outcomes among Indonesian vocational high school students, as demonstrated by a statistically significant t-test result ($t=5.548$, $p<0.05$), a large effect size (Cohen's $d = 1.42$), and a substantially higher normalised gain score ($g=0.52$ vs. $g=0.20$). Based on the research findings, data analysis, and hypothesis testing, the following conclusions are drawn. First, there is a statistically significant difference in learning outcomes between students taught using the Kahoot-assisted GBL model and those taught using conventional learning ($t_{\text{count}} = 5.548 > t_{\text{table}} = 2.001$; Sig. = $0.000 < 0.05$). This finding confirms that the two instructional models produced meaningfully distinct learning outcomes, with the experimental group consistently outperforming the control group on the posttest assessment. Second, the Kahoot-assisted GBL model demonstrated greater learning effectiveness compared to conventional learning, as evidenced by the normalized Gain analysis. The experimental class achieved a gain score of $g = 0.52$ (medium category), substantially higher than the control class's gain score of $g = 0.20$ (low category). This result confirms that the application of Kahoot-assisted GBL is a more effective instructional approach for improving student learning outcomes in the 2D Animation subject at the vocational high school level.

These findings contribute empirical evidence to the growing body of literature affirming the educational value of game-based learning platforms, particularly Kahoot, in vocational secondary education contexts in Indonesia. The results are consistent with prior meta-analytic and experimental studies confirming Kahoot!'s positive effects on academic achievement, student motivation, and engagement (Özdemir, 2025; Wang & Tahir, 2020). By directly addressing the previously identified gap in GBL research within Indonesian vocational multimedia subjects, this study provides one of the first empirical demonstrations of Kahoot!'s effectiveness specifically within 2D Animation instruction at the vocational secondary level — a context that had remained empirically underexplored in the gamification literature.

LIMITATION

Additional limitations include the absence of a delayed posttest to assess long-term knowledge retention, the exclusive reliance on cognitive test scores without affective or motivational measures, the potential Hawthorne effect arising from students' awareness of being studied, and the use of Adobe Flash as the instructional platform, which has been discontinued since 2020 and may limit the ecological validity and contemporary replicability of this study. The use of a single-school sampling context, which limits the generalizability of findings to vocational high schools with different demographic, infrastructural, or curricular characteristics.

FUTURE RESEARCH

Building on the findings and limitations of the present study, several directions for future research are recommended. First, future studies should employ a larger and more diverse sample drawn from multiple vocational high schools across different regions of Indonesia to enhance the generalizability of findings to broader vocational education contexts with varying demographic, infrastructural, and curricular characteristics. Second, longitudinal research designs incorporating a delayed post-test are encouraged to assess the long-term retention effects of Kahoot-assisted GBL, given that the present study only measured immediate post-intervention outcomes. Third, future investigations should adopt a mixed-methods approach by complementing quantitative achievement measures with qualitative or affective instruments — such as motivation scales, engagement questionnaires, or student interviews — to capture a more comprehensive picture of how Kahoot-assisted GBL influences both cognitive and non-cognitive learning dimensions. Fourth, future studies may explore the use of more contemporary and actively supported animation platforms (e.g., Adobe Animate or open-source alternatives) to replace Adobe Flash, which has been discontinued since 2020, thereby improving the ecological validity and contemporary replicability of the instructional intervention. Fifth, researchers are encouraged to investigate the comparative effectiveness of Kahoot-assisted GBL when combined with collaborative learning structures, such as the Team Games Tournament (TGT) model or project-based learning, which may further amplify the cooperative and constructivist dimensions of game-based instruction. Finally,

future research could examine the moderating effects of student-level variables — such as prior digital literacy, learning style, and motivational orientation — on the relationship between Kahoot-assisted GBL and learning outcomes, to identify the student profiles for whom this instructional approach is most beneficial.

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