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Effects of Game-Based Learning on Student Learning Outcomes: A Meta-Analysis

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ABSTRACT

Game-Based Learning (GBL) has increasingly been adopted as an interactive instructional approach to improve learning quality in digitally supported educational environments. However, findings from previous studies remain inconsistent regarding the magnitude of its effect on student learning outcomes. This meta-analysis aimed to estimate the overall effect of GBL on learning outcomes by synthesizing evidence from eligible primary studies. A systematic study-selection process was conducted, and 54 effect-size estimates were extracted from scientific articles published in national and international journals. Data were coded using a structured coding sheet containing publication characteristics, sample information, and statistical data required for effect-size calculation. Hedges' g was used as the standardized effect-size measure, and the pooled effect was estimated using a random-effects model. The analysis produced an overall effect size of g = 0.63, indicating a moderate positive effect of GBL on student learning outcomes. Thus, students exposed to GBL generally achieved better learning outcomes than those receiving conventional instruction. Nevertheless, substantial variation across the included findings suggests that the effectiveness of GBL may depend on instructional context, learner characteristics, subject area, game design, and intervention duration. These findings support the integration of GBL as a promising instructional strategy while emphasizing the need for context-sensitive design and implementation.

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1. INTRODUCTION

The rapid expansion of digital technology has transformed educational content delivery, learning engagement, and instructional design. Simultaneously, educators face persistent challenges in sustaining learner attention, participation, and academic performance in technology-mediated environments. Conventional teacher-centered instruction—frequently characterized by passive information transmission—offers limited opportunities for active exploration, immediate feedback, and experiential knowledge construction [1], [2]. To address these limitations, educational research has increasingly shifted toward learner-centered paradigms. Among these, Game-Based Learning (GBL) has emerged as a prominent instructional approach that integrates curriculum content into structured game environments [3], [4].

Theoretical foundations explain why GBL serves as an effective pedagogical model. Rooted in Experiential Learning Theory [5] and Situated Learning Theory [2], GBL posits that meaningful cognitive processing occurs when learners actively interact with meaningful contexts, perform goal-directed actions, receive immediate feedback, and iteratively refine their problem-solving strategies. Within a structured educational game, instructional content is embedded directly into core gameplay mechanics, goals, rules, narrative arcs, and reward systems [3], [4]. This structural alignment allows learners to experiment, encounter desirable difficulties, and learn from failure within a psychologically safe framework [4]–[6].

Across the literature, empirical investigations have demonstrated the multi-dimensional benefits of educational games. Collectively, existing studies indicate that well-designed GBL interventions enhance conceptual understanding, knowledge retention, problem-solving skills, and academic achievement across diverse discipline domains [7]–[10]. Evidence consistently suggests that the instructional efficacy of GBL stems from its capacity to foster high cognitive engagement while simultaneously sustaining intrinsic motivation, self-efficacy, and active participation [5], [7].

Nevertheless, outcomes reported across primary studies remain far from uniform. While several investigations demonstrate substantial positive learning gains, others report modest, non-significant, or highly context-dependent effects when compared to conventional instruction [11], [12]. Across the literature, this variability is attributed to contextual and structural moderators, including educational level, subject domain, game design format (digital vs. unplugged), intervention duration, and the degree of teacher facilitation [9], [12], [13].

Although previous meta-analyses have synthesized educational game research, three critical research gaps persist. First, earlier syntheses frequently combined GBL with *gamification* or *serious games* without maintaining strict conceptual boundaries. While gamification merely overlays point systems or badges onto non-game activities, true GBL

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relies on gameplay itself as the primary medium for learning; thus, combining them distorts the true effect size of GBL. Second, rapid technological advancements over the last decade have produced a new generation of adaptive and interactive GBL tools that require updated empirical synthesis. Third, existing reviews often present overall effect sizes without sufficiently accounting for extreme heterogeneity and potential small-study effects or publication bias.

To address these gaps, this study provides a focused, updated meta-analysis evaluating the specific impact of GBL on student learning outcomes across primary experimental studies. The novelty of this study lies in its rigorous conceptual boundary (isolating GBL from gamification), its comprehensive synthesis of 54 effect-size estimates spanning 20 years of empirical research, and its critical examination of between-study heterogeneity and publication bias.

2. RESEARCH METHOD

2.1. Research design

This study employed a meta-analytic research design to quantitatively synthesize the findings of primary studies examining the effects of Game-Based Learning (GBL) on student learning outcomes. Meta-analysis enables results from multiple studies to be converted into a common effect-size metric and statistically combined to produce a more precise estimate than that obtained from an individual study [11]. The primary outcome of this study was the standardized difference in learning outcomes between students who received GBL-based instruction and those who received conventional or non-game-based instruction.

2.2. Information sources and search strategy

A systematic literature search was conducted to identify experimental and quasi-experimental studies investigating the effects of GBL on student learning outcomes. To ensure consistency and complete data integrity, primary literature was systematically retrieved from two comprehensive academic databases: Scopus (n = 160) and Google Scholar (n = 200).

The core search terms included "Game-Based Learning," "game based learning," and the Indonesian equivalent "pembelajaran berbasis game." These keywords were combined using Boolean operators with terms related to learning outcomes, academic achievement, experimental design, and quasi-experimental design (e.g., ("Game-Based Learning" OR "pembelajaran berbasis game") AND ("learning outcomes" OR "academic achievement") AND ("experimental" OR "quasi-experimental")). The publication period was restricted from 2005 to 2025 to reflect contemporary educational and technological contexts.

2.3. Eligibility criteria

Studies were included if they satisfied all of the following criteria:

1) Employed a true-experimental or quasi-experimental design featuring both a GBL experimental group and a conventional/non-game control group.
2) Assessed cognitive learning outcomes, academic achievement, knowledge acquisition, or conceptual understanding using direct quantitative metrics.
3) Reported complete statistical data required for effect-size computation (sample sizes, means, standard deviations, or exact t/F/p statistics).
4) Focused specifically on Game-Based Learning (where gameplay is the primary learning medium) rather than standalone gamification (e.g., points/leaderboards applied to non-game tasks).
5) Were published in English or Indonesian between 2005 and 2025.

Studies were excluded if they lacked a comparison group, evaluated non-cognitive outcomes exclusively (e.g., motivation or satisfaction without achievement scores), presented duplicate datasets, or provided incomplete statistical reporting.

2.4. Study selection

Study selection adhered strictly to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11].A total of 360 records were initially identified through database searching: Scopus (n = 160) and Google Scholar (n = 200). Prior to screening, all 360 records were evaluated for duplicates across the two database sources. A total of 20 duplicate records were identified and removed, yielding 340 unique records for title and abstract screening.

During title and abstract screening, 280 records were excluded because they did not employ experimental designs, lacked relevant GBL interventions, or fell outside the scope of student learning outcomes. The remaining 60 full-text articles were retrieved and assessed for detailed eligibility. Of these, 6 articles were excluded due to incomplete statistical data necessary for standardized effect-size calculation. Ultimately, 54 primary studies (yielding 54 distinct effect-size estimates) met all eligibility criteria and were included in the quantitative meta-analysis. The selection flow is illustrated in Figure 1.

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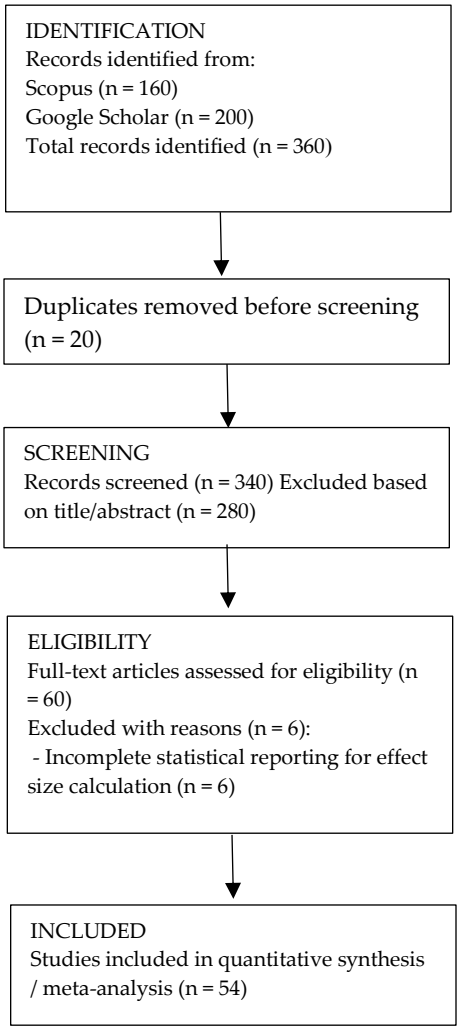


Figure 1. PRISMA flow diagram of the study-identification and selection process.

2.5. Data extraction and Coding

Data were extracted using a structured coding sheet developed in Microsoft Excel. The coding sheet recorded the study number, author and publication year, experimental-group sample size, experimental-group mean and standard deviation, control-group sample size, control-group mean and standard deviation, calculated Hedges' *g*, and its standard error.

Additional study characteristics should be coded to support heterogeneity and moderator analyses, including educational level, subject area, country, game type, digital or non-digital format, intervention duration, sample size, research design, and publication year. Coding these characteristics is important because the effectiveness of GBL may vary substantially across instructional contexts.

The extracted numerical data are summarized in Table 1. Because the complete table contains 54 effect-size estimates, the main manuscript may present a condensed version, while the full study-level dataset can be provided as an appendix or supplementary file.

Table 1. Extracted study-level data used for effect-size calculation

		Experiment			Control				
Study	**Author(year)**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**g**	**seg**
1	(C. Y. Chen et al., 2020)	40	85,87	8,54	40	79,05	7,27	0,85	0,23
2	(del Olmo-Muñoz et al., 2020)	33	80,24	9,33	31	72,14	12,01	0,75	0,26
3	(Sarvehana, 2019)	31	35,05	3,78	29	21,60	6,65	2,48	0,34
4	(Hooshyar, Malva, et al., 2021)	46	12,00	1,90	46	12,67	1,68	-0,37	0,21
5	(X. Ma et al., 2025)	47	3,40	1,15	41	3,32	1,08	0,07	0,21
6	(Chou, 2020)	22	49,77	18,64	25	40,90	19,67	0,45	0,29
7	(Kutay & Oner, 2022)	15	92,27	2,09	15	72,87	9,43	2,76	0,51
8	(Katchapakirin et al., 2022)	326	89,99	16,75	252	68,43	20,28	1,17	0,09
9	(All et al., 2021)	16	27,40	4,50	15	17,70	3,00	2,45	0,47
10	(Howland & Good, 2015)	30	2,03	3,67	30	2,30	5,19	-0,06	0,26
11	(Roodt & Ryklief, 2019)	30	3,43	0,60	30	3,43	0,53	0,00	0,26
12	(C. H. Chen et al., 2016)	18	92,13	11,43	18	83,33	11,43	0,75	0,34
13	(Byun & Joung, 2018)	20	16,75	1,59	20	14,05	1,33	1,81	0,37
14	(Chaves et al., 2015)	20	7,80	1,54	20	6,60	2,03	0,65	0,32
15	(Brown et al., 2023)	17	4,00	0,42	18	3,83	0,63	0,31	0,34
16	(Yildiz Durak, 2020)	29	16,48	1,72	29	16,86	1,51	-0,23	0,26
17	(Grivokostopoulou et al., 2020)	49	42,16	16,00	42	32,02	11,27	0,72	0,22
18	(Arnab et al., 2015)	30	15,21	3,74	30	13,48	2,83	0,51	0,26
19	(Zhao & Shute, 2019)	67	2,61	1,04	58	2,34	0,89	0,28	0,18
20	(Threekunprapa & Yasri, 2020)	35	2,72	2,03	52	2,58	1,89	0,07	0,22
21	(Psycharis & Kotzampasaki, 2019)	35	7,35	1,29	34	6,00	1,31	0,00	0,24
22	(Pellas & Vosinakis, 2018)	41	3,66	0,82	41	3,00	0,97	0,73	0,23
23	(Deng et al., 2020)	48	3,67	0,60	48	3,20	0,94	0,59	0,21
24	(Kert et al., 2020)	8	2,75	1,38	7	0,43	0,78	1,91	0,62
25	(Garneli & Chorianopoulos, 2019; Kert et al., 2020)	36	13,75	3,01	37	10,84	3,62	0,86	0,24
26	(Kuo & Hsu, 2020)	50	568,76	15,76	49	567,79	18,18	0,06	0,20
27	(Ríos Félix et al., 2020)	23	4,54	0,32	23	4,27	0,35	0,79	0,30
28	(Hooshyar, Pedaste, et al., 2021)	17	2,76	4,35	18	3,89	2,99	-0,30	0,34
29	(Sandberg et al., 2014)	26	3,25	1,28	20	3,12	1,22	0,10	0,30
30	(Jun et al., 2017)	35	4,20	0,54	38	3,90	0,47	0,59	0,24
31	(Brackmann et al., 2017)	53	11,43	3,44	53	13,25	2,76	-0,58	0,20
32	(Ayman et al., 2018)	44	4,59	1,89	44	4,63	1,52	-0,02	0,21
33	(Atmatzidou & Demetriadis, 2016)	22	8,95	2,54	21	6,52	0,62	1,28	0,33

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34	(Çakır et al., 2021)	28	97,23	28,16	24	88,75	19,87	0,34	0,28
35	(Chang et al., 2011)	23	7,70	2,18	33	5,55	2,32	0,94	0,28
36	(Bhuiyan & Mahmud, n.d.)	20	3,55	2,87	20	12,90	5,98	-1,95	0,38
37	(Barzilai & Blau, 2014)	42	6,30	1,65	42	7,08	1,46	-0,50	0,22
38	(Ahmed & Parsons, 2013)	12	7,50	1,11	12	1,00	0,77	6,57	1,05
39	(Aslanabadi & Rasouli, 2013)	24	3,89	0,95	24	2,89	0,74	1,16	0,31
40	(Q. Ma & Kelly, 2006)	26	3,88	1,04	26	2,88	0,73	1,10	0,30
41	(Jalali & Dousti, 2012)	115	4,36	0,52	115	3,71	0,71	1,04	0,14
42	(Papadakis & Kalogiannakis, 2019)	160	11,23	3,21	160	1,98	2,11	3,40	0,17
43	(Aghlara & Tamjid, 2011)	55	16,44	9,22	55	15,60	9,01	0,09	0,19
44	(Boeker et al., 2013)	112	89,93	7,65	109	84,81	10,86	0,54	0,14
45	(Vahdat & Behbahani, 2013)	20	3,66	0,48	23	3,60	0,78	0,09	0,30
46	(Liu & Chen, 2013)	72	6,75	0,74	72	8,09	0,98	-1,54	0,19
47	(Blunt, n.d.)	6	2,93	0,59	4	2,52	0,36	0,81	0,64
48	(Assapun & Thummaphan, 2023)	21	8,34	0,96	20	7,62	1,40	0,59	0,32
49	(Ariffin & Sulaiman, 2013)	58	17,34	2,93	57	13,70	3,92	1,05	0,20
50	(Telner et al., n.d.)	21	75,48	2,48	21	66,84	2,64	3,36	0,22
51	(Dewantara et al., 2020)	41	3,30	2,34	41	3,00	2,29	0,00	0,22
52	(Maulida et al., 2022)	25	71,80	11,15	24	61,62	14,51	0,78	0,29
53	(Lin et al., 2017)	39	87,70	11,60	39	73,40	14,60	1,07	0,24
54	(Papastergiou, 2009)	25	15,32	1,86	25	12,88	2,43	1,11	0,30

2.6. Effect-size calculation

Hedges' g was selected as the standardized mean-difference measure because it corrects the positive bias associated with Cohen's d, particularly in studies with relatively small sample sizes [11]. For each study, the pooled standard deviation was calculated as

$$S_p = \sqrt{\frac{(n_E-1)S_E^2+(n_C-1)S_C^2}{n_E+n_C-2}} \quad (1)$$

$$d = \frac{X^E-X^E}{S_p} \quad (2)$$

$$J = 1\frac{3}{4(n_E+n_C-2)-1} \quad (3)$$

$$g = Jd \quad (4)$$

A positive effect size indicated that the GBL group achieved higher learning outcomes than the control group, whereas a negative value favored the control condition. The standard error of each effect size was derived from its sampling variance and was used to determine the relative weight of each estimate in the meta-analysis.

2.7. Statistical analysis

All statistical analyses were conducted using JASP (Version 0.18.3) and the R package metafor. The standardized effect sizes (*Hedges'g*) and their corresponding sampling variances were analyzed using a random-effects model estimated via the Restricted Maximum Likelihood (REML) method. A random-effects model was selected *a priori* because the included primary studies varied across participant demographics, educational levels, subject domains, GBL formats (digital vs. non-digital), intervention durations, and instructional settings. Under this model, the true effect is assumed to vary across studies following a distribution of true effect sizes rather than sharing a single common effect [10].

To evaluate between-study heterogeneity, three standard metrics were employed: Cochran's *Q test*, the I^2, and τ^2 (tau-squared). Cochran's Q test assesses whether the observed variation across effect sizes exceeds what would be expected from sampling error alone. The I^2 statistic quantifies the proportion of total variation attributable to true between-study heterogeneity rather than random chance, where values of 25%, 50%, and 75% represent low, moderate, and high heterogeneity, respectively [12]. The τ^2 statistic estimates the variance of the true effect sizes across study populations.

To evaluate the stability and robustness of the pooled effect estimate, a leave-one-out sensitivity analysis was performed by systematically removing one study at a time and recalculating the pooled effect. Additionally, influence diagnostics (including Cook's distance and studentized residuals) were examined to identify potentially influential or outlying effect sizes.

Potential publication bias and small-study effects were evaluated through both qualitative and quantitative approaches. Visually, a funnel plot of effect sizes plotted against standard errors was inspected for symmetry. Quantitatively, Egger's linear regression test and Begg and Mazumdar's rank-correlation test were conducted to statistically assess funnel plot asymmetry. To estimate the impact of potential missing studies due to publication bias, Duval and Tweedie's trim-and-fill procedure was applied under the random-effects model. Furthermore, Rosenthal's Fail-Safe N was calculated to determine the number of unpublished or non-significant studies required to reduce the cumulative effect size to a statistically non-significant level ($p > .05$).

Finally, to address potential statistical dependence arising when multiple effect-size estimates originated from the same publication or student sample, a single primary outcome measure representing overall cognitive learning performance was selected per independent

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sample, ensuring that each effect size contributed independently to the primary meta-analytic model.

3. RESULTS AND DISCUSSION

3.1. Overall model and residual heterogeneity

A random-effects model was applied because the included effect-size estimates were expected to represent different underlying effects across educational levels, subject areas, instructional designs, intervention durations, and learner characteristics. Unlike a fixed-effect model, the random-effects approach assumes that the true effect of Game-Based Learning (GBL) may vary across studies. The model was estimated using the restricted maximum likelihood method.

Table 2. Omnibus Model and Residual Heterogeneity Tests

Test	(Q)	(df)	(p)
Omnibus test of model coefficients	22.321	1	< .001
Test of residual heterogeneity	927.728	53	< .001

Note: The model was estimated using the restricted maximum likelihood method. The reported (p)-values are approximate.

As presented in Table 2, the omnibus test of model coefficients was statistically significant, ($Q(1)=22.321$), ($p<.001$). This result indicates that the pooled effect of GBL on student learning outcomes differed significantly from zero. Therefore, across the included estimates, GBL was associated with better learning outcomes than the comparison conditions on average.

However, the residual heterogeneity test was also statistically significant, ($Q(53)=927.728$), ($p<.001$). Based on the reported (Q) statistic, the estimated heterogeneity index was ($I^2=94.29\%$), indicating that approximately 94% of the observed variation across effect sizes was attributable to genuine between-study differences rather than sampling error alone. This level of heterogeneity is considered substantial and suggests that the effectiveness of GBL was not uniform across the included studies.

The high heterogeneity may be associated with differences in educational level, subject domain, game format, intervention duration, assessment instrument, instructional support, and methodological quality. Consequently, the pooled effect should be interpreted as an average across heterogeneous educational contexts rather than as a universal effect that can be expected in every implementation. The use of a random-effects model was therefore appropriate, although moderator and subgroup analyses are still required to explain the sources of variation.

3.2. Pooled effect of game-based learning

The pooled effect represents the average standardized difference in learning outcomes between students who participated in GBL and those who received conventional or non-game-based instruction. The estimate was calculated using Hedges' (g), which corrects the upward bias of standardized mean differences in studies with relatively small samples.

Table 3. Random-Effects Summary Estimate

Effect-size measure	Estimate	Standard error	(z)	(p)	95% confidence interval
Hedges' (g)	0.633	0.134	4.725	< .001	[0.370, 0.896]

Note: The standard error, (z) statistic, and confidence interval were derived from the reported pooled estimate and omnibus statistic and should be confirmed against the complete JASP output.

As shown in Table 3, the random-effects model produced a pooled Hedges' (g) of 0.633, with a 95% confidence interval ranging from 0.370 to 0.896. Because the confidence interval did not include zero and the corresponding test was statistically significant, ($z=4.725$), ($p<.001$), the overall result indicates a statistically significant positive effect of GBL on student learning outcomes.

An effect size of ($g=0.633$) should not be interpreted as a 63.3% improvement. Instead, it represents a standardized mean difference of approximately 0.63 standard deviations between the GBL and comparison groups. According to commonly used effect-size benchmarks, this result indicates a moderate positive effect. Thus, students exposed to GBL achieved better learning outcomes than students receiving conventional instruction on average.

The forest plot in Fig. 2 presents the individual effect-size estimates and their confidence intervals, together with the pooled random-effects estimate.

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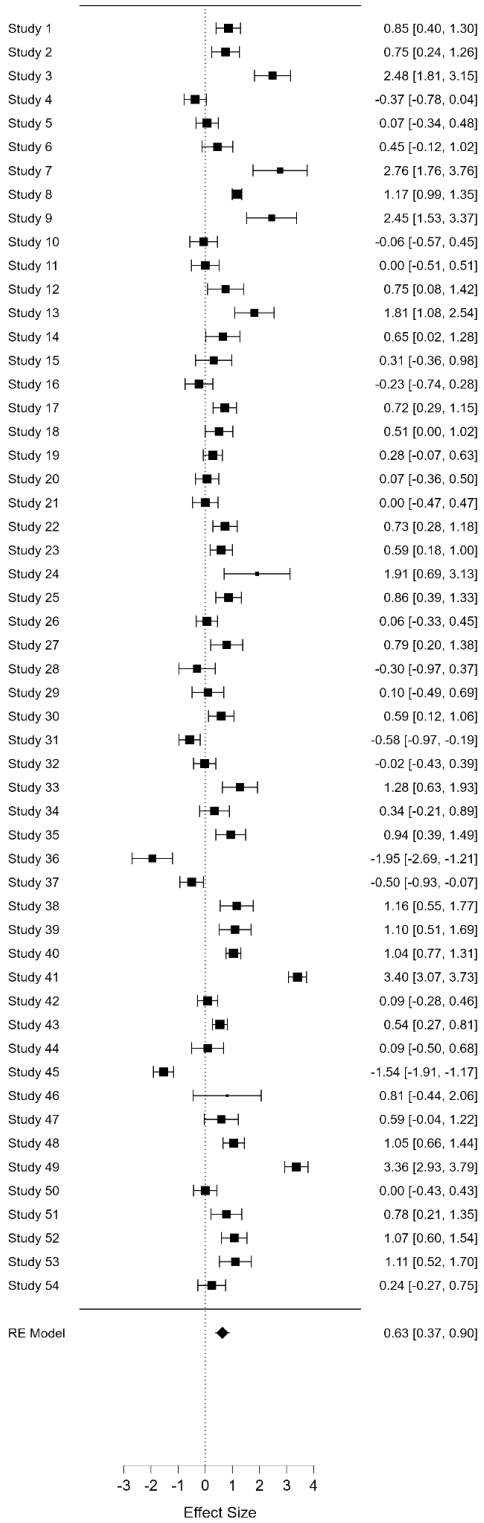


Figure 2. Forest plot of the effects of Game-Based Learning on student learning outcomes.

As illustrated in Fig. 2, the effect sizes varied considerably across studies. Several estimates favored GBL strongly, whereas some were close to zero or favored the control condition. This broad dispersion is consistent with the significant heterogeneity reported in Table 2. Therefore, the pooled effect provides evidence of an average positive association but does not imply that every GBL intervention was effective to the same degree.

The presence of unusually large positive or negative effect sizes also requires careful examination. Such estimates may result from small sample sizes, differences in outcome scales, unusually intensive interventions, data-extraction errors, or influential studies. A leave-one-out sensitivity analysis and influence diagnostics should therefore be performed to determine whether the pooled estimate is disproportionately affected by one or more studies.

3.3. Publication bias

Publication bias may arise when studies reporting statistically significant or positive findings are more likely to be published than studies reporting null or negative results. In a meta-analysis, such selective publication can lead to an overestimation of the pooled effect. A funnel plot was therefore examined to evaluate the distribution of effect sizes relative to their standard errors.

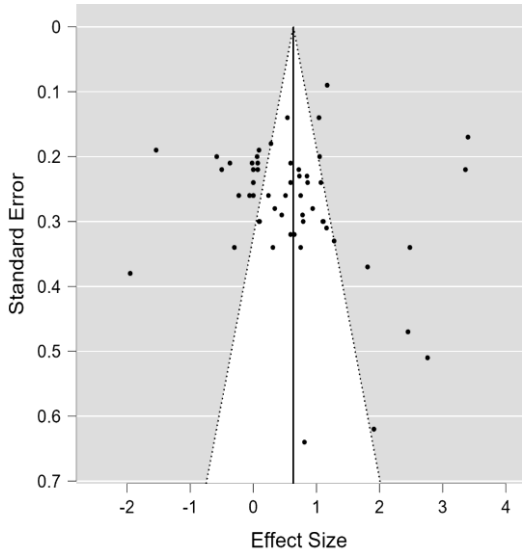


Figure 3. Funnel plot of effect sizes and standard errors.

As shown in Fig. 3, the distribution of effect-size estimates was not completely symmetrical around the pooled effect. A greater concentration of estimates appeared on the positive side of the plot, while fewer small studies with null or negative effects were observed. This pattern may indicate small-study effects or potential publication bias.

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Nevertheless, funnel-plot asymmetry should not be treated as definitive evidence of publication bias. Asymmetry may also be produced by substantial heterogeneity, methodological differences, small sample sizes, or influential effect-size estimates. Given the very high heterogeneity identified in this study, visual inspection alone is insufficient to establish the presence of publication bias.

To strengthen the analysis, the final study should report at least one statistical test of funnel-plot asymmetry, such as Egger's regression test or the rank-correlation test. A trim-and-fill analysis may also be used to estimate the possible influence of missing studies on the pooled effect. If Fail-Safe (N) is retained, its numerical result and interpretation must be reported explicitly rather than mentioned only in the method section.

3.4. Discussion

The present meta-analysis found that GBL had a statistically significant moderate positive effect on student learning outcomes, with a pooled Hedges' (g) of 0.633. This result indicates that, on average, students who participated in GBL achieved higher learning outcomes than students who received conventional or non-game-based instruction. The finding is broadly consistent with previous research suggesting that well-designed educational games can support academic achievement, active participation, knowledge acquisition, and problem-solving processes [7]–[9].

The educational value of GBL can be explained by its capacity to embed learning objectives within structured challenges, goals, rules, feedback systems, and opportunities for repeated practice. Immediate feedback allows learners to recognize errors and adjust their strategies, while progressively challenging tasks may encourage sustained cognitive engagement. Gee emphasized that effective game environments allow learners to explore problems, test alternatives, and learn through situated experience [3]. Similarly, Plass et al. argued that the effectiveness of GBL depends on the meaningful integration of cognitive, motivational, affective, and sociocultural dimensions into the game design [4].

However, the pooled result should not be interpreted as evidence that GBL is inherently effective in every educational setting. The residual heterogeneity was extremely high, with (I^2=94.29%), indicating that the effect varied substantially across studies. This finding is consistent with earlier reviews showing that the outcomes of digital games depend on instructional design, learner characteristics, game type, intervention duration, subject domain, assessment method, and teacher support [8], [9]. A game may be engaging without producing meaningful learning if its mechanics are weakly aligned with instructional objectives or if cognitive resources are directed toward gameplay features that are unrelated to the intended content.

The substantial variation also suggests that the largest effect sizes should be interpreted cautiously. Several included estimates were considerably larger than those typically reported in educational interventions. These extreme values may reflect effective

interventions, but they may also be influenced by small samples, measurement differences, or calculation errors. Sensitivity analysis is therefore essential before drawing strong conclusions regarding the stability of the pooled effect.

From a practical perspective, the findings support the use of GBL as a promising instructional strategy rather than as a universal replacement for conventional teaching. Educators should select or design games according to clearly defined learning objectives, learner readiness, subject characteristics, assessment requirements, and available technological resources. GBL is most likely to support learning when gameplay, feedback, instructional content, and classroom facilitation are closely aligned.

Future analyses should investigate possible moderators, including educational level, subject area, digital versus non-digital game format, intervention duration, sample size, publication year, and research design. Such analyses would provide a more precise understanding of the conditions under which GBL produces stronger or weaker effects. In addition, risk-of-bias assessment, influence diagnostics, and formal publication-bias tests are needed to strengthen the credibility and generalizability of the findings.

4. CONCLUSION

This meta-analysis synthesized 54 effect-size estimates published over the last two decades to examine the effects of Game-Based Learning (GBL) on student learning outcomes. The random-effects analysis produced a pooled Hedges' (g) of 0.633, indicating a statistically significant moderate positive effect of GBL compared with conventional or non-game-based instruction. This finding suggests that GBL can improve student learning outcomes on average by promoting active participation, meaningful practice, problem-solving, and immediate feedback. However, the substantial heterogeneity across the included effect sizes indicates that the benefits of GBL are not uniform across all educational settings.

The findings support the use of GBL as a promising instructional strategy rather than as a universal replacement for conventional teaching. Educators and curriculum developers should align game mechanics with learning objectives, subject characteristics, learner needs, assessment methods, and available technological resources. The interpretation of the pooled effect should also consider the variability and potential publication bias identified in the included evidence. Future research should conduct moderator and subgroup analyses to determine whether educational level, subject area, game type, platform, intervention duration, and instructional design influence the effectiveness of GBL. Additional sensitivity analyses, risk-of-bias assessments, and studies with stronger experimental designs are also required to improve the robustness and generalizability of the evidence.

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