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Review Article

Meta-Analysis on Investigating and Comparing the Effects on Learning Achievement and Motivation for Gamification and Game-Based Learning

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This meta-analysis aimed to investigate and compare the efficiencies of gamification and game-based learning in terms of learning achievement and motivation. With distinctive features, gamification and game-based learning were hypothesized to exert different effects on learning achievement and motivation. The effects on learning achievement were more stable and significant for game-based learning (ES = 0.54, 95% CI [0.38, 0.70]) than for gamification (ES = 0.85, 95% CI [0.32, 1.37]). The overall effects on motivation were more significant for gamification (ES = 0.77, 95% CI [0.53, 1.01]) than for game-based learning (ES = 0.60, 95% CI [0.42, 0.78]). Gamification exerted less significant but more stable effects on intrinsic motivation (ES = 0.64, 95% CI [0.37, 0.91]) than on extrinsic motivation (ES = 0.92, 95% CI [0.50, 1.34]). Game-based learning exerted less significant but more stable effects on extrinsic motivation (ES = 0.56, 95% CI [0.35, 0.77]) than on intrinsic motivation (ES = 0.62, 95% CI [0.12, 1.13]). The main conclusion was that gamification and game-based learning, as two distinct game-related pedagogies, differently influenced learning achievement, intrinsic motivation, and extrinsic motivation. The dependence on immersion subject to external or internal factors and ludic contexts associated with internalization of motivation influenced the effect stability on learning achievement and motivation.

1. Introduction

Technological and educational development contributed to upgrading approaches to implementing games in pedagogical practices. Game refers to a rule-based system involving variable and quantifiable outcomes [1]. While experiencing the game where the consequences are optional and flexible, the participants exert efforts to influence the outcomes assigned corresponding values [1]. In the aspect of education, instructors could use digital games created not with the primary purpose of pure entertainment to reinforce learning and improve training [2]. Defined by rules, games refer to the systems that encourage players to engage in an artificial conflict for quantifiable outcomes [3]. Educators could employ pedagogies involving games or game-related elements, that is, game-related pedagogies, for effective instruction on organization, learners' psychological and behavioral changes, and learning outcomes [4]. Various researchers investigated the implementations of game-related pedagogies, for example, the digital game-based learning (DGBL) model [5, 6], teaching games for understanding (TGfU) [7], game-based flipped learning [8–12], and serious educational games (SEG) model [13].

As game-related pedagogies gained much popularity, the efficiency of game-related pedagogies contributing to promising instructional contexts tended to be hypothesized [4, 14]. Besides, gamification and game-based learning are different game-related concepts with distinctive characteristics [14, 15], so we would assume different efficiencies for these game-related pedagogies (Section 2.1 described the differences between these two game-related pedagogies). Thus, this study aimed to test the hypothesized efficiency of game-related pedagogies by comparing the efficiencies of gamification and game-based learning.

We chose learning achievement and motivation as the dimensions to examine the efficiencies of game-related pedagogies. Learning achievement is an explicit criterion for evaluating the efficiency of particular pedagogies [4]. Besides, since game-related pedagogies also emphasize learners' psychological changes by cultivating their motivation [4, 14], motivation is another criterion to evaluate the efficiency of game-related pedagogies. Notably, motivation was classified into intrinsic motivation and extrinsic motivation [17] (Section 2.2 discussed the contrast relation between intrinsic and extrinsic motivations and the differences between them). Thus, we further investigated the efficiencies of game-related pedagogies in terms of intrinsic motivation and extrinsic motivation.

The potential implication of this study is the reflections on the differences between gamification and game-based learning in terms of the actual efficiencies of game-related pedagogies through meta-analytical techniques. Even if game implementation is an innovative approach in pedagogical practices [4, 14], educators should differentiate between gamification and game-based learning, consider potential consequences or influences, and choose the pedagogy based on practical needs. Educators could also accordingly refine the game-related pedagogies to maximize efficiency.

This study was arranged as follows. The literature review section discussed the key concepts of this study: differences between gamification and game-based learning (2.1) and the differences between intrinsic and extrinsic motivation (2.2), based on which we raised the research hypotheses. The methodology section described the process of collecting the eligible studies for this meta-analysis (3.1) and the statistical approaches based on the research materials (3.2-3.3). The result section (4.1–4.4) reported the findings from the meta-analyses to test the hypotheses. The discussion section (5) explained and evaluated the results of the current meta-analysis. The conclusion section summarized the findings (6.1) and presented insights for future research based on the limitations of this study (6.2).

2. Literature Review

This section provided the theoretical background for the hypotheses of this meta-analysis.

2.1. Gamification and Game-Based Learning: Two Different Game-Related Pedagogies. Gamification and game-based learning are distinctive game-related pedagogies. We began the process of differentiating these pedagogies by characterizing games. The game studies defined and characterized games based on various conditions [18].

Huotari and Hamari [18] summarized the three-level core conditions of games. At the first level of abstraction reflecting the essential elements of games, system centrally features games; at least one participant should be actively involved in the games [1, 3, 18–21]. The second level of abstraction reflected the features that were significant but not necessarily present in all cases. Rules, conflicting goals, and variable outcomes were the important characteristics of games; entertaining experiences, participants' processes of valuing the outcomes, and the mental state based on the balance between challenge and competence are the important elements in the experiential conditions [1, 3, 18–21]. Notably, at the third level of abstraction reflecting the features unique to games, the term "gamefulness," that is, the feature of being rule-based and goal-oriented [23], demonstrated the condition where participants could recognize a game [18].

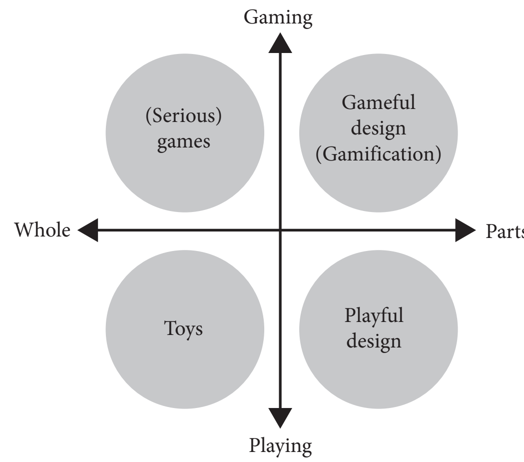

Figure 1: The dimensions of "whole versus parts" and "gaming versus playing" to distinguish game-related concepts based on Reference [22].

The abstractions of game features demonstrated that "gamefulness" was the unique feature of game. Since gamification and game-based learning are game-related pedagogies, both of them highlight rule-based mechanics that encourage participants to achieve goals in the immersive experiences. "Gamefulness" is consistent with "gaming" in the bidimensional framework proposed by Deterding et al. [23] to distinguish game-related concepts (see Figure 1). Different from "gaming," which emphasizes specific rules or goals during the playful experiences, "playing" emphasizes non-goal-oriented behaviors or activities [23]. Notably, the dimension "part versus whole" indicates the completeness of the game elements in the corresponding game-related products [23, 24]. "Part" means that the target game-related product involves separable game elements rather than a necessarily complete game, while "whole" means that the target game-related product involves complete existence of game with system, mechanism, and outcomes [23, 24]. The dimension "part versus whole" suggested that gamification required the process of gamifying the contexts with separable game elements and that serious games necessitated the complete existence of games. These distinctions provided the premise of differentiating gamification and game-based learning.

The term "gamification" was more widely utilized in the industrial area in 2010 [23]. Deterding et al. [23] defined gamification as the use of game elements in originally nongame contexts, reflecting the experiential aspects of games [18]. At the academic and practical levels, Werbach [25] defined gamification as the process of making the target activities more game-like. In the etymological aspect, the term "gamification" contains the Latin word "facere," suggesting the action of "making the game" [26]. Gamification aims to engage learners, enhance learning, and solve problems [4, 23, 27–33]. Gamifying contexts does not necessarily require complete games [23, 24], but it requires the immersive experiences created by the game elements [4]. Rule- and goal-oriented designs in gamification encourage participants to complete tasks, surpass others, and make progress by facilitating or constraining specific behaviors [23, 24, 34].

By contrast, game-based learning, as the pedagogical term, refers to the application of complete game(s) to facilitate learning rather than for entertainment purposes [35]. In educational contexts, game-based learning is the pedagogy based on serious games that are inseparable and complete systems consistent with educational or pedagogical purposes [23, 24]. Serious games aim to create immersive ludic experiences to enhance awareness, understanding, and mastery of specific concepts or skills [34]. Notably, although both gamification and serious game aim to engage participants, gamification usually engages participants in a relatively incorporated manner, while serious game usually provides implicit immersion in a relatively holistic manner [34].

Overall, the distinction between gamification and game-based learning lies in the separability of game elements in the game-related products [16]. Gamification involves separable gamifying game elements and does not necessarily require complete forms of games, while game-based learning involves complete serious game(s) for educational purposes [34]. Gamification can exist without complete games, whereas game-related learning should be implemented based on the inseparably systematic game [16]. As for the typical quantitative dimensions to assess the efficiencies of these pedagogies, learning achievement and motivation were the choices reflecting participants' academic progress and psychological changes based on the corresponding pedagogies. Since gamification and game-based learning were distinct game-related pedagogies, we assumed that gamification and game-based learning presented different efficiencies in terms of learning achievement and motivation. Thus, we raised the following hypotheses.

H1: gamification and game-based learning exert different effects on learning achievement.

H2: gamification and game-based learning exert different effects on motivation.

2.2. Gamification and Game-Based Learning in Terms of Intrinsic and Extrinsic Motivations. Intrinsic and extrinsic motivations were the specific domains to present the efficiencies of game-related pedagogies in terms of motivation. Intrinsic and extrinsic motivations elicit individuals' different preferences in performing learning behaviors, choosing learning strategies, and showing persistence in learning processes [17, 36, 37].

Intrinsic motivation is a need based on which individuals achieve voluntary engagement in particular activities for their own sakes [38]. Intrinsically motivated individuals do not necessarily achieve satisfaction associated with the rewards or derivatives [37]. By contrast, extrinsic motivation is a need based on which individuals perform particular behaviors to gain separable consequences or rewards [40].

Intrinsically and extrinsically motivated learning behaviors are the factors distinguishing intrinsic and extrinsic motivations, respectively. Individuals perform intrinsically motivated behaviors for their inherent interest and enjoyment, while individuals perform extrinsically motivated behaviors for separable outcomes from the learning processes [38]. Besides, the goal that individuals emphasize during learning is another factor differentiating intrinsic and extrinsic motivations. Intrinsic goals include growth, relationship, and community, for example, community contribution, health, personal growth, or affiliation, while extrinsic goals include wealth, fame, and image [37], for example, interpersonal comparisons [41], approval [42], or external signs of self-worth [43]. Intrinsic goals satisfy individuals' voluntary needs for learning [17], while extrinsic goals provide reasons or motives for learning based on individuals' perceptions of worth. Notably, excessive dependence on extrinsic goals leads to less optimal learning conditions [44].

The distinction between intrinsic and extrinsic goals could reflect different degrees of learning achievement and persistence in learning activities [37]. Experimental studies revealed that intrinsic goals enhanced deeper processing of learning materials, greater conceptual understanding of the materials, and more stable short-term or long-term persistence in learning tasks [37]. Thus, intrinsic motivation is associated with learning achievement. Since we assumed that gamification and game-related learning, as distinct pedagogies, would exert different effects on learning achievement (H1), we assumed that the effects on intrinsic motivation would be different between gamification and game-based learning, as the following hypothesis presented.

H3: gamification and game-based learning exert different effects on intrinsic motivation.

Furthermore, external stimuli, that is, goals, rules, and interactions, feature game and game-related elements [4]. Goals present players' desired outcomes, such as rewards or positions from playful experiences [4]. Rules emphasize mechanisms for playing games [4], associated with autonomy conducive to internalization of the rules [17]. Interactions are reciprocal actions, including competition, conflict, challenge, feedback, control, feelings, event perceptions, and game results [4, 45]. Since gamification and game-based learning, as game-related pedagogies, involve external stimuli as the distinctive features, we assumed that the effects of these game-related pedagogies would be more significant on extrinsic motivation than on intrinsic motivation, as the following hypothesis presented.

Table 1: Descriptions of the studies involved in this meta-analysis.

No	Authors and publication years	Game-related pedagogical models	Game-related pedagogies	Research domains
1	[27]	Leverage learning with gamification	Gamification	Learning achievement
2	[48]	Machine learning inspired approach	Gamification	Learning achievement
3	[49]	Integration of board games and augmented reality (AR)	Gamification	Intrinsic motivation Extrinsic motivation
4	[13]	Serious educational games (SEG)	Gamification	Learning achievement
5	[30]	Virtual reality (VR): a virtual ecological environment	Game-based learning	Learning achievement
6	[32]	Open and flexible blended learning environments	Game-based learning	Learning achievement
7	[28]	Multigenre digital game-based instruction (MGI)	Game-based learning	Learning achievement
8	[29]	Physical games stimulating acquisition	Game-based learning	Learning achievement
9	[50]	Multiteam participatory simulated game (MPSG)	Game-based learning	Learning achievement Intrinsic motivation Extrinsic motivation
10	[12]	Gamification as a complement to flipped learning	Gamification	Learning achievement Intrinsic motivation Extrinsic motivation
11	[9]	Student-generated questioning (SGQ) with game-based flipped learning	Gamification	Learning achievement Intrinsic motivation
12	[8]	Problem-based mathematics teaching	Gamification	Learning achievement
13	[6]	Digital game-based learning (DGBL) based on inquiry, communication, mystery, decision making, challenge, and rewards (ICMDCR)	Game-based learning	Learning achievement Extrinsic motivation
14	[51]	Digital game-based information and communication technologies	Game-based learning	Intrinsic motivation Extrinsic motivation
15	[31]	Teaching personal and responsibility (TPSR) and sport education model (SEM)	Game-based learning	Learning achievement Extrinsic motivation
16	[10]	Game-based flipped learning	Game-based learning	Intrinsic motivation
17	[10]	Gamified flipped classroom approach	Gamification	Intrinsic motivation Extrinsic motivation

Table 1: Continued.

No	Authors and publication years	Game-related pedagogical models	Game-related pedagogies	Research domains
18	[15]	Game-based learning based on activity theory (AT) and MAKE (motivation, attitude, knowledge, and engagement) framework. Gamification based on activity theory (AT) and MAKE framework	Game-based learning Gamification	Intrinsic motivation Extrinsic motivation Intrinsic motivation Extrinsic motivation
19	[52]	Gamification supported flipped classroom	Gamification	Extrinsic motivation
20	[7]	Teaching games for understanding (TGfU)	Game-based learning	Learning achievement Intrinsic motivation
21	[53]	Problem-based and game-based learning	Game-based learning	Learning achievement Extrinsic motivation
22	[5]	3D cardiac catheterization game-based learning system (3D-CCGBLS)	Game-based learning	Learning achievement Extrinsic motivation
23	[55]	Team-based competitive environment	Game-based learning	Learning achievement
24	[5]	Digital game-based learning (DGBL) based on self-efficacy, motivation, anxiety, and achievements	Game-based learning	Learning achievement Extrinsic motivation
25	[56]	Pedagogically driven serious game	Game-based learning	Learning achievement
26	[57]	Peer assessment-based game development approach	Game-based learning	Learning achievement Extrinsic motivation
27	[58]	Context-aware ubiquitous learning environment called the handheld English language learning organization (HELLO)	Game-based learning	Learning achievement Intrinsic motivation

H4: both gamification and game-based learning exert more positive effects on extrinsic motivation than on intrinsic motivation.

After raising the research hypotheses, we searched the research materials compatible with the meta-analytic techniques.

3. Methodology

This section concentrates on the research methods and research materials.

3.1. The Collection of the Data. We collected the data based on the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [46] and the methodology from Seaborn and Fel [47] and Sailer and Homner [14]. The collection of articles involved identification, screening, and inclusion.

In the identification step, we roughly sought the articles through keywords. We searched ERIC, IEEE Xplore, PubMed, SpringerLink, and Web of Science for the potentially eligible studies. The publication time for the studies ranged from 2010 to 2021. The research string was [gamifi∗ OR gamification OR game-based learning AND education]. The initial dataset included 8072 records at this stage.

In the screening step, we further selected the potentially relevant studies based on the inclusion and exclusion criteria. The included studies should (1) be published in English; (2) involved participants' achievement or test results as the dependent variable; (3) explicitly described the domain(s) of the achievement or test to quantitatively measure the efficiency of game-related pedagogies; (4) explicitly described to which type the target game-related pedagogies belong (gamification or game-based learning); and (5) explicitly described the grades of the participants. Meanwhile, we also excluded the studies not consistent with the criteria for further screening. The excluded studies would (1) not mainly investigate or discuss the use of game-related pedagogies in the experimental procedure(s); (2) not explicitly demonstrate the quantitative domain(s) of the achievement or test results; and (3) not contain data collection for quantitative measurements. After this step, we gained 1044 and 455 records on the learning achievement and motivation influenced by the game-related pedagogies, respectively.

In the inclusion step, we searched for the studies compatible with the meta-analytic procedures. The included studies should (1) compare the quantified effects for the experimental group(s) employing the game-related elements or designs and control group(s) and (2) explicitly report sufficient statistical findings, that is, the numbers of participants, mean effects, and standard deviations. Even if some studies were compatible with the criteria for screening, those studies were still excluded if they (1) did not involve the comparison(s) of the quantified results for the experimental and control groups and (2) insufficiently reported the number of participants, average values of domain effects, and standard deviations. After this step, we finally gained 27 eligible studies for this meta-analysis (see Table 1).

3.2. The Organization of the Data. The eligible studies involved three domains to present the efficiencies of game-related pedagogies: learning achievement, intrinsic motivation, and extrinsic motivation. Thus, we collected and organized the data from the eligible studies into four datasets, that is, "Data about effects on learning achievement," "Data about effects on motivation," "Data about effects on intrinsic motivation," and "Data about effects on extrinsic motivation" to perform this meta-analysis. The data for the current meta-analysis were updated and reorganized based on the study of Zhang, L. Yu, and Z. Yu, 2021, performed by the same first author.

As for the criteria to identify the motivation domains, we coded the domains according to the characteristics of intrinsic and extrinsic motivation. Since intrinsic motivation emphasizes that voluntary will to participate in corresponding activities for growth and relationship [37, 38], the motivation domains reflecting voluntary aspects were coded as intrinsic motivation. By contrast, since extrinsic motivation is associated with participants' satisfaction from the external approvals or rewards, for example, wealth, fame, and image [37], the motivation domains associated with the external stimuli to reinforce specific behaviors or encourage progress were coded as extrinsic motivation.

Admittedly, some studies, that is, [5–7, 9, 10, 15, 49, 50, 53, 57], Liu and Chu [12, 31, 51, 54, 58], simultaneously reported multiple effect sizes that demonstrated the same research domain(s), that is, learning achievement, intrinsic motivation, or extrinsic motivation. For conciseness of the data, we combined some data investigating the same research domains, that is, learning achievement, intrinsic motivation, and extrinsic motivation by using the platform "StatTools: Combine Means and SDs Into One Group Program" (https://www.obg.cuhk.edu.hk/ResearchSupport/StatTools/CombineMeansSDs_Pgm.php) [69 (StatTools: Combine Means and SDs Into One Group Program, 1995)] developed by the Chinese University of Hong Kong. After combining the figure groups that assessed the same domains, we gained 21 figure groups on learning achievement (see the supplementary material "Data about effects on learning achievement"), 11 figure groups on intrinsic motivation (see the supplementary material "Data about effects on intrinsic motivation"), and 14 figure groups on extrinsic motivation (see the supplementary material "Data about effects on extrinsic motivation").

3.3. Statistical Approaches. We employed STATA 15 as the platform for this meta-analysis involving pooling model analyses and subgroup analyses [61]. The selection of a pooling model was based on whether we expected that the involved studies shared a common effect size and the goals in performing the analysis [61]. Random-effects model is generally a more plausible choice if the studies are from the published literature [61]. Since the involved studies that were operated independently did not necessarily have functionally equivalent interventions, we would assume that these studies did not have a common effect size [61]. Since this study aimed to investigate and generalize the efficiency of gamification and game-based learning in terms of learning achievement and motivation, the random-effects model was more suitable than the fixed-effects model [61]. Thus, we chose the random-effects model to perform this meta-analysis.

The scale of measurement would differ among studies because the studies involved in this study employed different instruments to assess the outcomes [61]. In this case, the standardized mean difference that was comparable across studies was the choice to describe the effects in statistical analyses [61]. Additionally, since the involved studies that were compatible with meta-analytic techniques reported findings based on the comparisons between the experimental and the control groups, the standardized mean difference would reflect the difference between the two research groups. Thus, we chose Cohen's d as the effect size for investigating the significantly different mean pairs [61, 62]. Notably, under the random-effects model, the summary effect represented by the diamond in the forest plot is the estimate criterion of the mean of the distribution of effect sizes [61].

Then, we designed the specific approaches to testing the hypotheses. To test H1, we compared the effects on learning for the gamification and game-based learning subgroups based on "Data about effects on learning achievement." To test H2, we compared the overall effects on motivation for the gamification and game-based learning subgroups based on "Data about effects on motivation." To test H3, we compared the effects on intrinsic motivation for the gamification and game-based learning subgroups based on "Data about effects on intrinsic motivation." To test H4, we compared the effects of game-related pedagogies on intrinsic

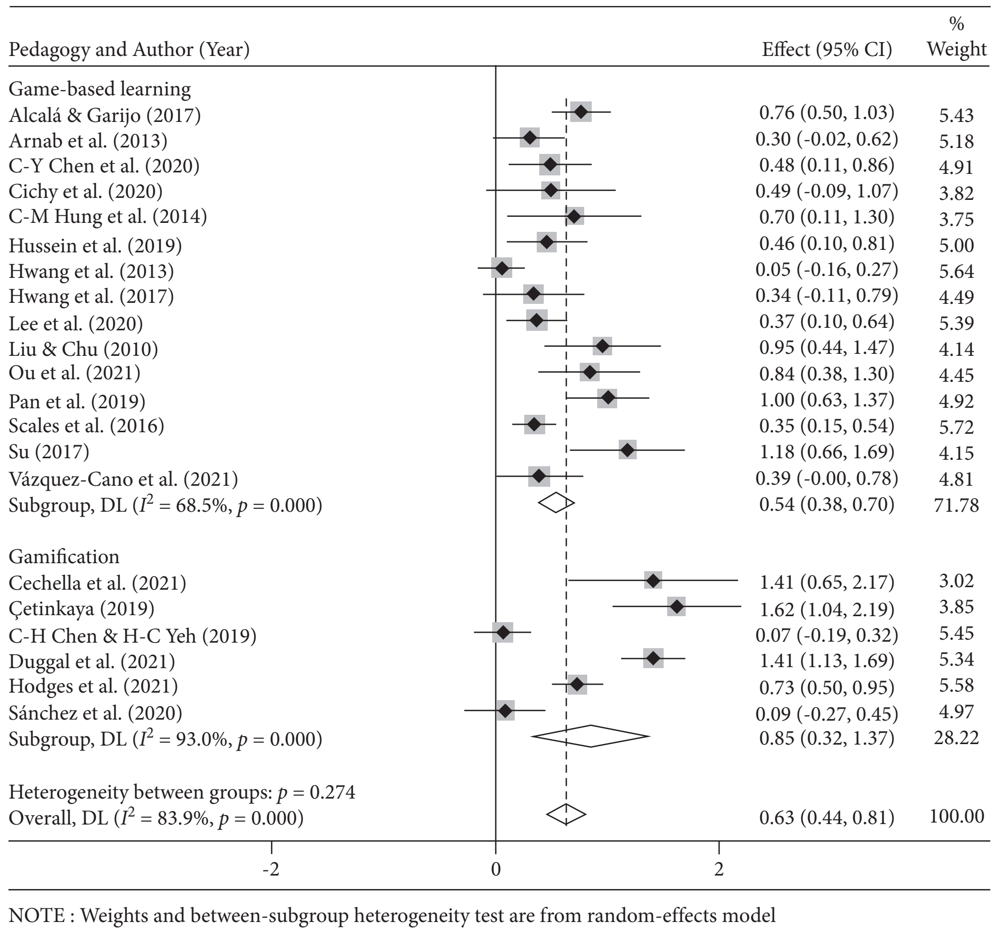

Figure 2: The forest plot presenting the effect sizes on learning achievement for gamification and game-based learning.

motivation and on extrinsic motivation based on "Data about effects on intrinsic motivation" and "Data about effects on extrinsic motivation."

At the end of each analysis, we conducted the sensitivity analysis and publication bias analysis to investigate whether the results were comprehensive and persuasive. The sensitivity analysis demonstrates how robust the findings are [61] and how results might change if particular studies were omitted [61]. The funnel plot is the mechanism displaying the relation between study size and effect size and identifying whether the involved studies are a biased sample [61].

4. Results

This section reported the research results to test the aforementioned hypotheses.

4.1. Do Gamification and Game-Based Learning Exert Different Effects on Learning Achievement? The forest plot (see Figure 2) demonstrated that game-related pedagogies exerted overall positive effects on learning achievement. The diamond near the bottom presents the summary effect of the overall effects of game-related pedagogies on learning achievement [61]. The central location of the diamond stands for the effect size, and the width of the diamond represents the precision of the estimate [61]. The diamond was centered at 0.63, reflecting effect size (ES) = 0.63, and extended from 0.44 to 0.81, reflecting the 95% confidence interval (95% CI) of [0.44, 0.81].

Notably, some studies may report multiple groups of effect sizes, so we aggregated the homogeneous figure groups, that is, the figure groups examining the efficiencies of the same game-related pedagogies (gamification or game-based learning) AND the same publication time (year) AND the presented the same research domain (learning achievement). For the dataset "Data about effects on motivation," we aggregated the homogeneous figure groups using the platform "StatTools: Combine Means and SDs Into One Group Program" (https://www.obg.cuhk.edu.hk/ResearchSupport/StatTools/CombineMeansSDs_Pgm.php) developed by the Chinese University of Hong Kong [69 (StatTools: Combine Means and SDs Into One Group Program, 1995)].

As for the subgroup analyses, both gamification and game-based learning subgroups presented positive effects on learning achievement (see Table 2 and Figure 2). The diamond for the gamification subgroup was centered at 0.85 (ES = 0.85) and extended from 0.32 to 1.37 (95% CI [0.32, 1.37]). The diamond for the game-based learning subgroup

Table 2: A summary of the effects of game-related pedagogies on learning achievement, intrinsic motivation, and extrinsic motivation.

Dataset with subgroups		Effect size (ES)	95% confidence interval (95% CI)	Significance level of Egger's test
Data about effects on learning achievement	Gamification subgroup	0.85	[0.32, 1.37]	0.059
	Game-based learning subgroup	0.54	[0.38, 0.70]	
Data about effects on motivation	Gamification subgroup	0.77	[0.53, 1.01]	0.815
	Game-based learning subgroup	0.60	[0.42, 0.78]	
Data about effects on intrinsic motivation	Gamification subgroup	0.64	[0.37, 0.91]	0.556
	Game-based learning subgroup	0.65	[0.32, 0.99]	
Data about effects on extrinsic motivation	Gamification subgroup	0.92	[0.50, 1.34]	0.154
	Game-based learning subgroup	0.56	[0.12, 1.13]	

was centered at 0.54 (ES = 0.54) and extended from 0.38 to 0.70 (95% CI [0.38, 0.70]). Thus, the standardized mean difference for the gamification subgroup was 0.85 with a 95% confidence interval of 0.32 to 1.37, while the standardized mean difference for the game-based learning subgroup was 0.54 with a 95% confidence interval of 0.38 to 0.70. The distribution of the individual study effect sizes was wider for the gamification subgroup than for the game-based learning subgroup, and game-based learning exerted more stable and significant effects on learning achievement.

The effect size >0.8 of 0.85 reflected the large and perceptible differences in the effects of gamification on learning achievement [62]. By contrast, the effect size of 0.54 between the medium (0.5) and the large (0.8) sizes reflected the visible differences in the effects of game-based learning on learning achievement [62]. According to these findings, gamification and game-based learning exerted visibly positive effects on learning achievement, and game-based learning exerted more significant effects on learning achievement than gamification.

The funnel plot and Egger's test investigated the potential publication bias and the potential nonsignificant or significant studies in the dataset. Egger's test indicated the significance level >0.05 of 0.059, suggesting no obvious publication bias (see Table 2). According to the funnel plot (see Figure 3), most studies were distributed symmetrically about the mean difference in the effects on learning achievement. Three dots outside the left part of the funnel represented the relatively nonsignificant data groups, while five dots outside the right part of the funnel represented the relatively significant data groups [61].

The sensitivity analysis demonstrated the potential nonsignificant and significant studies that would relatively remarkably change the research results. According to the sensitivity analysis (see Figure 4), the findings of effect sizes significantly decreased if the studies of Çetinkaya [8]; Duggal et al. [48]; and Su [54] were omitted. These significant studies contributed the most to the positive effects on learning achievement [61]. By contrast, the findings of effect sizes significantly increased if the studies of Arnab et al. [56]; Chen and Yeh [9]; Hwang et al. [57]; Pozo Sánchez et al. [12]; and Scales et al. [55] were omitted. These nonsignificant

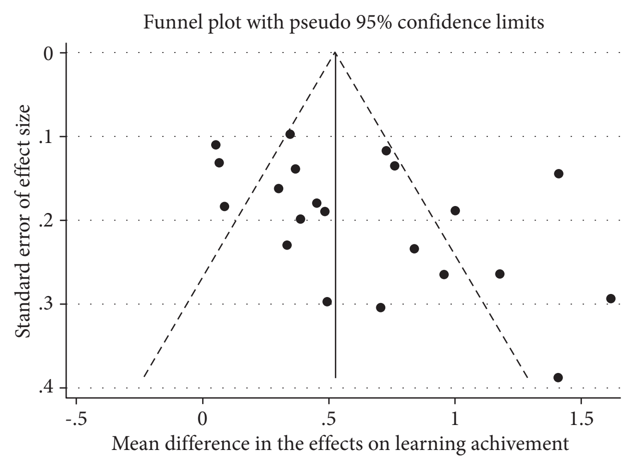

Figure 3: The funnel plot presenting the distribution of effects on learning achievement.

studies contributed the most limiting power to the effects on learning achievement [61].

Based on these findings, we concluded that game-based learning exerted more stable and significant effects on learning achievement than gamification, even if both gamification and game-based learning positively impacted learning achievement. Thus, we remained H1 that gamification and game-based learning would exert different effects on learning achievement.

4.2. Do Gamification and Game-Based Learning Exert Different Effects on Motivation? The diamond near the bottom of the forest plot (see Figure 5) presented the summary effect of the overall effects of game-related pedagogies on motivation [61]. The diamond was centered at 0.67 (ES = 0.67) and extended from 0.53 to 0.81 (95% CI [0.53, 0.81]).

Notably, some studies may report multiple groups of effect sizes, so we aggregated the homogeneous figure groups, that is, the figure groups examining the efficiencies of the same game-related pedagogies (gamification or game-based learning) AND the same publication time (year) AND the presented the same research domains (intrinsic motivation or extrinsic motivation). We aggregated the

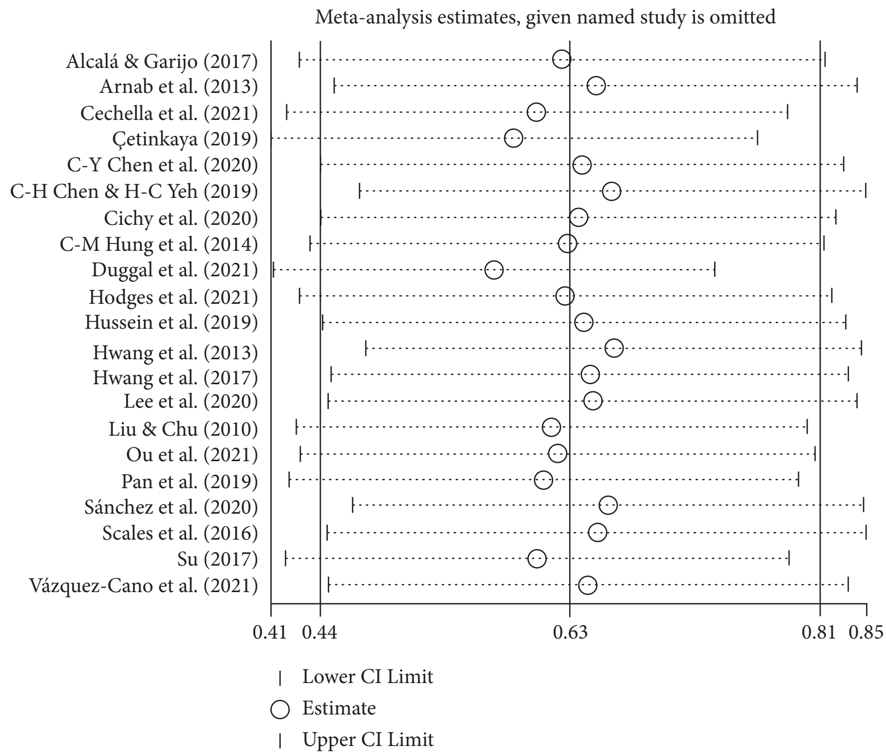

Figure 4: The sensitivity analysis examining the robustness of the results on learning achievement.

homogeneous figure groups using the platform "StatTools: Combine Means and SDs Into One Group Program" (https://www.obg.cuhk.edu.hk/ResearchSupport/StatTools/CombineMeansSDs_Pgm.php) developed by the Chinese University of Hong Kong [69 (StatTools: Combine Means and SDs Into One Group Program, 1995)]. For the dataset "Data about effects on motivation," we aggregated most studies, but we still remained multiple figure groups that presented heterogeneous contents from some studies. The study of Haruna et al. [15] examined two different pedagogical models each of which was investigated in terms of intrinsic motivation and extrinsic motivation (see Table 1). The studies of Hung [11]; Lin et al. [49]; and Pozo Sánchez et al. [12] examined the efficiency of gamification in terms of intrinsic motivation and extrinsic motivation (see Table 1). The studies of Lee et al. [50] and Magen-Nagar et al. [51] investigated the efficiency of game-based learning in terms of intrinsic motivation and extrinsic motivation (see Table 1).

Considering the subgroup analyses, both gamification and game-based learning subgroups presented positive effects on motivation (see Table 2 and Figure 5). The diamond for the gamification subgroup was centered at 0.77 (ES = 0.77) and extended from 0.53 to 1.01 (95% CI [0.53, 1.01]). The diamond for the game-based learning subgroup was centered at 0.60 (ES = 0.60) and extended from 0.42 to 0.78 (95% CI [0.42, 0.78]). The effect sizes between the medium (0.5) and the large (0.8) sizes indicated the visible differences between the experimental and control groups in motivation [62]. The distribution of the individual study effect sizes was similar for the gamification subgroup and for the game-based learning subgroup. Since the gamification subgroup showed a higher effect size (0.77) than the game-based learning (0.60), gamification exerted more significant effects on motivation than game-based learning.

Egger's test indicated the significance level >0.05 of 0.815, suggesting no obvious publication bias (see Table 2). According to the funnel plot (see Figure 6), six dots outside the left part of the funnel represented the relatively non-significant data groups, while four dots outside the right part of the funnel represented the relatively significant data groups [61].

According to the sensitivity analysis (see Figure 7), the findings of effect sizes significantly decreased if the studies of Hortigüela Alcalá and Hernando Garijo [7], Liu and Chu [58], Ã-zer et al. [52], and three data groups from Haruna et al. [15] were omitted. These significant studies contributed the most to the positive effects on motivation [61]. By contrast, the findings of effect sizes on significantly increased if the studies of Pan et al. [31], Sánchez et al. [26], and Lee et al. [50] were omitted. These nonsignificant studies contributed the most limiting power to the effects on motivation [61].

Based on these findings, we concluded that gamification exerted more significant effects on motivation than game-based learning, even if both gamification and game-based learning exerted similarly stable and positive effects on motivation. Thus, we remained H2 that gamification and game-based learning would exert different effects on motivation.

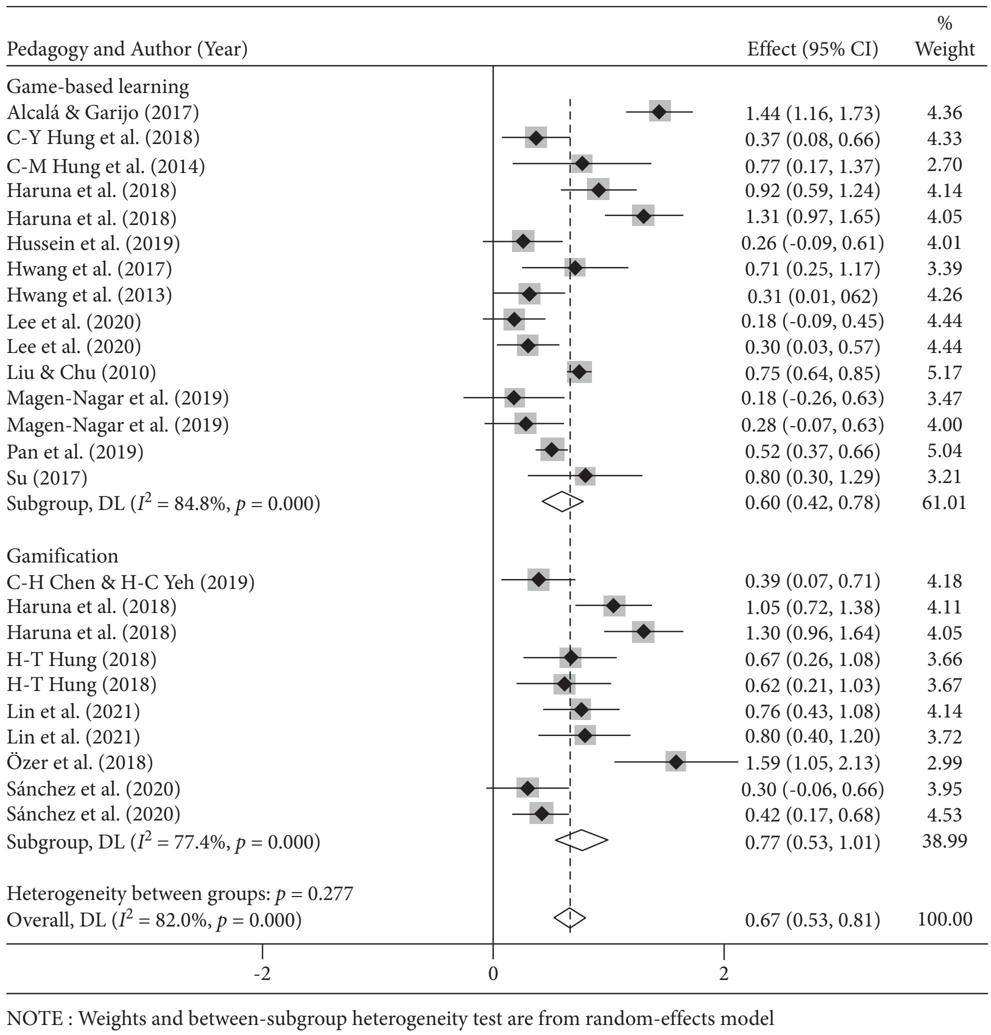

Figure 5: The forest plot presenting the effect sizes on motivation for gamification and game-based learning.

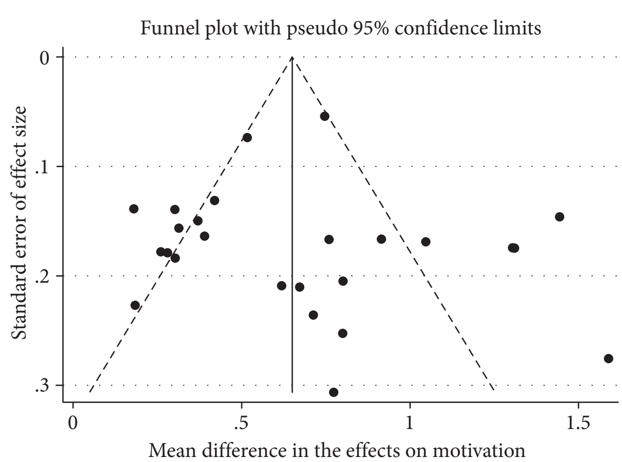

Figure 6: The funnel plot presenting the distribution of effects on motivation.

4.3. *Do Gamification and Game-Based Learning Exert Different Effects on Intrinsic Motivation?*

The diamond near the bottom of the forest plot (see Figure 8) presented the summary effect of the overall effects of game-related pedagogies on intrinsic motivation [61]. The diamond was centered at 0.65 (ES = 0.65) and extended from 0.43 to 0.86 (95% CI [0.43, 0.86]).

We aggregated the homogeneous figure groups using the platform "StatTools: Combine Means and SDs Into One Group Program" (https://www.obg.cuhk.edu.hk/ResearchSupport/StatTools/CombineMeansSDs_Pgm.php) developed by the Chinese University of Hong Kong [69 (StatTools: Combine Means and SDs Into One Group Program, 1995)]. For the dataset "Data about effects on intrinsic motivation," we aggregated most studies, but we still remained multiple figure groups that presented heterogeneous contents from some studies. The study of Haruna et al. [15] examined two different pedagogical models each of which was investigated in terms of intrinsic motivation and extrinsic motivation (see Table 1).

Regarding the subgroup analyses, both gamification and game-based learning subgroups presented positive effects on intrinsic motivation (see Table 2 and Figure 8). The diamond for the gamification subgroup was centered at 0.64

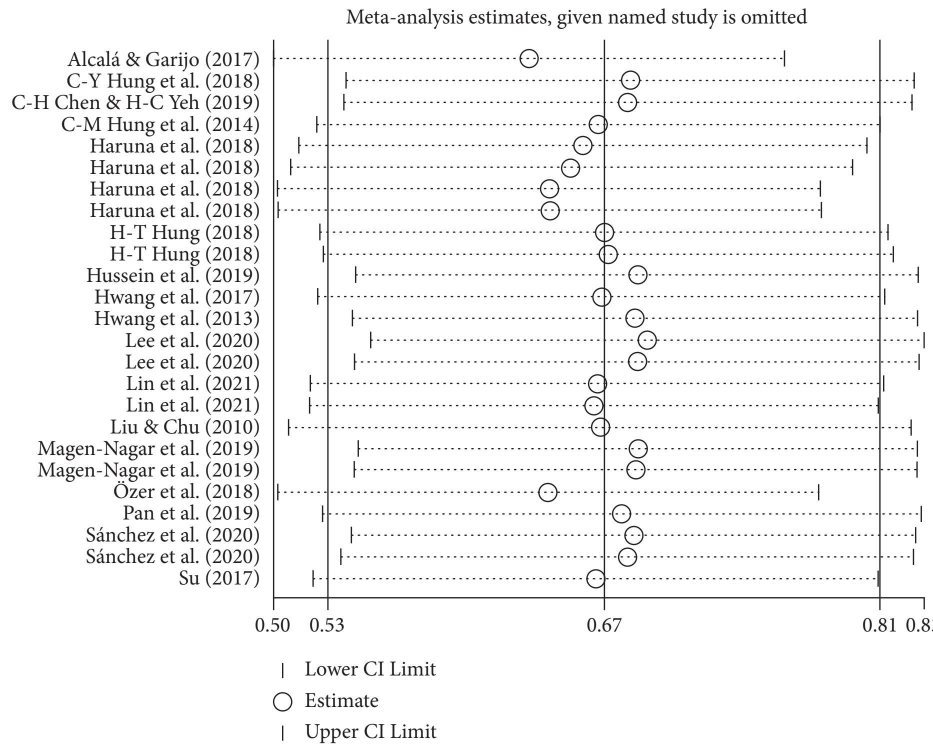

Figure 7: The sensitivity analysis examining the robustness of the results on motivation.

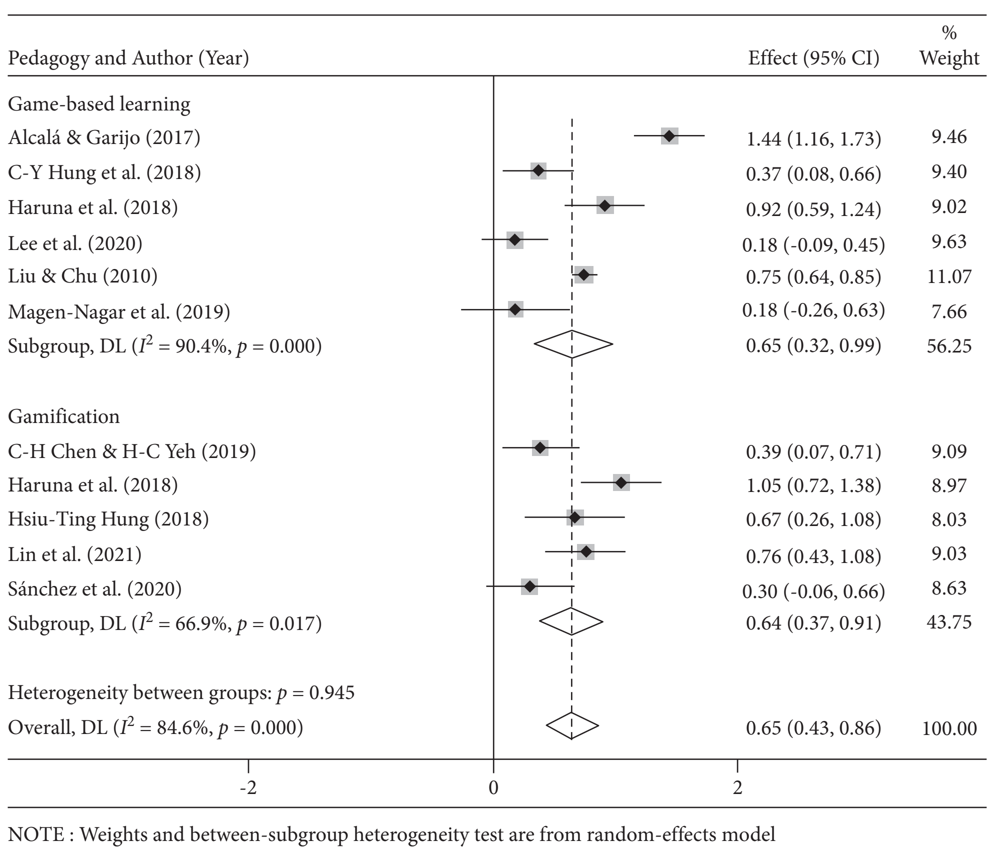

Figure 8: The forest plot presenting the effect sizes on intrinsic motivation for gamification and game-based learning.

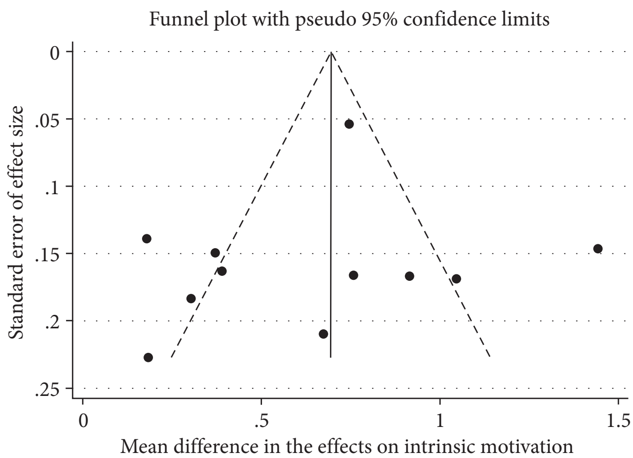

Figure 9: The funnel plot presenting the distribution of effects on intrinsic motivation.

(ES = 0.64) and extended from 0.37 to 0.91 (95% CI [0.37, 0.91]). The diamond for the game-based learning subgroup was centered at 0.65 (ES = 0.65) and extended from 0.32 to 0.99 (95% CI [0.32, 0.99]). The effect sizes between the medium (0.5) and the large (0.8) sizes indicated the visible differences between the experimental and control groups in intrinsic motivation [62]. The distribution of the individual study effect sizes was similar for the gamification subgroup and for the game-based learning subgroup. Even if the effect sizes were similar for the gamification (0.64) and game-based learning subgroups (0.65), the distribution of the individual study effect sizes was wider for the game-based learning subgroup than for the gamification subgroup. Thus, gamification exerted more stable and significant effects on intrinsic motivation.

Egger's test indicated the significance level >0.05 of 0.566, suggesting that no obvious publication bias (see Table 2). The funnel plot (see Figure 9) presented that most dots were located symmetrically. Four dots outside the left part of the funnel represented the relatively nonsignificant data groups, while two dots outside the right part of the funnel represented the relatively significant data groups [61].

According to the sensitivity analysis (see Figure 10), the findings of effect sizes significantly decreased if the studies of Hortigüela Alcalá and Hernando Garijo [7], Lin and Chu [58], and two data groups from Haruna et al. [15] were omitted. This significant study contributed the most limiting power to the positive effects on intrinsic motivation [61]. By contrast, the findings of effect sizes significantly increased if the studies of Lee et al. [50] and Magen-Nagar et al. [51] were omitted. These nonsignificant studies contributed the most limiting power to the effects on intrinsic motivation [61].

Based on these findings, we concluded that gamification exerted more stable effects on intrinsic motivation than on extrinsic motivation, even if both gamification and game-based learning exerted similarly positive effects on intrinsic motivation. Thus, we remained H3 that gamification and game-based learning would exert different effects on intrinsic motivation.

4.4. Do Both Gamification and Game-Based Learning Exert More Positive Effects on Extrinsic Motivation Than on Intrinsic Motivation? The diamond near the bottom of the forest plot (see Figure 11) presented the summary effect of the overall effects of game-related pedagogies on extrinsic motivation [61]. The diamond was centered at 0.69 (ES = 0.69) and extended from 0.49 to 0.89 (95% CI [0.49, 0.89]).

We aggregated the homogeneous figure groups using the platform "StatTools: Combine Means and SDs Into One Group Program" (https://www.obg.cuhk.edu.hk/ResearchSupport/StatTools/CombineMeansSDs_Pgm.php) developed by the Chinese University of Hong Kong [69 (StatTools: Combine Means and SDs Into One Group Program, 1995)]. For the dataset "Data about effects on extrinsic motivation," we aggregated most studies, but we still remained multiple figure groups that presented heterogeneous contents from some studies. The study of Haruna et al. [15] examined two different pedagogical models each of which was investigated in terms of intrinsic motivation and extrinsic motivation (see Table 1).

Regarding the subgroup analyses, both gamification and game-based learning subgroups presented positive effects on extrinsic motivation (see Table 2 and Figure 11). The diamond for the gamification subgroup was centered at 0.92 (ES = 0.92) and extended from 0.50 to 1.34 (95% CI [0.50, 1.34]), reflecting the large and perceptible differences between the research groups due to the effect size >0.8 [62]. The diamond for the game-based learning subgroup was centered at 0.56 (ES = 0.56) and extended from 0.12 to 1.13 (95% CI [0.12, 1.13]), reflecting the visible differences between the research groups due to the effect sizes between the medium (0.5) and the large (0.8) sizes [62].

Even if the effect size for the gamification subgroup (0.92) was greater than that of the game-based learning subgroup (0.58), the distribution of the individual study effect sizes was wider for the gamification subgroup than for the game-based learning subgroup. Thus, although gamification exerted more positive effects on extrinsic motivation, game-based learning exerted more stable and significant effects on extrinsic motivation.

Egger's test indicated the significance level >0.05 of 0.154, suggesting that there was no obvious publication bias (see Table 2). The funnel plot (see Figure 12) presented that three dots outside the right part of the funnel had remarkably significant effects on the mean difference [61]. According to the sensitivity analysis (see Figure 13), the findings of effect sizes significantly decreased if the two data groups from Haruna et al. [15] and Ã-zer et al. [52] were omitted. These significant studies contributed the most to the positive effects on extrinsic motivation [61].

To test H4, we compared the effect on intrinsic motivation (see Figure 8) with that on extrinsic motivation (see Figure 11) for specific subgroups. For the gamification subgroup, although the effect size for extrinsic motivation (0.92) was significantly greater than the effect size for intrinsic motivation (0.64), the distribution of the individual study effect sizes was wider for extrinsic motivation than for intrinsic motivation based on the 95% CIs. For the game-based learning subgroup, although the effect size for intrinsic

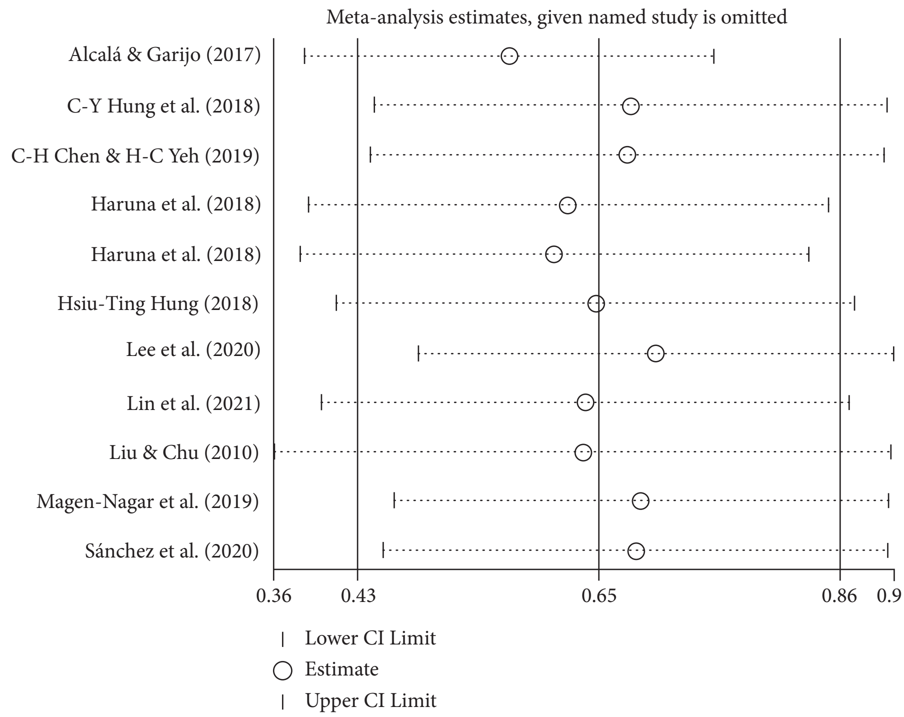

FIGURE 10: The sensitivity analysis examining the robustness of the results on intrinsic motivation.

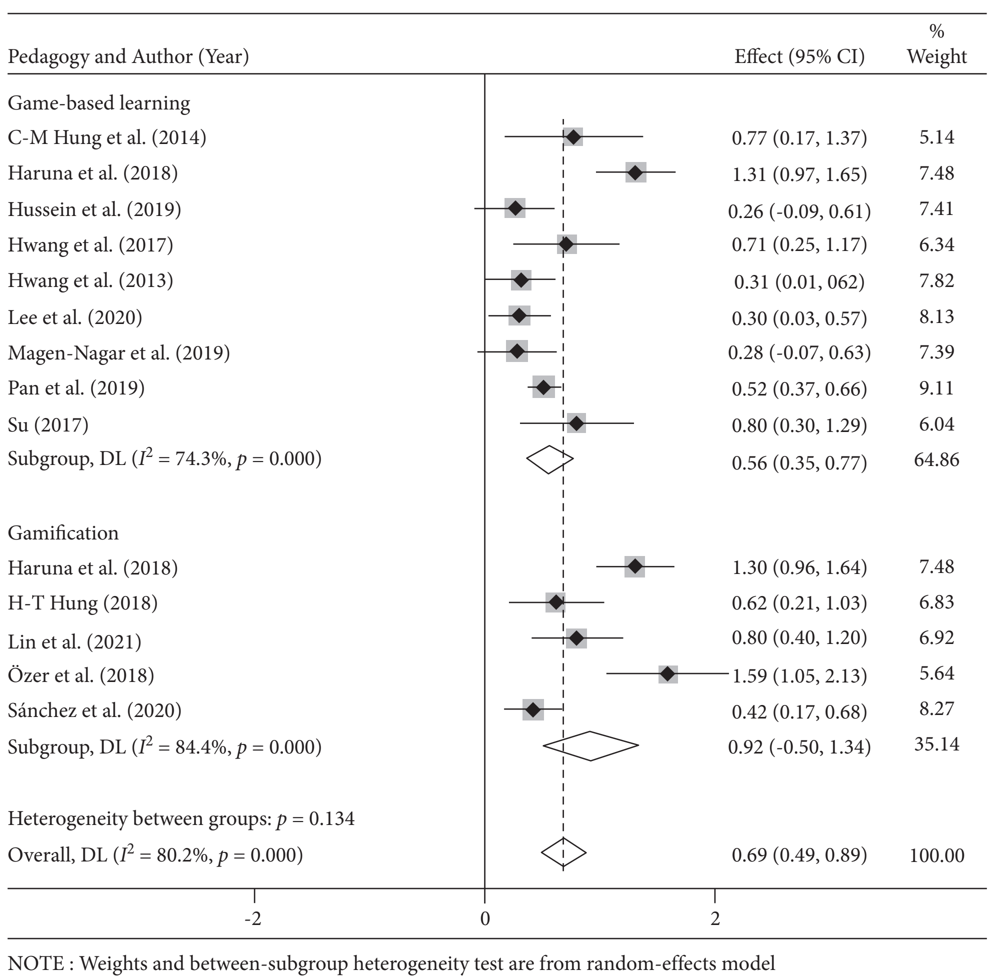

FIGURE 11: The forest plot presenting the effect sizes on extrinsic motivation for gamification and game-based learning.

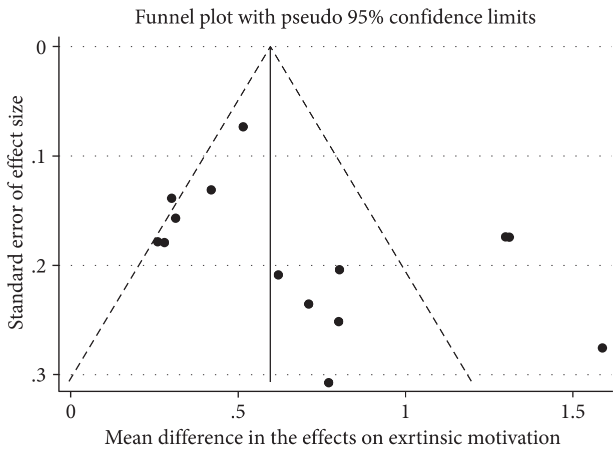

Figure 12: The funnel plot presenting the distribution of effects on extrinsic motivation.

motivation (0.65) was greater than the effect size for extrinsic motivation (0.56), the distribution of the individual study effect sizes was wider for intrinsic motivation than for extrinsic motivation based on the 95% CIs. Thus, gamification exerted more stable effects on intrinsic motivation despite the larger effect size for extrinsic motivation, while game-based learning exerted more stable effects on extrinsic motivation despite the larger effect size for intrinsic motivation.

Based on these findings, we concluded that the effect sizes for the game-related pedagogies were relatively in contrast to the stability of their effects on intrinsic and extrinsic motivation. Gamification exerted more stable but less positive effects on intrinsic motivation than on extrinsic motivation, while game-based learning exerted more stable but less positive effects on extrinsic motivation than on intrinsic motivation. Thus, we rejected H4 that both gamification and game-based learning would exert more positive effects on extrinsic motivation than on intrinsic motivation.

5. Discussion

This section presented how significant the current research results based on the analyses of the potential reasons for the effects of game-related pedagogies on learning achievement, intrinsic motivation, and extrinsic motivation.

The effects of game-related pedagogies were associated with the contexts created for participants to perceive interaction. Games or game-related elements could offer autonomy-supportive contexts where participants could relatively freely make decisions, receive timely feedback, and promote particular behaviors based on limited amount of pressure [63]. In the autonomy-supportive contexts, participants internalize the external stimuli and voluntarily perform specific behaviors, gradually contributing to intrinsic motivation [37]. Besides, autonomy-supportive contexts satisfy participants' needs of competence, autonomy, and relatedness, also positively associated with intrinsic or well-internalized extrinsic motivation that enhances learning achievement [37].

Game-related pedagogies could meet the demand for autonomy through independent learning environments involving created elicit reciprocal and interactive actions, that is, competition, conflict, challenge, feedback, control, feelings, event perceptions, and game results [4, 45]. Besides, game-related pedagogies emphasize the central role of the learners during pedagogical practice [57]. The learner-centered contexts inspire class participation and raise the sense of belonging to the class [57], fulfilling the demand for relatedness. Moreover, game-related pedagogies positively influence participants' information processing ability [64], problem-solving capability [65], and learning effectiveness [49], meeting the demand for competence. Thus, gaming environments could foster intrinsic motivation positively associated with learning achievement. Notably, users should notice the approaches of implementing games or gamifying platforms in pedagogical practices. Coercive instructions or rewards and excessive pressure lead to adverse effects on learning achievement and motivation [66].

Additionally, the current meta-analysis demonstrated that two game-related pedagogies, that is, gamification and game-based learning, had different significant degrees of effects on learning achievement, intrinsic motivation, and extrinsic motivation. As for the effects on learning achievement, the effects on learning achievement were more stable for game-based learning than for gamification. Immersion would lead to a difference in the effects on learning achievement. Gamification requires systematic integration of game elements aiming to create immersive activities for participants' engagement in the gaming experiences [4]. During the immersive activities, participants would achieve heightened simultaneous experiences of concentration, interest, and enjoyment [63]. Since gamification emphasizes the process of gamifying the nongame contexts [23], gamification requires participants' much immersion to make them adapt to the ludic environments. However, uncontrollable external factors, for example, the gamification designs or pedagogical contexts, or internal factors, for example, learners' frustration or distraction, would negatively influence participants' experiences and progress [4, 64]. Thus, although gamification could theoretically guarantee learning achievement, high dependence on immersion subject to uncontrollable factors leads to relatively unstable effects of gamification on learning achievement.

As for the effects of gamification on motivation, gamification presents less significant but more stable effects on intrinsic motivation than on extrinsic motivation. Considering the psychological and behavioral effects, gamification could enhance motivation, learning, and problem-solving skills [4] [4, 68 (Sailer et al., 2017)] since highly internalized extrinsic motivation reflects high autonomy and is positively associated with the cultivation of individuals' intrinsic motivation [36, 37]. As a game-related pedagogy, gamification fulfills the demands of autonomy, relatedness, and competence that are positively associated with intrinsic motivation. Thus, gamification contributes to highly internalized extrinsic motivation that would develop into intrinsic motivation [37]. Due to the non-bidirectional

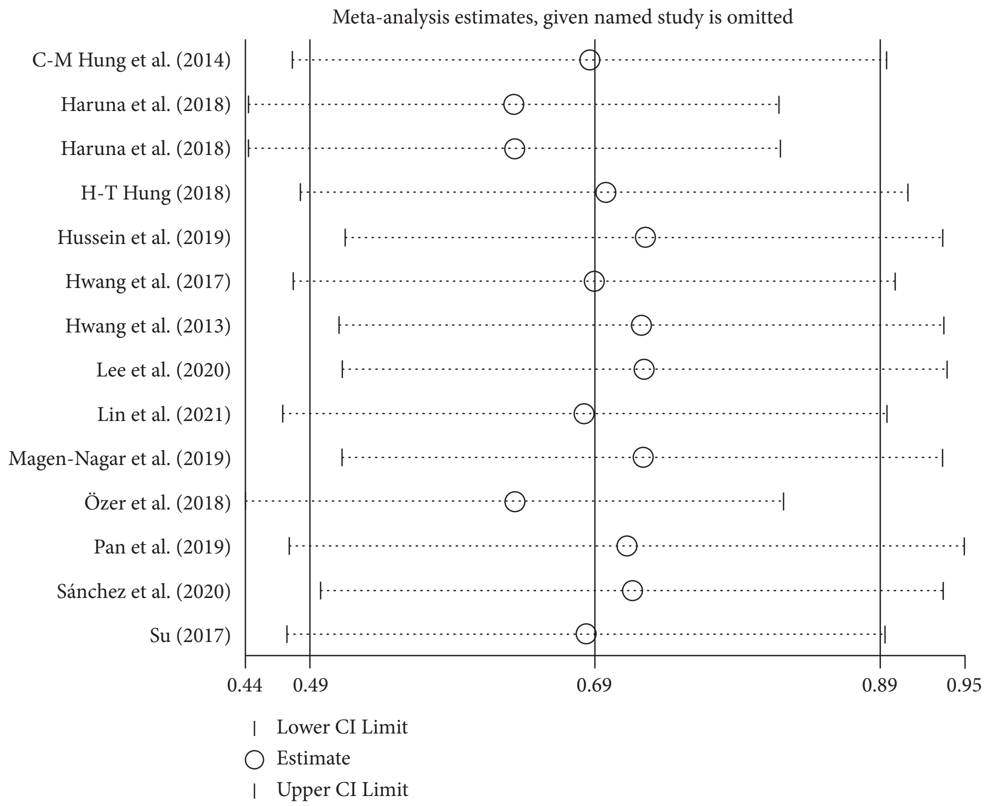

Figure 13: The sensitivity analysis examining the robustness of the results on extrinsic motivation.

development process from highly internalized extrinsic motivation into intrinsic motivation [36, 37], gamification exerts relatively more stable effects on intrinsic motivation than on extrinsic motivation.

As for the effects of game-based learning on motivation, game-based learning exerts less remarkable but more stable effects on extrinsic motivation than on intrinsic motivation. Game-based learning requires complete serious games involving rule-based and goal-oriented activities [3]. Rule-based, voluntary, and enjoyable activities in the games are the essential elements for outcomes or rewards, consistent with explicit rule systems and outcomes [3, 52]. Thus, game-related learning depends on rules, rewards, or punishments to reinforce specific behaviors and encourage participants to reach goals, indicating relatively less internalized extrinsic motivation supported by external stimuli [68 (Sailer et al., 2017)]. Individuals' poorly internalized extrinsic motivation would limit intrinsic motivation [37, 65]. Thus, game-based learning exerts less stable effects on intrinsic motivation than on extrinsic motivation.

Overall, gamification and game-based learning present their efficient aspects on learning achievement and motivation. However, they still show different stability degrees of their effects. The dependence on immersion influences the stability of the effects of game-related pedagogies on learning achievement. The effects on learning achievement are relatively less stable for gamification than for game-based learning because gamification highly depends on immersion subject to external or internal factors. Besides, individuals' internalization of motivation would account for the different effects of game-related pedagogies on intrinsic and extrinsic motivations. Gamification that creates autonomy-supportive contexts focuses on the cultivation of intrinsic motivation, while game-based learning involving various external stimuli cultivates individuals' relatively less internalized extrinsic motivation.

6. Conclusion

This section presented the answers to the research hypotheses, conclusions from the analyses, and insights for future studies based on the limitations of this study.

6.1. Major Findings. This study aimed to investigate the efficiencies of gamification and game-based learning in terms of learning achievement, intrinsic motivation, and extrinsic motivation. Since gamification and game-based learning were distinct game-related pedagogies, they were assumed to have different effects on learning achievement and motivation. H1 concentrated on the different effects of gamification and game-based learning on learning achievement. We found that the effects on learning achievement were more stable and significant for game-based learning than for gamification. Thus, we remained H1 that gamification and game-based learning exert different effects on motivation. H2 focused on the different effects of gamification and game-based learning on motivation. We found that the overall effects on motivation were more positive for gamification than for game-based learning.

Thus, we remained H2 that gamification and game-based learning exert different effects on motivation.

Since motivation was classified into intrinsic motivation and extrinsic motivation, we compared the efficiencies of gamification and game-based learning in terms of these motivation subtypes. H3 concentrated on the different effects of gamification and game-based learning on intrinsic motivation. We found that the effects on intrinsic motivation were more stable for gamification than for game-based learning despite the similar effect sizes. Thus, we remained H3 that gamification and game-based learning exert different effects on intrinsic motivation. H4 investigated whether gamification and game-based learning exerted more positive effects on extrinsic motivation than on intrinsic motivation. We found that the effects of gamification and game-based learning were less positive on extrinsic motivation than on intrinsic motivation. Thus, we rejected H4 and concluded that the effect size of game-related pedagogies was in contrast to the stability of the effects on intrinsic and extrinsic motivation.

Based on the aforementioned analyses, we arrived at the main conclusion that gamification and game-based learning presented different degrees to which they could positively influence learning achievement, intrinsic motivation, and extrinsic motivation. Compared with gamification, game-based learning exerted more significant and stable effects on learning achievement. While gamification had relatively stable impacts on intrinsic motivation, game-based learning exerted relatively stable effects on extrinsic motivation.

6.2. Limitations of This Study and Insights for Future Research. Admittedly, some limitations still existed in the current study. One major limitation of this study was the coverage of the studies. Even if we attempted to search and included the eligible quasi-experimental studies as much as possible to guarantee relatively comprehensive results, we might not include all the studies that could provide valuable information for the meta-analysis. Diversity in experimental procedures could contribute to relatively more comprehensive explanations and assessments on the efficiency of game-related pedagogies. Another potential limitation was the generalization of the research domains. We investigated and discussed the effects of game-related pedagogies on educational contexts in a general term. Game-related pedagogies were still available in the occupational training contexts.

These points provided us with the following insights for future research. Based on the expanded research coverage, future research could investigate the use of game-based learning or gamification in occupational training contexts. How the pedagogies would balance skill development and knowledge acquisition could be another criterion to evaluate the efficiency of game-related pedagogies. References marked with asterisks indicate the studies included in the meta-analysis.

Data Availability

All data and materials support our published claims and comply with field standards. The data for the current study were updated and reorganized based on the study of Zhang, L. Yu, Z. Yu, 2021, finished by the same first author. The citation of this study is as follows and included in the references of Zhang, Q., Yu, L., and Yu, Z. (2021). A content analysis and meta-analysis on the effects of Classcraft on gamification learning experiences in terms of learning Achievement and motivation, Education Research International, Article 9429112.

Conflicts of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Acknowledgments

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Supplementary Materials

This study involved four datasets as the supplementary materials: "Data about effects on learning achievement," "Data about effects on motivation," "Data about effects on intrinsic motivation," and "Data about effects on extrinsic motivation." "Data about effects on learning achievement" presented the information of empirical studies that investigate the effects of game-related pedagogies on learning achievement. The variables "author" and "year" described the authors and publication years of the studies. The variable "pedagogy" described the target game-related pedagogies, that is, gamification and game-based learning, of the studies. The variables "ExpN," "ExpMean," and "ExpSE" referred to the number of participants, mean result, and standard error in the experimental group. The variables "CtrlN," "CtrlMean," and "CtrlSE" referred to the number of participants, mean result, and standard error in the control group. "Data about effects on motivation" presented the information of empirical studies that investigate the effects of game-related pedagogies on motivation. The variables "author" and "year" described the authors and publication years of the studies. The variable "pedagogy" described the target game-related pedagogies, that is, gamification and game-based learning, of the studies. The variables "ExpN," "ExpMean," and "ExpSE" referred to the number of participants, mean result, and standard error in the experimental group. The variables "CtrlN," "CtrlMean," and "CtrlSE" referred to the number of participants, mean result, and standard error in the control group. The variable "motivation" described the motivation types, that is, intrinsic motivation and extrinsic motivation, as the target dimension for the empirical studies. "Data about effects on motivation" and "Data about effects on intrinsic motivation" entail "Data about effects on motivation" to present the effects of game-related pedagogies on specific motivation types. (*Supplementary Materials*)

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