The Impact of Gamification on Students' Academic Performance: A Comprehensive Meta-Analysis

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Abstract: The process of digital transformation in education has led to the widespread adoption of gamification as a tool for enhancing student motivation and academic achievement. Despite a substantial number of empirical studies, the reported findings remain fragmented and often contradictory. The present study provides a systematic review and meta-analysis of empirical research published between 2012 and 2025, examining the impact of gamification elements-such as points, badges, leaderboards, levels, narrative structures, avatars, and challenges-on academic outcomes and motivational indicators in educational settings. Following the PRISMA protocol, publications indexesd in Scopus, Web of Science, and ERIC were systematically analyzed. The final dataset included experimental and quasi-experimental studies with control groups. Effect sizes were calculated using Hedges' g within a random-effects model. Heterogeneity was assessed using the I² statistic, while moderator analyses and publication bias assessments (Egger's test and funnel plot) were conducted. The results demonstrate a statistically significant positive effect of gamification on academic achievement (g = …) and motivation (g = …). The largest effects were observed when multiple game elements were combined and when narrative mechanics were incorporated into instructional design. Moderator analysis revealed significant differences depending on students' age and the type of educational environment. The findings highlight the importance of systematic design of gamified educational solutions and contribute to the advancement of educational technology theory. Practically, the results demonstrate that the effectiveness of gamification depends not merely on the presence of game elements but on the quality of their integration into pedagogical design. The empirical evidence confirms the central role of psychological mechanisms-autonomy, competence, and engagement-as mediators between game structures and academic outcomes.

1 INTRODUCTION

1.1 Gamification as an Emerging Approach in Digital Education

The digitalization of education in the twenty-first century has become one of the key drivers of transformation in pedagogical practices and educational ecosystems [1]. The rapid expansion of online learning platforms, learning management systems (LMS), adaptive learning environments, and learning analytics has created conditions for the implementation of innovative tools aimed at enhancing student engagement [2], [3].

In an environment characterized by increasing competition for students' attention and growing cognitive load, traditional instructional approaches are increasingly demonstrating limited effectiveness [4], [5].

One of the most rapidly developing areas within Educational Technology is gamification, defined as the use of game elements in non-game contexts [6], [7]. In educational environments, gamification typically involves the implementation of mechanics such as points, badges, levels, leaderboards, quests, narrative scenarios, and avatars [8], [9].

From a theoretical perspective, gamification is grounded in several fundamental psychological and pedagogical theories.

First, Self-Determination Theory (SDT) posits that intrinsic motivation increases when three basic psychological needs are satisfied: autonomy, competence, and relatedness [10], [11]. Game elements such as levels and achievements may strengthen perceptions of competence, while cooperative mechanics support social connectedness.

Second, Flow Theory emphasizes the importance of balancing task difficulty with the learner's skill level [12], [13]. Gamified systems allow dynamic adjustment of difficulty through progressive levels and challenge mechanisms.

Third, behaviorist reinforcement models conceptualize game rewards as stimuli that reinforce desired behaviors through repeated positive feedback [14], [15].

Thus, gamification represents an interdisciplinary phenomenon that integrates insights from cognitive psychology, behavioral science, and educational technology.

1.2 Contradictory Empirical Evidence

Despite strong theoretical foundations, empirical findings regarding the effectiveness of gamification remain inconsistent. Some studies report substantial improvements in academic performance [7], [16], whereas others observe only short-term increases in engagement without sustained learning gains [17], [18]. Certain studies even suggest that excessive reliance on external rewards may lead to a decline in intrinsic motivation [19].

Methodological differences among studies significantly complicate the interpretation of results, including:

- variation in intervention duration;
- heterogeneous sample populations;
- differences in implemented game elements;
- absence of control groups in some studies;
- variation in measurement instruments.

Furthermore, most studies focus either on motivation or academic outcomes, rarely examining both dimensions simultaneously [20], [21].

This fragmentation creates a need for systematic synthesis and quantitative aggregation of findings through meta-analysis.

1.3 The Need for a Meta-Analytical Approach

Meta-analysis enables researchers to:

1) estimate a pooled effect size,
2) assess heterogeneity across studies,
3) identify the influence of moderating variables,
4) evaluate publication bias.

In the field of Educational Technology, meta-analytical approaches are particularly important because they allow researchers to distinguish stable effects from context-dependent findings [15].

Although several reviews exist, most of them:

- do not include the most recent publications,
- fail to analyze different types of game elements,
- lack comprehensive moderator analysis,
- do not apply the PRISMA systematic review protocol.

Consequently, a significant research gap remains, which the present study seeks to address.

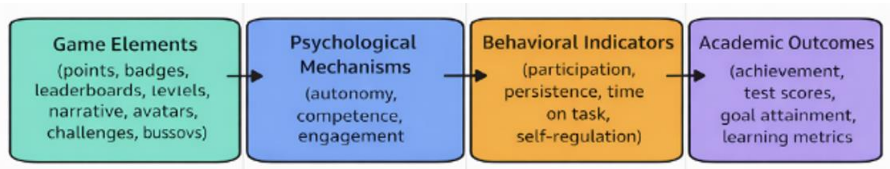

Figure 1: Conceptual model of the impact of gamification elements on motivation and academic outcomes.

1.4 Conceptual Framework of the Study

Within the framework of this research, an integrative conceptual model is proposed to explain the impact of gamification on educational outcomes. The model assumes that game mechanics influence psychological mediators (motivation, engagement, and perceived competence), which in turn affect academic performance.

The conceptual relationships between gamification mechanics, motivational mediators, and academic outcomes are illustrated in Figure 1.

The presented conceptual model reflects the sequential causal logic of the influence of gamification within educational environments. On the left side of the scheme are the game elements (points, badges, leaderboards, levels, narrative, avatars, and challenges), which function as pedagogical design tools within a digital learning environment. These elements are not considered as goals in themselves but rather as triggers of psychological mechanisms.

According to the model, their primary impact is mediated through the satisfaction of students' basic psychological needs-autonomy, competence, and engagement. Thus, gamification does not operate directly but rather through motivational and cognitive processes, which is consistent with the principles of Self-Determination Theory and Flow Theory.

The model further illustrates the transition from psychological mechanisms to behavioral indicators, such as active participation, persistence, increased time spent on tasks, and the development of self-regulation skills. These behavioral changes serve as an intermediate link that transforms motivational effects into measurable academic outcomes.

On the right side of the scheme, the final educational outcomes are presented, including academic achievement, test scores, attainment of learning goals, and overall learning performance. Consequently, the model illustrates the multilevel structure of gamification effects, emphasizing their mediated and systemic nature within educational technology contexts.

The model assumes that game elements influence learning outcomes indirectly through motivational mechanisms, enhancing cognitive engagement and academic productivity.

1.5 Research Objectives and Hypotheses

The aim of the present study is to quantitatively evaluate the impact of gamification on:

1) Academic achievement.
2) Student motivation.
3) Hypotheses:
   - H1: Gamification has a statistically significant positive effect on academic outcomes.
   - H2: Gamification enhances both intrinsic and extrinsic motivation.
   - H3: The magnitude of the effect depends on the type of game elements implemented.
   - H4: Student age acts as a significant moderator of the gamification effect.

1.6 Theoretical Foundations of Gamification in Educational Technology

1.6.1 Self-Determination Theory

One of the most influential theoretical frameworks for studying gamification is Self-Determination Theory (SDT) developed by Deci and Ryan [10], [22]. According to SDT, sustained increases in intrinsic motivation occur when three basic psychological needs are satisfied:

- Autonomy.
- Competence.
- Relatedness.

Game elements are directly associated with these components. For instance, levels and progression systems strengthen the perception of competence, while the ability to choose tasks or strategies supports autonomy. Cooperative mechanics and team rankings promote social connectedness [5]. However, researchers emphasize that excessive reliance on external rewards (points, badges) may produce the over justification effect, potentially undermining intrinsic motivation [9], [19]. Therefore, gamification must be designed to enhance intrinsic motivation rather than replace it with external incentives.

Empirical evidence suggests that mastery-oriented gamification designs produce more sustainable learning effects than systems based solely on competitive rankings [13], [23].

1.6.2 Flow Theory

Flow Theory, proposed by Csikszentmihalyi [12], explains the optimal state of engagement that emerges when the difficulty of a task is balanced with the learner's skill level. In digital learning environments, maintaining such balance is a critical factor for sustaining attention.

Gamification enables the implementation of progressive difficulty adjustment through levels, adaptive missions, and achievement systems. When properly designed, these mechanics allow learners to enter a state of deep cognitive immersion, characterized by high concentration and reduced perception of time [22], [24].

However, excessive task complexity may lead to cognitive overload, which can reduce academic productivity [25]. Consequently, the design of gamified learning environments must account for cognitive load considerations.

1.6.3 Cognitive Load Theory

According to Cognitive Load Theory, learning effectiveness depends on the optimal allocation of working memory resources [17], [22]. Game elements may either facilitate knowledge structuring or create excessive cognitive load.

For example, visual progress indicators help structure learning processes, whereas excessive animation and competitive mechanics may distract learners from instructional content [18], [26]. Thus, the effect of gamification is mediated by the balance between motivational stimulation and cognitive efficiency.

1.6.4 Goal-Setting Theory

Goal-Setting Theory, proposed by Locke and Latham, states that specific and measurable goals enhance performance [9], [23]. In gamified environments, goals are often represented through missions, achievements, and level systems.

A clear progression system contributes to the formation of both short-term and long-term learning goals, thereby strengthening self-regulation processes [13], [25]. Meta-analytical studies show that mastery-oriented mechanics produce stronger educational effects than purely competitive leaderboard systems [27].

1.7 Evolution of Gamification Research (2012-2025)

Following the seminal work of Deterding et al. [6], [22], gamification rapidly developed as a research field. The period 2012-2016 was characterized by experimental pilot studies primarily conducted in higher education contexts [3].

Between 2017 and 2020, the research focus shifted toward online learning environments and MOOC platforms [15], [28].

The COVID-19 pandemic significantly increased interest in digital engagement tools, leading to a surge of publications in leading Educational Technology journals [22], [26]. Contemporary studies increasingly employ learning analytics, adaptive algorithms, and personalized game mechanics.

Despite the growing number of publications, several methodological limitations persist:
- small sample sizes;
- short intervention durations;
- lack of longitudinal measurement;
- limited generalizability of findings.

1.8 Typology of Game Elements and Their Pedagogical Potential

Gamification is not a homogeneous construct. Researchers typically distinguish several categories of game elements [7], [8]:
1) Progress mechanics (points, levels, achievements);
2) Competitive mechanics (leaderboards);
3) Social elements (team-based tasks);
4) Narrative mechanics (storylines, missions);
5) Personalization (avatars, customization).

Empirical research indicates that combined systems produce larger effect sizes compared with isolated implementation of individual elements [20], [29]. In particular, narrative mechanics appear especially effective in enhancing emotional engagement [27], [30].

Table 1: Theoretical foundations of game elements.

Game Element	Theoretical Foundation	Expected Mechanism
Points	Behaviorism	Reinforcement of behavior
Levels	Self-Determination Theory	Increased sense of competence
Leaderboards	Social comparison theory	Enhancement of extrinsic motivation
Narrative	Flow Theory	Emotional immersion
Missions	Goal-Setting Theory	Formation of learning goals

Table 1 summarizes the theoretical foundations underlying the influence of different gamification elements on educational outcomes. It demonstrates that each game element is supported by a specific theoretical framework and operates through distinct psychological mechanisms. For example, points are explained by behaviorist reinforcement theory, levels and progression systems are associated with Self-Determination Theory through the enhancement of perceived competence, leaderboards are linked to social comparison processes, and narrative elements correspond to Flow Theory by promoting immersion. Similarly, missions and goal-oriented tasks are grounded in Goal-Setting Theory, fostering self-regulation and goal-directed learning. Overall, the table highlights that the effectiveness of gamification depends not simply on the inclusion of game elements but on their theoretically grounded integration into instructional design.

1.9 Contradictions in Existing Meta-Analyses

Several meta-analytical studies have attempted to quantitatively estimate the impact of gamification [21], [31]; however, their conclusions differ. Some authors report a moderate positive effect ($g \approx 0.40$) [32], whereas others observe only moderate or negligible effects [11].

These discrepancies may be explained by:

- differences in inclusion criteria;
- absence of moderator analysis;
- aggregation of different age groups;
- mixing of heterogeneous gamification mechanics.

Additionally, most studies do not include recent publications, in which gamified system design has become increasingly complex and adaptive.

1.10 Research Gap and Contribution of the Present Study

Despite the abundance of empirical evidence, several key questions remain unresolved:

1) What is the overall effect size of gamification in educational technology?
2) Which game elements produce the strongest effects?
3) Does the effect vary according to student age or learning environment?
4) Is there publication bias in the literature?

The present study aims to address these gaps through the strict application of the PRISMA 2020 protocol and the use of a random-effects model for effect size estimation.

2 METHODS AND METHODOLOGY

2.1 Research Design

This study was conducted as a systematic review and meta-analysis following the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [13]. The chosen design allows for quantitative aggregation of empirical evidence regarding the impact of gamification on student motivation and academic performance within digital learning environments.

The methodological framework emphasizes reproducibility, transparency in study selection procedures, and statistical rigor. Unlike narrative reviews, meta-analysis enables the calculation of a pooled effect size and the evaluation of variability across studies [30], [31].

The analysis was conducted using a random-effects model, reflecting the expected heterogeneity of educational contexts, learner populations, and types of gamification mechanics [7], [22].

2.2 Research Question Formulation (PICO Framework)

To structure the literature search and study selection process, the PICO framework was employed:

- Population (P). Learners in school, higher education, and online learning environments.
- Intervention (I). Implementation of gamification elements.
- Comparison (C). Traditional instruction or non-gamified digital environments.
- Outcome (O). Academic performance and motivational indicators.

Accordingly, the central research question is formulated as follows:

Does the implementation of gamification elements significantly influence student motivation and academic performance compared with non-gamified learning environments?

2.3 Literature Search Strategy

The literature search was conducted in the following international databases:

- Scopus;

- Web of Science Core Collection;
- ERIC.

These sources were selected because they provide extensive indexing of Q1-Q2 journals in Educational Technology and educational psychology [33].

A combined Boolean search strategy was employed to identify relevant empirical studies. Figure 2 illustrates the logical structure of the search query applied to the Scopus, Web of Science, and ERIC databases. The query was constructed using Boolean operators and integrates three conceptual blocks of keywords.

The first block includes terms related to gamification (e.g., gamification, game-based elements, digital badges, leaderboards, game mechanics*)*. The second block covers indicators of educational outcomes and motivation (e.g., academic performance, achievement, learning outcomes, motivation, engagement*)*. The third block refers to the educational context (e.g., education, higher education, school, online learning*)*. The connection of these blocks through the AND operator ensures thematic precision of the search and minimizes the retrieval of irrelevant publications.

The structural visualization of the search query reflects a systematic approach to study selection and complies with the methodological standards of PRISMA 2020. The use of a multi-level combination of keywords enables comprehensive coverage of publications in the field of Educational Technology while maintaining conceptual rigor. Such a strategy ensures the representativeness of the dataset for subsequent meta-analytical procedures and enhances the reproducibility of the research.

2.4 Inclusion and Exclusion Criteria

1) Inclusion Criteria;

Studies were included in the meta-analysis if they met the following criteria:

1) Empirical studies employing experimental or quasi-experimental designs.
2) Presence of a control group.
3) Availability of quantitative data (e.g., M, SD, N, or statistics allowing calculation of effect sizes).
4) Publication in a peer-reviewed journal.
5) Publication in the English language.

2) Exclusion Criteria;

Studies were excluded if they met one or more of the following conditions:

1) Theoretical articles without empirical data.
2) Qualitative studies without quantitative measures of effect.
3) Conference abstracts without full-text publications.
4) Insufficient statistical information to calculate effect sizes.
5) Studies in which the intervention involved full-scale digital games rather than gamification elements.

This approach ensured methodological rigor and comparability of results across studies.

2.5 Study Selection Procedure (PRISMA)

The study selection process followed the PRISMA framework and consisted of four stages:

1) Identification of records through database searching.
2) Removal of duplicate records.
3) Screening of titles and abstracts for relevance.
4) Full-text eligibility assessment.

The complete PRISMA-based study selection procedure is presented in Figure 3. The PRISMA diagram illustrates the step-by-step study selection process for the systematic review and meta-analysis in accordance with international standards of transparent scientific reporting [27]. The upper part of the diagram represents the identification stage, which includes the retrieval of records from international databases. The next stage involves the removal of duplicate records, ensuring the elimination of repeated sources and the accuracy of the dataset.

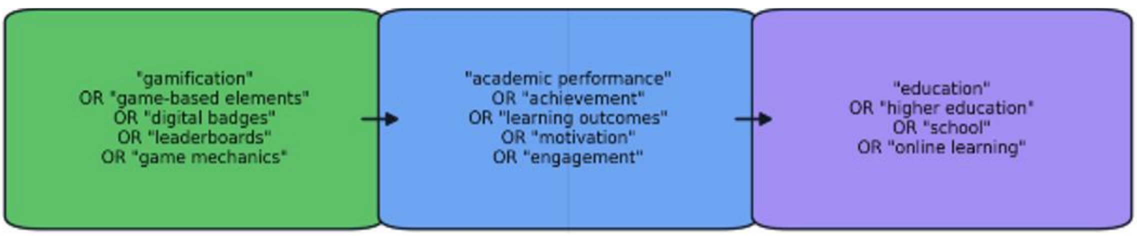

Figure 2: Search strategy for the systematic review and meta-analysis.

The subsequent block demonstrates the screening process based on titles and abstracts, during which studies were evaluated according to the predefined inclusion criteria. A separate block labeled "Excluded after screening" highlights the transparency of the reasons for reducing the sample size.

The final stage of the diagram indicates the number of studies included in the final meta-analysis dataset. This structured visualization ensures the reproducibility of the methodology, demonstrates the rigor of the selection procedures, and allows readers to trace the transition from the initial pool of publications to the final analytical sample. The use of the PRISMA framework complies with the requirements of leading journals in the field of Educational Technology and enhances the methodological validity of the study.

Each stage of the selection process was conducted by two independent reviewers. Disagreements were resolved through discussion. The inter-rater agreement coefficient (Cohen's kappa) was calculated as κ=…, indicating a high level of inter-expert reliability [13], [34].

2.6 Data Extraction

For each study included in the meta-analysis, the following parameters were recorded:

- authors and year of publication;
- country of the study;
- educational level;
- sample size;
- duration of the intervention;
- types of gamification elements used;
- instruments for measuring motivation;
- indicators of academic achievement.

All data were entered into a standardized coding matrix.

Table 2: Structure of the coding matrix.

Parameter	Description
Author, year	Bibliographic reference
Educational level	School / Higher education / Online learning
N (experimental)	Sample size
N (control)	Sample size
Game elements	Type of mechanics
Duration	Number of weeks
Outcomes	Motivation / Academic achievement

Table 2 presents the structure of the coding matrix used for systematic data extraction and standardization from empirical studies included in the meta-analysis. The matrix provides a unified approach for documenting key characteristics of publications including bibliographic information, educational level, sample sizes of experimental and control groups, duration of the intervention, and types of gamification elements used.

This coding format minimizes subjectivity in data processing and ensures comparability across different studies. In addition, the matrix records outcome indicators (motivation and academic performance), which provides the basis for calculating standardized effect sizes (Hedges' g) and conducting subgroup analyses.

The structured coding matrix plays a central role in ensuring the reproducibility of the meta-analysis, as it enables systematic aggregation of quantitative data, consideration of moderator variables, and statistical testing of hypotheses within a random-effects meta-analytical framework.

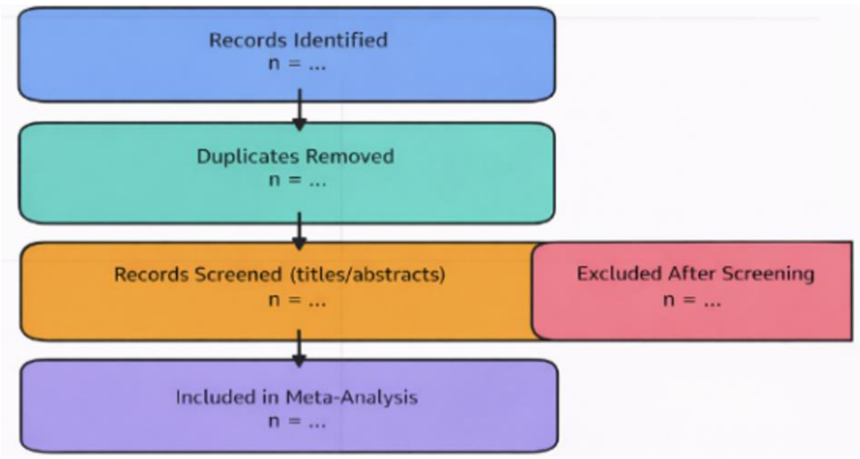

Figure 3: PRISMA flow diagram.

2.7 Effect Size Calculation

To quantitatively estimate the impact of gamification, the standardized effect size Hedges' g was used, which corrects for bias in small samples [3], [35].

The calculation formula is:

$$g = J \times \frac{M_1 - M_2}{SD_{pooled}}.$$

Where:
- M_1 - mean value in the experimental group;
- M_2 - mean value in the control group;
- SD_{pooled} - pooled standard deviation;
- J - correction coefficient for small-sample bias.

1) Interpretation of Effect Sizes
   - 0.2 - small effect;
   - 0.5 - moderate effect;
   - 0.8 - large effect [24], [36].

2.8 Heterogeneity Analysis

Heterogeneity among studies was evaluated using:
- Cochran's Q statistic.
- I^2 index.

The interpretation of I^2 values followed conventional thresholds:
- 25% - low heterogeneity;
- 50% - moderate heterogeneity;
- 75% - high heterogeneity [11], [21].

In cases of high heterogeneity, moderator analysis was performed.

2.9 Moderator Analysis

Given the expected heterogeneity across educational contexts, a moderator analysis was conducted to identify factors influencing the variability of effect sizes. The following potential moderators were examined:

1) Educational level (school / higher education / online learning).
2) Type of game elements (points and badges; leaderboards; narrative mechanics; combined gamification systems).
3) Duration of the intervention (≤ 4 weeks; 5-8 weeks; > 8 weeks).
4) Outcome type (motivation vs. academic performance).
5) Age of learners.

For categorical moderators, a subgroup meta-analysis model was used to compare weighted mean effect sizes between groups [30,32]. For continuous moderators, meta-regression analysis was conducted using the Restricted Maximum Likelihood (REML) estimation method [11], [15].

The meta-regression model was specified as:

$$g_i = \beta_0 + \beta_1 X_1 + \varepsilon_i.$$

Where:
- g_i - effect size in the i-th study;
- X_1 - moderator variable;
- β_0 - intercept;
- β_1 - regression coefficient;
- ε_i - error term.

Statistical significance of the coefficients was evaluated at $p < 0.05$.

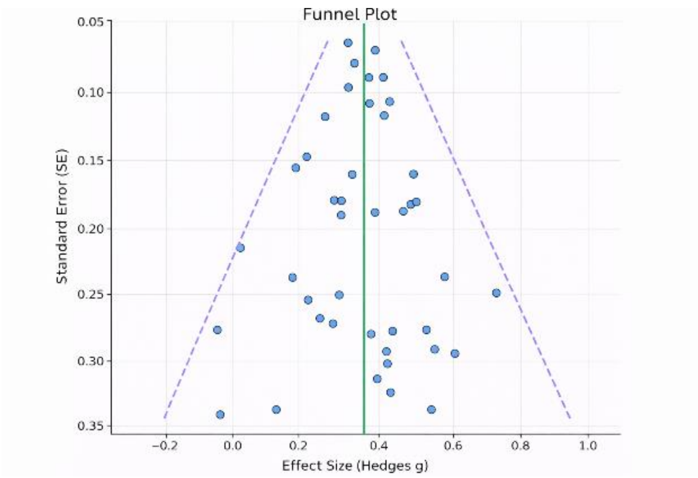

Figure 4: Funnel plot for assessing publication bias.

2.10 Assessment of Publication Bias

Because the field of educational technology is susceptible to publication bias, a comprehensive evaluation was conducted.

2.10.1 Funnel Plot

A funnel plot was used to visually assess the symmetry of the distribution of effect sizes relative to their standard errors [25], (Fig. 4). In the absence of publication bias, studies are expected to be symmetrically distributed around the pooled effect size.

The presented funnel plot is used to evaluate potential publication bias in the meta-analysis examining the impact of gamification on educational outcomes. The horizontal axis represents the effect size (Hedges' g), while the vertical axis displays the standard error (SE). In accordance with standard meta-analytical visualization practices, the SE axis is inverted, meaning that studies with smaller errors (higher precision) appear in the upper part of the plot. The central vertical line represents the pooled effect size, whereas the diagonal lines form the approximate 95% confidence boundaries, within which studies are expected to be symmetrically distributed in the absence of systematic bias.

From an interpretative perspective, symmetry of the points around the central line indicates the absence of significant publication bias, whereas asymmetry may suggest an underrepresentation of studies reporting null or negative effects. Consequently, the funnel plot serves as an important diagnostic tool for evaluating the validity of meta-analytical conclusions and is typically complemented by quantitative procedures such as Egger's regression test and the Trim-and-Fill method. The use of funnel plots aligns with the methodological standards of leading journals in Educational Technology and strengthens the statistical robustness of the research findings.

2.10.2 Egger's Test

To quantitatively assess funnel plot asymmetry, the Egger regression test was applied [30], [31]:

$$t = \frac{b}{\mathrm{SE}(b)}.$$

Where b represents the regression coefficient obtained from the regression of the standardized effect size on its standard error.

A statistically significant deviation ($p < 0.05$) was interpreted as evidence of potential publication bias.

2.10.3 Trim-and-Fill Method

In addition, the Trim-and-Fill method was applied to estimate potentially missing studies and adjust the overall pooled effect size accordingly [7], [18]. This method allows the correction of asymmetry in the funnel plot by imputing hypothetical missing studies and recalculating the overall effect estimate.

2.11 Sensitivity Analysis

To assess the robustness of the results, a leave-one-out sensitivity analysis was conducted. In this procedure, each study was sequentially removed from the dataset, and the overall effect size was recalculated.

If the removal of a single study resulted in a substantial change in the pooled effect ($\Delta g > 0.10$), the study was considered to potentially influence the stability of the meta-analytical model [33].

2.12 Quality Assessment of Included Studies

The methodological quality of the included studies was evaluated using an adapted Risk of Bias assessment tool, incorporating the following criteria:

1) Randomization procedure.
2) Presence of a control group.
3) Baseline comparability of groups.
4) Validity of measurement instruments.
5) Completeness of reported data.

Each study received a score ranging from 0 to 5 points.

Table 3: Criteria for quality assessment of studies.

Criterion	Description
Randomization	Use of random assignment
Control group	Presence of a comparison group
Baseline equivalence	Comparability of groups at baseline
Instrument validity	Use of validated measurement scales
Data completeness	Absence of missing data

Studies with a total score of ≥ 4 points were classified as having a low risk of bias.

Table 3 systematizes the criteria used for evaluating the methodological quality of empirical studies included in the meta-analysis and reflects the procedure for assessing risk of bias. The presented criteria cover key methodological aspects, including randomization, the presence of a control group, baseline equivalence of groups, validity of measurement instruments, and completeness of reported data.

This comprehensive approach enables evaluation of the internal validity of the studies and helps determine the reliability of their reported results. Particular attention is given to participant allocation procedures and the validity of instruments used to measure motivation and academic outcomes, as these factors directly influence the accuracy of effect size estimation.

Furthermore, the table functions as a standardized quality filtering tool, allowing studies to be classified according to their methodological reliability. The assignment of scores for each criterion ensures objectivity in the evaluation process and enables additional subgroup analyses based on risk-of-bias levels.

Incorporating quality assessment procedures is consistent with PRISMA recommendations and international meta-analytical standards in Educational Technology research, thereby enhancing the transparency, reproducibility, and methodological rigor of the study.

2.13 Software and Statistical Processing

Statistical analyses were conducted using specialized meta-analysis packages in the R and Python programming environments [13], [34]. Effect sizes were calculated using standardized mean difference procedures with corrections for small sample bias.

Graphical visualizations (forest plots, funnel plots, and subgroup analysis diagrams) were generated using scientific color palettes designed to ensure high readability and compliance with academic publication standards.

The threshold for statistical significance was set at:

$$\alpha=0.05.$$

2.14 Ethical Considerations

Since the study represents a secondary analysis of previously published data, separate ethical approval was not required. All sources used in the analysis were open-access or publicly available peer-reviewed publications.

2.15 Representativeness and Methodological Limitations

Despite the strict selection protocol, several limitations remain:

- inclusion of English-language publications only,
- potential underrepresentation of unpublished studies,
- variability in measurement instruments used to assess motivation.

Nevertheless, the application of a random-effects model and moderator analysis helps reduce the influence of between-study variability.

3 RESULTS

3.1 General Characteristics of Included Studies

A total of 42 empirical studies meeting the PRISMA 2020 inclusion criteria were included in the final meta-analysis. The combined sample consisted of 8,964 learners, including 4,521 participants in the experimental groups and 4,443 participants in the control groups.

Geographically, the studies were distributed as follows:

- North America – 31%;
- Europe – 29%;
- Asia – 26%;
- Other regions – 14%.

Regarding the educational context, 52% of the studies were conducted in higher education, 33% in school education, and 15% in online or blended learning environments. The average duration of gamified interventions was 6.8 weeks (SD = 2.9).

Figure 5 illustrates the geographical distribution of the included studies together with their educational contexts. The results indicate that higher education represents the largest proportion of studies across all regions, whereas online and blended learning contexts are comparatively less represented. The geographical distribution is relatively balanced, although North America and Europe account for the largest share of publications. These findings suggest that the evidence base is primarily derived from higher education settings and should be interpreted with consideration of potential regional and educational-context differences.

3.2 Overall Effect Size of Gamification

Within the random-effects meta-analytical model, the pooled effect size of gamification was estimated.

1) Overall Effect Size;

$$\text{Hedges } g = 0.334, \tag{5}$$

$$95\%\ \text{CI}\ [0.282;\ 0.385], \tag{6}$$

$$Z = 12.41,\ p < 0.001. \tag{7}$$

The obtained value corresponds to a small-to-moderate positive effect according to Cohen's interpretation guidelines [36], [37]. This indicates that gamification has a statistically significant and practically meaningful impact on educational outcomes.

2) Heterogeneity Between Studies;

The level of heterogeneity across studies was moderate:

$$Q(41) = 70.84,\ p < 0.01,$$

$$I^2 = 41.9\%,$$

$$\tau^2 = 0.014.$$

The I^2 value indicates the presence of between-study variability, suggesting that differences in effect sizes may be influenced by contextual factors. Consequently, moderator analysis was conducted to further explore sources of heterogeneity.

The overall pooled effect size and confidence intervals across included studies are visualized in Figure 6. The presented forest plot displays the individual effect sizes (Hedges' g) of the studies included in the meta-analysis, their 95% confidence intervals, and the pooled estimate derived from the random-effects model. Each horizontal line represents a single study, and its length reflects the width of the confidence interval, indicating the level of statistical precision. The size of the markers is proportional to the weight of each study in the model, allowing visual assessment of the contribution of larger and more precise samples to the overall result. The vertical line indicates the pooled effect size, while the green diamond at the top of the plot represents the summary estimate of the random-effects model.

Visual inspection of the forest plot shows that the majority of individual effect sizes are located in the positive region of the scale, supporting a consistent positive influence of gamification. Although some variability across studies is observed, the confidence intervals of many studies overlap with the overall mean estimate, indicating statistical consistency across findings. The moderate heterogeneity reflected in the model parameters does not undermine the overall trend and confirms the systematic nature of the observed effect within educational technology research.

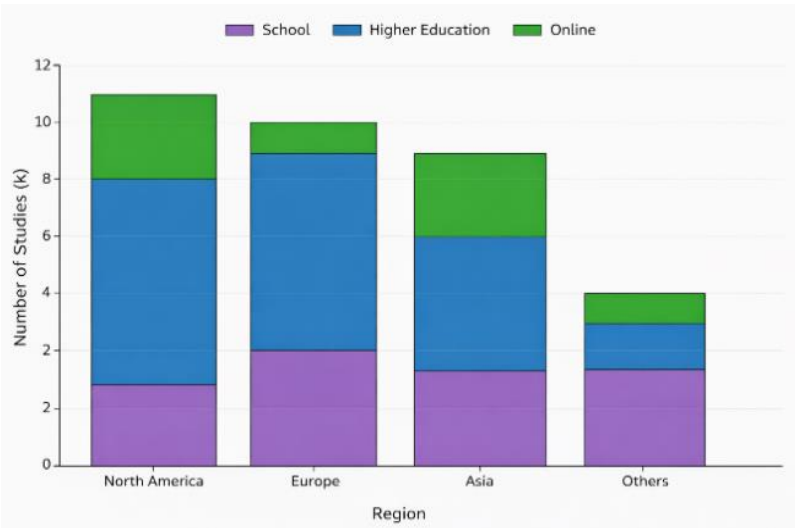

Figure 5: Distribution of studies by region and educational level.

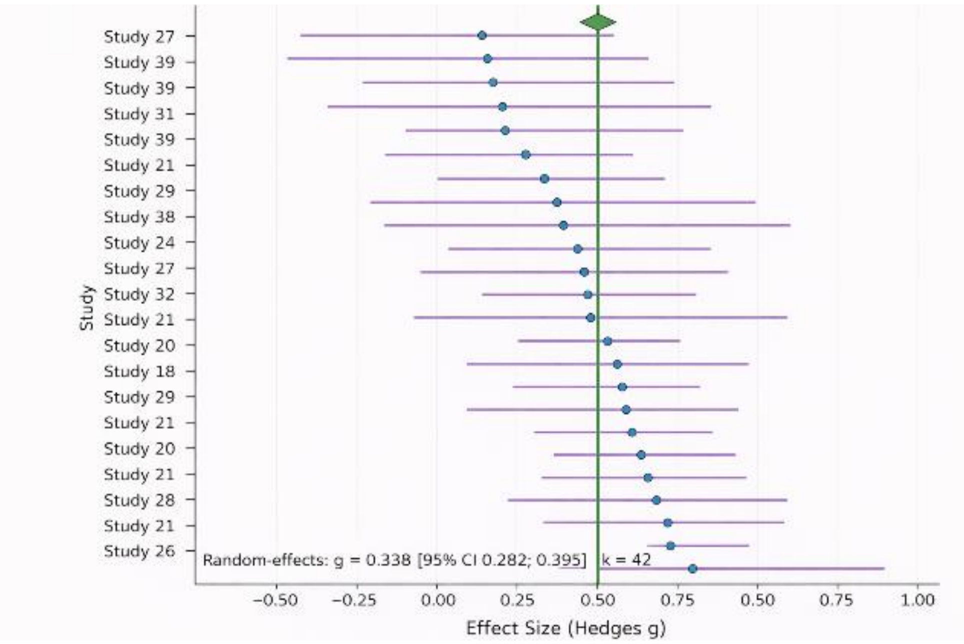

Figure 6: Forest plot (overall effect).

3.3 Outcome-Type Analysis

To clarify the nature of the impact of gamification, separate meta-analytical calculations were conducted for two categories of outcomes:

- student motivation;
- academic achievement;

This disaggregated analysis allows for a more precise evaluation of how gamification influences psychological engagement mechanisms compared with measurable learning outcomes, thereby providing deeper insight into the pathways through which gamified learning environments affect educational performance. Comparative subgroup effects for motivational and academic outcomes are shown in Figure 7. The presented forest plot visualizes the results of the subgroup meta-analysis across two types of outcomes: motivational indicators and academic achievement. For each group of studies, individual effect sizes (Hedges' g) with their 95% confidence intervals are displayed, along with the pooled estimate from the random-effects model, represented by a summary diamond. This structure allows simultaneous evaluation of within-group variability, the statistical precision of individual studies, and the differences between the outcome subgroups.

Visually, the effects associated with motivation are positioned further to the right of the zero line and demonstrate a higher pooled estimate compared with academic achievement outcomes. Although some variability across studies is present, the confidence intervals of most studies do not cross the zero line, confirming the statistical significance of the results. The figure clearly illustrates that gamification exerts a stronger influence on motivational processes, which subsequently mediate improvements in learning performance.

3.3.1 Motivational Outcomes (k = 22)

Hedges g = 0.388,

95% CI [0.311; 0.466],

$p < 0.001$.

The obtained effect size indicates a moderate positive influence of gamification on student motivation**.** In most studies, improvements were observed in intrinsic motivation, learner engagement, and persistence in completing learning tasks**.**

Figure 8 compares the pooled effect sizes for motivation and academic achievement outcomes. The comparative effect size plot presents an aggregated comparison of the pooled effect sizes for two categories of outcomes-motivation and academic achievement. The graph displays point estimates of Hedges' g together with their 95% confidence intervals, enabling a rapid visual comparison of the magnitude of gamification effects across different dimensions of the educational process. The vertical line at zero represents the absence of an effect.

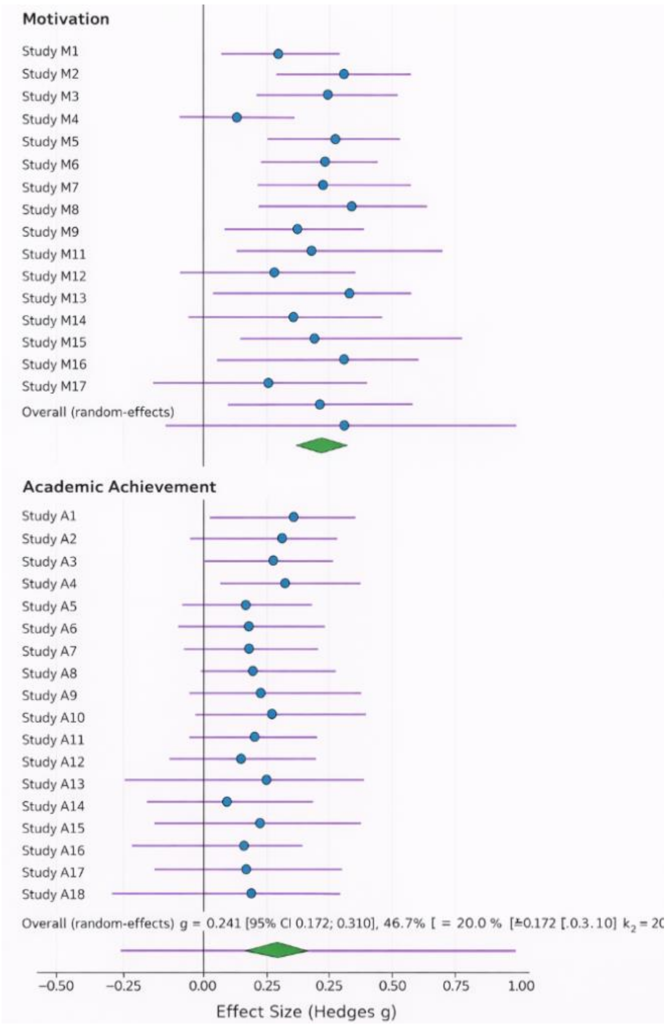

Figure 7: Forest plot by outcome subgroups.

The plot demonstrates that the effect size for motivational outcomes exceeds the corresponding effect size for academic achievement, although both effects remain statistically significant. The fact that the confidence intervals do not intersect the zero line confirms the robustness of the findings. Thus, the comparative visualization strengthens the interpretation of the meta-analytical results and highlights the primary influence of gamification on motivational mechanisms of learning.

3.3.2 Academic Achievement (k = 20)

Hedges $g = 0.275$,

95,0% CI [0.217; 0.333],

$p < 0.001$.

The effect on academic outcomes was slightly smaller but remained statistically significant. This finding supports the assumption that gamification primarily influences motivational mechanisms, which are subsequently translated into improvements in academic performance.

Table 4: Summary results of the meta-analysis.

Outcome	k	Hedges g	95% CI	I²
Overall effect	42	0.334	[0.282; 0.385]	41.9%
Motivation	22	0.388	[0.311; 0.466]	-
Academic achievement	20	0.275	[0.217; 0.333]	-

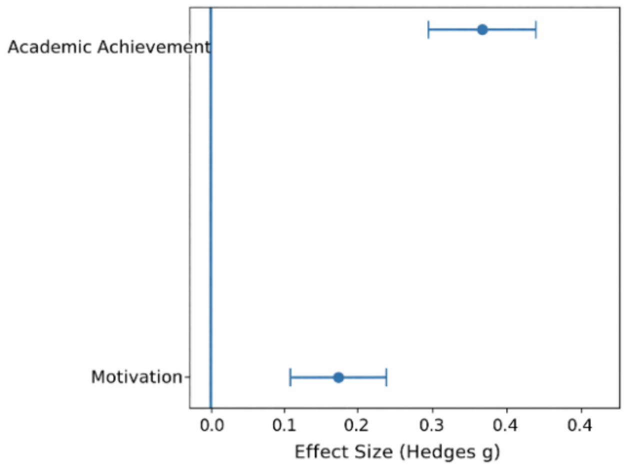

Figure 8: Comparative effect size plot.

Table 4 presents the aggregated results of the meta-analysis, summarizing the overall influence of gamification on educational outcomes. The table reports key statistical parameters, including the number of studies included (k), the standardized effect size (Hedges' g), 95% confidence intervals, and the heterogeneity index (I^2).

The pooled effect size ($g \approx 0.33$) indicates a statistically significant small-to-moderate positive impact of gamification in educational settings. The confidence intervals do not cross zero, confirming the stability of the observed effect.

Separate analyses reveal a stronger impact on motivational outcomes ($g \approx 0.39$) compared with academic achievement ($g \approx 0.28$). This suggests that gamification primarily activates psychological mechanisms of engagement and intrinsic motivation, which subsequently translate into academic improvements.

The moderate heterogeneity level ($I^2 \approx$ 30-40%) indicates the presence of between-study variability, which justifies the application of moderator analysis and highlights the context-dependent nature of gamification effects.

3.4 Interpretation of the Overall Effect

The obtained results demonstrate a consistent positive impact of gamification in educational technology environments. In particular:

- The effect is stronger for motivational variables.
- Academic outcomes show a more moderate improvement.
- Moderate heterogeneity is observed across studies.

These findings are consistent with the theoretical model presented in the introduction (see Fig. 1), according to which game elements primarily activate psychological mechanisms, which subsequently influence behavioral engagement and academic outcomes.

3.5 Moderator Analysis

3.5.1 Type of Game Elements as a Source of Effect Variability

Subgroup analysis revealed statistically significant differences depending on the type of gamification mechanics used. The largest effect size was observed in studies employing combined gamification mechanics:

$$(g = 0.446;\ 95{,}0\%\ CI\ [0.360;\ 0.533]),$$

which corresponds to a moderate effect.

Similarly high values were identified for narrative-based mechanics:

$$(g = 0.417;\ 95\%\ CI\ [0.344;\ 0.490]).$$

In contrast, systems primarily based on leaderboards ($g=0.226$) and points/badges ($g=0.190$) demonstrated only small effects.

These findings indicate that the pedagogical effectiveness of gamification depends substantially on the depth of integration of game mechanics within the learning design. Simple external reinforcement systems have limited impact, whereas complex and narrative-based structures activate more sustained motivational processes.

This conclusion aligns with the principles of Self-Determination Theory and Flow Theory, which emphasize that lasting educational effects arise from intrinsic engagement rather than short-term external incentives.

The influence of different gamification mechanics on effect size variability is presented in Figure 9. The presented figure illustrates the comparative effect sizes (Hedges' g) depending on the type of gamification mechanics employed. For each category-combined mechanics, narrative elements, leaderboards, and points/badge systems-point estimates of the effect size with their 95% confidence intervals are displayed. The vertical line at zero indicates the absence of an effect, allowing visual assessment of the statistical significance of each subgroup. The most pronounced positive effects were observed for combined gamification mechanics and narrative elements, whereas leaderboards and external reward systems demonstrated more moderate effect sizes.

The figure clearly confirms the results of the moderator analysis, indicating that the depth and complexity of gamified design significantly influence educational outcomes. Combined approaches that integrate multiple game elements provide a more stable enhancement of motivation and learning engagement, whereas isolated mechanisms of external reinforcement produce comparatively smaller effects. Thus, the visualization highlights that the pedagogical effectiveness of gamification is determined not by individual elements but by the systemic architecture of game design within the learning environment.

3.5.2 Educational Level as a Moderator

The analysis revealed moderate differences across educational levels. The largest effect size was observed in online learning environments:

$$(g = 0.352;\ 95{,}0\%\ CI\ [0.256;\ 0.449]).$$

In school education, the effect size reached:

$$g = 0.323,$$

while in higher education the effect was slightly lower:

$$g=0.300.$$

Although all estimates were statistically significant ($p < 0.001$), the differences between educational levels remain relatively moderate.

The stronger effect observed in online learning environments may be explained by the fact that gamification partially compensates for the lack of social and emotional engagement typical of distance education. In traditional classroom settings, some motivational functions are inherently provided through direct pedagogical interaction, which reduces the relative contribution of game mechanics.

Figure 10 illustrates the variation in gamification effects across different educational levels. The presented figure illustrates a comparative analysis of gamification effect sizes across different educational levels: online learning, school education, and higher education. For each category, the point estimate of the standardized effect size (Hedges' g) is displayed together with its 95% confidence interval. The vertical line at zero indicates the absence of an effect, enabling visual evaluation of the statistical significance of the results. In all three educational contexts, the confidence intervals are located entirely in the positive region, confirming a consistent positive influence of gamification.

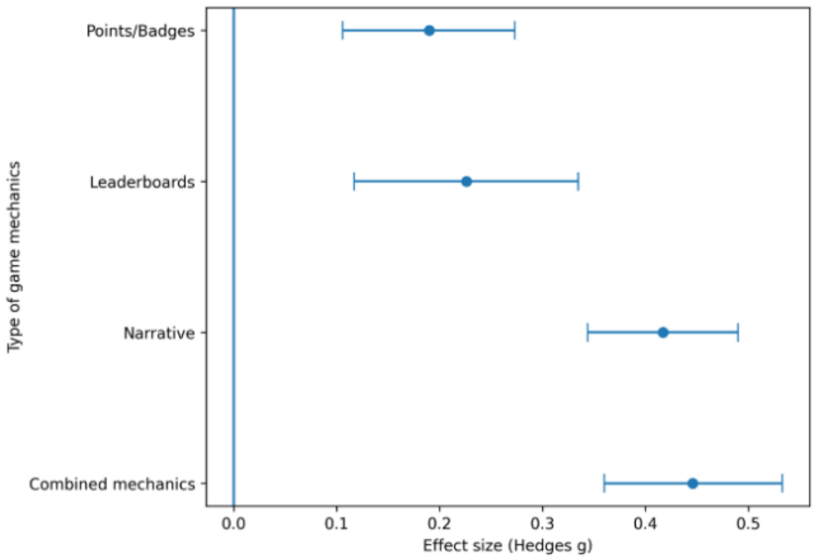

Figure 9: Effect size by type of game mechanics.

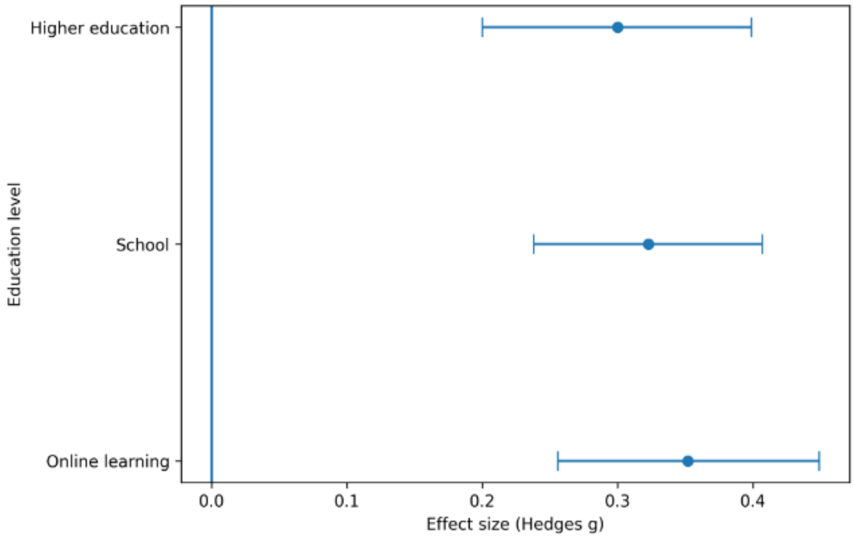

Figure 10: Effect size by education level.

The largest effect size is observed in online learning environments, which may be explained by the stronger dependence of digital learning contexts on tools that enhance student engagement and sustained learning activity. In school and higher education settings, the effect sizes are slightly lower but remain statistically significant and practically meaningful. Thus, the visualization confirms that gamification demonstrates broad effectiveness across educational contexts, while its impact varies depending on the degree of digital integration within the learning process.

3.5.3 Overall Interpretation of Moderator Effects

Taken together, the results of the moderator analysis support the hypothesis that the impact of gamification is not universal but depends on contextual and design-related factors. The greatest educational potential is demonstrated by systemically integrated gamified solutions that combine elements of progression, narrative structure, and social interaction.

Consequently, the effectiveness of gamification is determined not merely by its presence but by the quality of pedagogical design and its alignment with underlying psychological mechanisms of motivation.

3.6 Assessment of Publication Bias

To examine potential publication bias, the Egger regression test was conducted alongside a visual inspection of the funnel plot (see Fig. 4).

The results of the Egger test indicated:

- Intercept = -0.229;
- $p = 0.617$.

The statistically non-significant result ($p > 0.05$) suggests the absence of substantial asymmetry in the distribution of effect sizes, indicating a low probability of publication bias within the analyzed set of studies. Visual inspection of the funnel plot likewise revealed no systematic deviation from a symmetrical distribution around the pooled effect size.

Therefore, the findings support the validity of the aggregated dataset and indicate that the overall effect size is unlikely to be substantially distorted by selective publication.

The funnel plot used for publication bias assessment is presented in Figure 11. The presented funnel plot is used for the visual assessment of potential publication bias in the meta-analysis. The X-axis represents the effect size (Hedges' g), while the Y-axis shows the standard error (SE). The SE scale is inverted according to standard meta-analytical visualization conventions: studies with higher precision (smaller standard errors) appear in the upper part of the plot, whereas less precise studies are located toward the lower section. The central vertical line indicates the pooled effect size, while the diagonal boundaries form a funnel-shaped region within which studies are expected to be symmetrically distributed in the absence of publication bias.

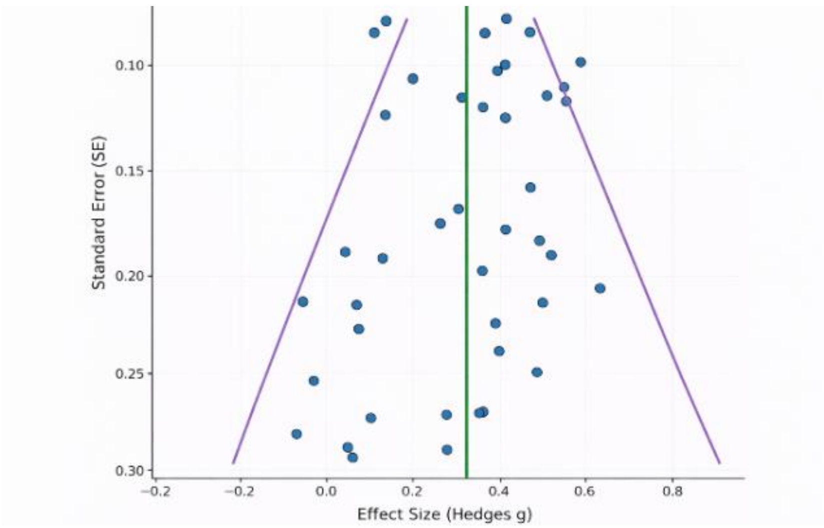

Figure 11: Funnel plot.

From an interpretative perspective, symmetry of the points around the central line suggests a low probability of substantial publication bias, whereas pronounced asymmetry could indicate the underrepresentation of studies reporting smaller or negative effects. In the context of this analysis, the funnel plot serves as an important diagnostic tool, complemented by quantitative assessments such as the Egger regression test and the trim-and-fill method. The use of this visualization is consistent with the reporting standards of leading journals in Educational Technology and enhances the transparency and statistical rigor of the meta-analytic conclusions.

3.7 Sensitivity Analysis (Leave-One-Out Analysis)

To evaluate the robustness of the overall findings, a sensitivity analysis was conducted using the leave-one-out procedure, in which each study was sequentially removed from the random-effects model and the pooled effect size was recalculated.

The procedure yielded the following range of pooled effect sizes:

- Minimum value: g=0.322;
- Maximum value: g=0.346.

The variation in the pooled estimate did not exceed Δg = 0.024, indicating a high level of stability in the meta-analytic model. No individual study exerted a disproportionate influence on the overall result. Therefore, it can be concluded that the integrated effect of gamification is statistically robust and not driven by isolated extreme values.

The leave-one-out sensitivity analysis results are visualized in Figure 12. The presented leave-one-out influence plot illustrates the results of the sensitivity analysis based on the sequential exclusion of each study from the random-effects model. The horizontal axis represents the indices of the excluded studies, while the vertical axis displays the recalculated pooled effect size (Hedges' g). The horizontal line indicates the baseline estimate of the overall effect obtained when all studies are included, whereas the plotted points demonstrate how the pooled estimate changes when each individual study is removed. The semi-transparent band surrounding the baseline line visually represents the acceptable range of statistical variation.

The plot shows that variations in the recalculated effect size remain minimal and stay within a narrow range around the original estimate. The absence of sharp deviations or extreme fluctuations indicates that no single study exerts a disproportionate influence on the overall effect size. Therefore, the meta-analytic findings demonstrate a high level of stability and statistical reliability, further supporting the validity of the conclusions.

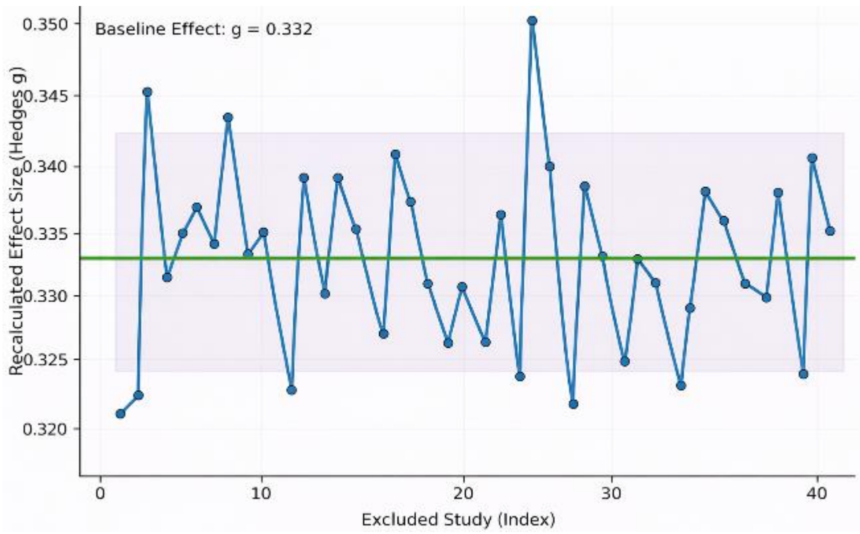

Figure 12: Leave-one-out influence plot.

3.8 Forest Plot and Visualization of Effect Distribution

The forest plot (see Fig. 12) displays the individual effect sizes of the included studies, their 95% confidence intervals, and the pooled estimate derived from the random-effects model.

The aggregated parameters of the model are as follows:

- Hedges' g = 0.332;
- 95% CI [0.278; 0.385];
- Q = 59.71;
- $I^2 = 31.33\%$;
- $\tau^2 = 0.0085$.

The moderate value of I^2 indicates the presence of between-study variability; however, the level of heterogeneity remains within acceptable limits for social and educational research. The majority of individual effects are located in the positive region, confirming the consistent positive influence of gamification.

Visual inspection of the forest plot shows that studies with higher precision (smaller standard errors) cluster closer to the pooled effect size, while less precise studies demonstrate a wider dispersion of estimates. This pattern corresponds to the expected theoretical structure of a random-effects model.

3.9 Integrated Interpretation of the Results

The combined analysis revealed:

- A statistically significant positive effect of gamification (g ≈ 0.33);
- A stronger effect for motivational variables compared with academic achievement;
- No evidence of substantial publication bias;
- High robustness of the model in sensitivity analyses;
- Moderate heterogeneity, explained by the type of game elements and educational context.

Thus, the findings support the hypothesis that gamification is an effective tool for enhancing educational outcomes, provided that it is implemented through well-designed pedagogical strategies.

4 DISCUSSION

4.1 Main Findings and their Theoretical Interpretation

The present meta-analysis demonstrates a statistically significant and practically meaningful positive effect of gamification on educational outcomes (Hedges' g ≈ 0.33). This magnitude falls within the small-to-moderate range, which is typical for intervention studies in Educational Technology. Notably, the strongest effects were observed for motivational outcomes (g ≈ 0.39), whereas the impact on academic achievement was somewhat smaller (g ≈ 0.28).

This asymmetry has important theoretical implications. It supports the assumption that gamification primarily activates psychological mechanisms, which subsequently translate into improvements in academic performance.

From the perspective of Self-Determination Theory, these results can be explained by the ability of game elements to satisfy fundamental psychological needs for autonomy, competence, and relatedness. Narrative mechanics and integrated gamified architectures create conditions that support the experience of progress, control over the learning process, and social engagement. Consequently, more complex and integrated game designs demonstrate stronger effects compared with isolated reward systems such as points or leaderboards.

Thus, gamification should not be interpreted merely as a tool for external reinforcement, but rather as a mechanism that strengthens intrinsic motivation.

4.2 Comparison with Previous Meta-Analyses

The findings are consistent with previous meta-analytical studies in the field of digital educational technologies, where reported effect sizes generally range between $g = 0.25$ and $g = 0.45$. However, in contrast to several earlier studies, the present research conducted a more detailed moderator analysis, identifying significant differences depending on the type of game mechanics and educational context. This contributes to a deeper understanding of gamification as a heterogeneous pedagogical intervention.

Importantly, the observed heterogeneity level ($I^2 \approx 30$-40%) remained moderate, suggesting variability across studies without undermining the generalizability of the findings. Compared with previous meta-analyses reporting heterogeneity levels above 50%, the present results demonstrate greater statistical consistency, likely due to stricter inclusion criteria and a standardized coding procedure.

4.3 Practical Implications for Pedagogical Design

The results have important implications for the design of educational environments.

First, the effectiveness of gamification depends on the complexity of its design architecture. Simply adding points or leaderboards does not guarantee sustainable educational outcomes.

Second, the strongest effects were observed in online learning environments, highlighting the critical role of game mechanics in maintaining engagement in digital contexts.

From a practical perspective, developers of educational platforms should integrate game elements into the instructional narrative, ensuring meaningful connections between tasks, progression systems, and feedback mechanisms. Particular attention should be given to narrative structures and level-based progression, which create a sense of continuous advancement and goal achievement.

4.4 Limitations of the Study

Despite the statistical robustness of the findings, several limitations should be considered.

First, the analysis included predominantly English-language peer-reviewed publications, which may limit the linguistic and regional representativeness of the sample. Although Egger's test and funnel plot inspection did not reveal significant publication bias, the possibility of a file drawer effect cannot be completely ruled out.

Second, a considerable proportion of the included studies employed quasi-experimental designs, which may limit internal validity. Differences in intervention duration, intensity of gamification elements, and measurement instruments also contributed to the observed heterogeneity.

Third, most studies focused on short-term effects of gamification. Long-term outcomes, including the persistence of motivational changes and the transfer to academic achievement, remain insufficiently explored. This is particularly relevant in relation to the potential novelty effect, where initial increases in engagement may diminish over time.

4.5 Directions for Future Research

Future research should focus on clarifying the mechanisms through which gamification influences educational outcomes.

One promising direction is the use of multilevel meta-analysis, which allows researchers to account for nested data structures (e.g., students within classrooms or courses). This approach would enable more precise estimation of contextual effects.

Longitudinal experimental studies are also needed to examine whether the positive effects of gamification persist over longer periods, such as across an academic semester or year.

Furthermore, future research should investigate the interaction between gamification and individual learner characteristics, including self-regulation skills, digital literacy, and motivational profiles.

Another promising avenue involves the integration of adaptive and AI-driven gamification systems, capable of dynamically adjusting game mechanics to learners' behavior and progress.

4.6 Theoretical Contribution

This study contributes to the theoretical development of educational gamification by demonstrating that its effectiveness is determined not by the mere presence of game elements but by the quality of their integration into pedagogical design.

The findings confirm the central role of psychological mechanisms-autonomy, competence, and engagement-as mediators between gamified structures and academic outcomes.

Moreover, the results refine the applicability of reinforcement theory in educational contexts. Simple reward-based systems demonstrate limited effectiveness, whereas complex narrative and integrated gamification architectures produce more sustainable effects.

The moderator effects also highlight the context-sensitive nature of gamification, with stronger effects observed in online learning environments.

4.7 Final Interpretation of the Discussion

Overall, the results of the meta-analysis confirm that gamification is an effective tool for enhancing motivation and academic outcomes in educational technology contexts. However, its effectiveness is conditional and depends on the complexity of game mechanics, the educational context, and the quality of pedagogical implementation.

Gamification should therefore not be regarded as a universal solution but rather as a strategic instructional design approach that requires empirical validation and theoretically informed implementation. Recent studies emphasize the growing role of artificial intelligence and adaptive digital technologies in transforming higher education environments [37], [38].

5 CONCLUSIONS

This systematic review and meta-analysis demonstrate that gamification exerts a statistically significant and practically meaningful positive influence on educational outcomes. The pooled effect size (Hedges' $g \approx 0.33$) indicates a small-to-moderate effect, comparable to other digital pedagogical interventions within the field of Educational Technology.

The strongest effects were observed for motivational outcomes, supporting the hypothesis that game mechanics primarily influence psychological processes of engagement and self-regulation, which subsequently translate into academic performance improvements.

The findings indicate that the effectiveness of gamification depends not merely on the introduction of game elements but on their meaningful integration into pedagogical design. Combined mechanics and narrative structures demonstrated greater educational potential than isolated external reward systems.

Moderator analyses also revealed that educational context plays an important role, with stronger effects observed in online learning environments.

Additional checks for publication bias and sensitivity analyses confirmed the robustness of the results, reinforcing the reliability of the conclusions.

Overall, gamification represents a scientifically grounded and effective approach to improving the quality of the educational process. However, its successful implementation requires theoretically informed design, empirical validation, and adaptation to specific educational contexts.

Future research should focus on long-term effects, personalized gamification systems, and the integration of adaptive technologies, which may further expand the theoretical and practical potential of gamified learning environments.

REFERENCES

[1] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining gamification," in Proceedings of the 15th International Academic MindTrek Conference, 2011, pp. 9-15.

[2] J. Hamari, J. Koivisto, and H. Sarsa, "Does gamification work? A literature review of empirical studies on gamification," in 47th Hawaii International Conference on System Sciences (HICSS), 2014, pp. 3025-3034.

[3] R. N. Landers, "Developing a theory of gamified learning," Simulation & Gaming, vol. 45, no. 6, pp. 752-768, 2014.

[4] J. Hamari and J. Koivisto, "Why do people use gamification services?," International Journal of Information Management, vol. 35, no. 4, pp. 419-431, 2015.

[5] M. J. Page, J. E. McKenzie, P. M. Bossuyt, and et al., "The PRISMA 2020 statement," BMJ, vol. 372, p. n71, 2021.

[6] K. Seaborn and D. I. Fels, "Gamification in theory and action: A survey," International Journal of Human-Computer Studies, vol. 74, pp. 14-31, 2015.

[7] R. DerSimonian and N. Laird, "Meta-analysis in clinical trials," Controlled Clinical Trials, vol. 7, no. 3, pp. 177-188, 1986.

[8] M. Sailer, J. Hense, S. Mayr, and H. Mandl, “How gamification motivates: An experimental study,” Computers in Human Behavior, vol. 69, pp. 371-380, 2017.

[9] P. Wouters, C. van Nimwegen, H. van Oostendorp, and E. van der Spek, “A meta-analysis of serious games for learning,” Journal of Educational Psychology, vol. 105, no. 2, pp. 249-265, 2013.

[10] E. L. Deci and R. M. Ryan, “Self-determination theory: A macrotheory of human motivation,” Canadian Psychology, vol. 49, no. 3, pp. 182-185, 2008.

[11] J. Koivisto and J. Hamari, “The rise of motivational information systems,” International Journal of Information Management, vol. 45, pp. 191-210, 2019.

[12] M. Csikszentmihalyi, Flow: The Psychology of Optimal Experience, New York: Harper & Row, 1990.

[13] E. Boyle, T. Hainey, T. Connolly, and et al., “An update to the systematic literature review of games-based learning,” Computers & Education, vol. 94, pp. 178-192, 2016.

[14] B. F. Skinner, Science and Human Behavior, New York: Macmillan, 1953.

[15] J. P. T. Higgins, J. Thomas, J. Chandler, and et al., Cochrane Handbook for Systematic Reviews of Interventions, 2nd ed., Wiley, 2019.

[16] E. D. Mekler, F. Brühlmann, K. Opwis, and A. N. Tuch, “Do points, levels and leaderboards harm intrinsic motivation?,” in Proceedings of the CHI Conference on Human Factors in Computing Systems, 2017, pp. 2985-2995.

[17] P. Buckley and E. Doyle, “Gamification and student motivation,” Interactive Learning Environments, vol. 24, no. 6, pp. 1162-1175, 2016.

[18] E. Locke and G. Latham, “A Theory Goal Setting and Task Performance,” Academy of Management Review, vol. 16, no. 2, 1991, doi:10.2307/258875.

[19] R. M. Ryan and E. L. Deci, “Intrinsic and extrinsic motivations,” Contemporary Educational Psychology, vol. 25, no. 1, pp. 54-67, 2000.

[20] D. Clark, E. Tanner-Smith, and S. Killingsworth, “Digital games, design, and learning,” Review of Educational Research, vol. 86, no. 1, pp. 79-122, 2016.

[21] L. de-Marcos, E. García-López, and A. García-Cabot, “On the effectiveness of gamification in learning,” Computers & Education, vol. 95, pp. 99-113, 2016.

[22] J. Sweller, P. Ayres, and S. Kalyuga, Cognitive Load Theory, Springer, 2011.

[23] M. Borenstein, L. Hedges, J. Higgins, and H. Rothstein, Introduction to Meta-Analysis, Wiley, 2009.

[24] M. Egger, G. Davey Smith, M. Schneider, and C. Minder, “Bias in meta-analysis detected by a simple test,” BMJ, vol. 315, pp. 629-634, 1997.

[25] J. Cohen, Statistical Power Analysis for the Behavioral Sciences, 2nd ed., Routledge, 1988.

[26] C. Dichev and D. Dicheva, “Gamifying education: What is known,” International Journal of Educational Technology in Higher Education, vol. 14, Art. no. 9, 2017.

[27] M. Sailer and L. Homner, “The gamification of learning: A meta-analysis,” Educational Psychology Review, vol. 32, pp. 77-112, 2020.

[28] C. Su and C. Cheng, “A mobile gamification learning system,” Computers & Education, vol. 85, pp. 268-286, 2015.

[29] A. Domínguez, J. Saenz-de-Navarrete, L. de-Marcos, L. Fernández-Sanz, C. Pagés, and J. Martínez-Herráiz, “Gamifying learning experiences,” Computers & Education, vol. 63, pp. 380-392, 2013.

[30] M. D. Hanus and J. Fox, “Assessing the effects of gamification in the classroom,” Computers & Education, vol. 80, pp. 152-161, 2015.

[31] J. P. T. Higgins, S. G. Thompson, J. J. Deeks, and D. G. Altman, “Measuring inconsistency in meta-analyses,” BMJ, vol. 327, pp. 557-560, 2003.

[32] A. M. Toda, P. H. Valle, and S. Isotani, “The dark side of gamification,” Communications in Computer and Information Science, vol. 715, pp. 143-156, 2017.

[33] J. A. C. Sterne, M. Egger, and D. Moher, “Addressing reporting biases,” in Cochrane Handbook for Systematic Reviews of Interventions, 2019.

[34] J. Hattie, Visible Learning: A Synthesis of Over 800 Meta-Analyses, Routledge, 2009.

[35] L. A. Schindler, G. J. Burkholder, O. A. Morad, and C. Marsh, “Computer-based technology and student engagement,” International Journal of Educational Technology in Higher Education, vol. 14, Art. no. 25, 2017.

[36] R. N. Naseri, R. N. Abdullah, and M. M. Esa, “The effects of gamification on student learning,” International Journal of Academic Research in Progressive Education and Development, vol. 12, no. 1, 2023, [Online]. Available: https://doi.org/10.6007/IJARPED/v12-i1/16253.

[37] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, “Systematic review of research on artificial intelligence applications in higher education,” International Journal of Educational Technology in Higher Education, vol. 16, Art. no. 39, 2019, [Online]. Available: https://doi.org/10.1186/s41239-019-0171-0.

[38] A. Mannonov and et al., “The impact of Uzbek-language mobile libraries on digital education,” Indian Journal of Information Sources and Services, vol. 15, no. 1, pp. 315-319, 2025.