Review of European Studies; Vol. 14, No.2; 2022
ISSN 1918-7173 E-ISSN 1918-7181
Published by Canadian Center of Science and Education

The Active Methodology of Gamification to Improve Motivation and Academic Performance in Educational Context: A Meta-Analysis

Javier Mula-Falcón[1], Iñaki Moya-Roselló[2] & Alberto Ruiz-Ariza[3]

[1] School of Education, University of Granada, Granada, Spain

[2] Department of Food and Nutrition, Metropolitan University of Manchester, Manchester, United Kingdom

[3] School of Education, University of Jaen, Jaen, Spain

Correspondence: Javier Mula-Falcón, School of Education, University of Granada, Granada, Spain E-mail: javiermf@ugr.es

Received: March 6, 2022 Accepted: April 6, 2022 Online Published: April 12, 2022

doi:10.5539/res.v14n2p32 URL: https://doi.org/10.5539/res.v14n2p32

Abstract

Gamification is an active methodology that involves using game elements in a non-game situation. Gamification has shown to increase motivation and learning in different types of academic students; however, the educational literature shows inconclusive findings. The aim of this meta-analysis is to analyse the effects of gamification on motivation and academic performance in an educational context. Sixteen interventions carried out between January 2010 and the end of January 2022 were retrieved from the databases and included in this meta-analysis. One study was carried out in Primary school, three in Secondary school, and twelve in universities. Four papers analysed the effects on motivation, five on academic performance and seven on both. Results showed that gamification could increase the motivation (SMD = 0.51; 95% CI [0.29, 0.73]; I^2 59%; $p < 0.00001$) and academic performance (SMD = 0.89; 95% CI [0.45, 1.32]; I^2 90%; $p < 0.0001$) in all the educational stages. The implications of including gamification programmes in the educational context are discussed.

Keywords: gamification, active methodologies, motivation, academic performance, learning

1. Introduction

Active methodologies have appeared as a potential strategy of learning in the 21st century (Niemi, Nevgi and Aksit, 2016; Segura-Robles, Parra-González, and Gallardo-Vigil 2020b). Among them, gamification has become considerably popular during the last decade (Dichev and Dicheva 2017). Gamification is an educational active methodology which uses elements, designs, mechanics and rewards from games or videogames, adapted to a non-game environment such as the educational context (Kapp 2012). This strategy has been previously used successfully in many companies to increase employee performance and consumer engagement (Domínguez et al. 2013). During gamified dynamic, there are stories, avatars, groups/team of characters, or challenges to achieve points or badges, to level up or to reach some objective, and advance in the adventure (Sailer and Homner 2020). A main characteristic of this methodology is that provides narrative features or presents a game world, which includes elements of fantasy (Melero-Cañas, Morales-Baños, Manzano-Sánchez, Navarro-Ardoy, and Valero-Valenzuela 2021). Marczewski (2013) indicated that gamified intervention should take in account four important motivational components: Conection whith peers in a social context, autonomy in order to can take decisions, improvement through the process to raise the level, and the purpose why it is required the intervention. Werbach and Hunter (2012), and Dichev and Dicheva (2017) mentioned three categories as part of the gamified structure, which are composed by:

(a) Dynamics: it contains a powerful narrative based on a common topic in order to achieve a complete goal. The dynamic must have an appropriate progression, emotions, limits, and social relationships.

(b) Mechanics: it embraces the elements that make the action progress, such as rules, challenges, cooperation, competition, rewards, or feedback before, during or after the intervention to know the efficacy, points or rewards of each task. For example, the challenges can be proposed across individual or group task with different levels of difficulty, inside or outside the school.

(c) Components: it includes avatars, achievements, points, badges, leaderboards, or levels. For example, the points (components) provide rewards (mechanics) and generate a progression (dynamics).

Educational gamification engages participants, motivates action and promotes learning, with its subsequent effect on the

academic performance (Sailer and Homner 2020). Effective learning mechanisms based on gamification may appear in theories such as self-determination, which shows three types of motivation: intrinsic motivation (inherent to the person), extrinsic motivation (encouraged from outside the person), and amotivation (absence of motivation) (Ryan and Deci 2017). Motivation is a key variable for success in school, and it is based on the psychological needs for autonomy, competence and social relationships (Ryan and Deci 2002). In addition, novelty has been suggested as a fourth need, and it is defined as the proclivity to engage in interesting activities (González-Cutre et al. 2016). In this sense, teachers must incorporate novel pedagogical approaches such as gamification into their classes that can meet the needs of individual students and maintain their motivation in a short-long term (Fernández-Río, de las Heras, González, Trillo, and Palomares 2020). The satisfaction of these needs is essential to intrinsic motivation and, consequently, to learning (Deci and Ryan 2000). The intrinsic motivation denotes the highest position of self-determined motivation, and has been related to numerous positive results in educational contexts, such as increased concentration or engagement in class (Ceccini, et al. 2020; Fernández-Río et al. 2020). Self-determination theory has already been effectively applied in gamified situations, increasing the motivation (Fernández-Río et al. 2020). Consequently, improvements in motivation usually lead to improvements in academic performance (Ryan and Deci 2002).

Academic performance is the main variable related to success in the educational context, and is usually measured with academic scores in the different subjects (Tomporowski, Davis, Miller and Naglieri 2008). To this successful achievement, cognitive performance is important to adjust and process data, mainly perceptual data; it is a wide concept that includes psychological ability affected by the executive functions (planning, inhibitory control or memory). These factors, together with the motivation or behaviour, are important for the general academic performance (Ruiz-Ariza, Grao-Cruces, Loureiro and Martínez-López 2017). Several studies over the last decade, have associated the use of gamification with a better academic performance (Charles et al. 2011; Frącz 2015; Chen, Huang, Gribbins, and Swan 2018; Wichadee and Pattanapichet, 2018; Ortiz-Rojas, Chiluiza, and Valcke, 2019; Alharti, 2020; Jiménez-Hernández, Oktaba, Díaz-Barriga, and Piattini, 2020). However, this relationship is inconsistent (De Marcos, Domínguez, Saenz-de-Navarrete, and Pagés, 2014; Domínguez et al. 2013; Hanus and Fox 2015).

Previous investigations that attempted to synthesize the effects of gamification on motivation and learning outcomes, have performed it almost exclusively with review designs as bibliographical mapping or systematic reviews. These previous reviews have examined the associations between gamification and motivation and academic performance, with inconclusive results (Dichev and Dicheva 2017; Hamari, Koivisto, and Sarsa 2014; Seaborn and Fels 2015). The results of these reviews were attributed to differences in gamification contexts and participant features. Besides, the proposals of gamification are varied and the concepts of motivation or academic performance are broad and encompass a multitude of aspects (González-Cutre et al. 2016; Ryan and Deci 2017; Tomporowski et al. 2008). A first novel meta-analysis identified that gamification showed a positive medium-sized correlation with learning results in educational context (r = .31). The learning results were referred almost totally to motivational measures, with the exception of one study that researched knowledge retention (Garland 2015). More recently, other meta-analysis has also analysed the effects of gamification on learning or academic performance with mild positive results (Bai, Hew, and Huang 2020; Sailer and Homner 2020; Yıldırım and Şen 2020). Dichev and Dicheva (2017) also highlight the need for more in-depth studies to analyse which rigorously tested approaches can confirm the educational benefits of gamification, in order to recognize gamified learning as an instructional approach.

In summary, we are not aware of any meta-analysis that have analysed the specific effects of gamification on motivation and academic performance together, during several educational stages (from primary school to university). Hence the research question that guided this research was: *Does gamification improve motivation and academic performance in educational context?* The aim was to carry out a meta-analysis to analyse the effects of gamification on motivation and academic performance in educational context. This investigation may reinforce previous reviews and meta-analysis and help to raise awareness about the importance of increasing the use of active methodologies as gamification during didactical proposals. Finally, results are discussed in depth showing gamified proposal and practical implications from/for educators.

2. Method

2.1 Selecting Studies

The main priority when selecting publications was to maximize the sensitivity of the search. To this end, we established inclusion and exclusion criteria, which allowed us to include those studies that met the desirable study characteristics. Table 1 shows the selection criteria used in this meta-analysis.

Table 1. Inclusion/Exclusion Criteria

Inclusion criteria	Exclusion Criteria
• Thematic adequacy. • Experimental and quasi-experimental design studies with Control Group (CG) and Experimental Group (EG). • Experimental designs with Post-test. • Studies that analyse performance or motivation outcomes. • Studies focused on any educational stage. • Research published between 2010-2021.	• Not meeting inclusion criteria. • Studies that do not analyse performance or motivation outcomes. • Studies that do not contain mean (M), standard deviation (SD) data. • Studies without CG.

In order to ensure that our study complied with an inclusive approach to literature searching, we included both published and unpublished studies in order to have the opportunity to consider the grey literature (Conn, Valentine, Cooper and Rantz, 2003).

The keywords used were "gamification", "academic performance" and "motivation". In addition, terms such as "gamif*" were included in order to include derivatives of this term. The databases in which the search was carried out were: *Web of Science* (*WoS*), *SCOPUS*, *Educational Research Information Centre* (*ERIC*), *PubMed*, *ScienceDirect* and *SpringerLink*. Moreover, we carried out a complementary search in Google Scholar to maximise our bibliographic search in order to complete the process of selecting publications.

The bibliographical search yielded a total of 648 studies which was reduced to 242 after applying filters such as: studies published in the last decade and studies in English or Spanish. These studies were subjected to an inclusion process consisting of a series of phases. Firstly, articles that met the proposed thematic adequacy of this meta-analysis were examined through the title and abstract. After this first analysis, repeated articles (79) were eliminated, as well as studies that did not really analyse the effect of gamification on student motivation or performance (56). This initial process reduced the number of initial papers to 107. Subsequently, several rounds of meticulous screening were established, in which several of the members of this study reviewed this initial group of studies and selected those that met the pre-set inclusion criteria. In this case, a large number of articles were eliminated for various reasons such as not being experimental or quasi-experimental designs with a control group (42), not showing values relative to the mean (M) or standard deviation (SD) (28) or using gamification as a complementary intervention to another main intervention (13). Finally, a first complete and thorough reading of the papers for false positives was carried out (Codina 2018), which led us to discard another 8 articles.

Once the documents had been selected, another complementary literature search process was carried out. In this case, the reference list of the included studies was examined. However, no articles were found that could be integrated due to their characteristics and thematic suitability. Thus, after these screening phases, 16 studies were finally considered for meta-analysis (Figure 1).

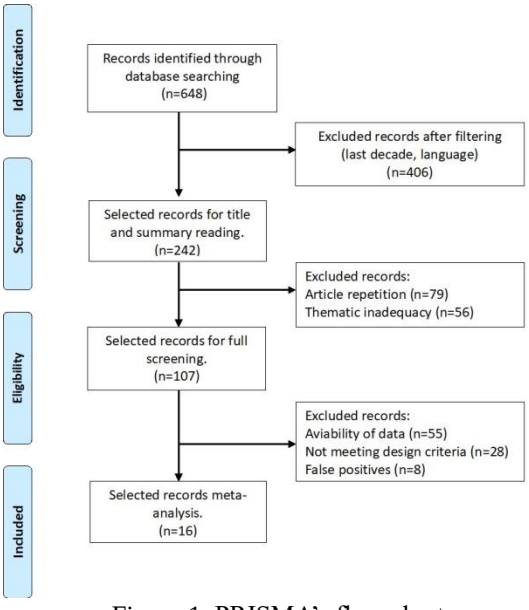

Figure 1. PRISMA's flow chart

3.2 Selection of Studies

Once the final group of studies had been selected, a phase of data extraction and coding was carried out. This phase consisted of extracting the relevant information from each of the publications included in this study. This required the retrieval of the full PDF. The coding of these studies was carried out by two independent researchers. The coding was satisfactory, showing an agreement of $\kappa = .81$. Where discrepancies occurred, they were resolved by mutual agreement. In the case of disagreement between the two researchers, the lead author of the research was consulted. This author was responsible for the overall review of the coding of each publication to ensure accuracy in this process. Furthermore, in order to ensure maximum reliability of the coding process, the statistical data were coded twice.

The following characteristics were extracted from each study for both control (CG) and experimental group (EG): (1) sample size (n); (2) outcomes; (3) M and (4) SD. Baseline and general characteristics included the effects of gamification on students as the main intervention. In addition, outcome data included: effects on motivation and academic performance. All study data were extracted in an Excel spreadsheet (Microsoft, Seattle, USA).

Table 2 shows the information on the sample sizes of each research, the mean and standard deviation of each of the dependent variables analysed (motivation and academic performance) in the studies.

Table 2. Correlation of each study with the analysed variables

			Motivation		Academic Performance	
Author (year)	Group	N	M	SD	M	SD
Alharti (2020)	EG	20			50.64	9.35
	CG	16			41.2	6.22
Bernik et al. (2015)	EG	28			20.89	5.78
	CG	27			15.3	4.5
Chen et al. (2018)	EG	44			272.4	8.91
	CG	36			251.44	10.56
Chen and Chiu (2016)	EG	28			41.66	9.48
	CG	30			34.81	12.19
Dziob (2020a)	EG	37			58.44	12.44
	CG	36			50.67	11.57
Dziob (2020b)	EG	31			67.76	15.38
	CG	26			57.65	15.72
Ferriz-Valero et al. (2020)	EG	62	17.06	1.9		
	CG	65	16.75	2.3		
Frącz (2015)	EG	31			10.84	4.13
	CG	39			9.76	3.66
Frost et al. (2015)	EG	41	4.767	1.8972	79.79	8.874
	CG	39	4.646	1.6868	76.96	11.665
Jiménez-Hernández et al. (2020)	EG	31	4.05	0.57	80.00	13.66
	CG	31	3.65	0.64	70.00	20.49
Khaleel et al. (2019)	EG	30			28.6	1.1
	CG	30			19.23	3.16
Ortiz-Rojas et al. (2019)	EG	55	5.13	1.15	11.58	2.44
	CG	34	4.78	1.47	8.88	2.95
Pozo et al. (2020)	EG	30	3.4	0.92		
	CG	30	2.87	1.02		
Segura-Robles et al. (2020a)	EG	32	3.25	0.56		
	CG	32	2.36	0.715		
Standsbury and Earnest (2017)	EG	49	4.34	0.48		
	CG	44	4.05	0.46		
Su (2016a)	EG	34	4.0882	0.885	82.94	10.009
	CG	34	3.1882	1.325	72.2	8.128
Su (2016b)	EG	34	3.8118	1.051	73.24	8.518
	CG	34	3.1882	1.325	72.2	8.128
Wichadee and Pattanapichet (2018)	EG	38	3.42	0.44	12.63	3.37
	CG	39	3.02	0.66	14.15	2.23

2.3 Statistical Analysis

The software used to perform the statistical analysis was Review Manager (Revman) version 5.3. The extracted statistics are described as M, SD and 95% confidence intervals (CI). Thus, to compare the effects of gamification

between the experimental group and the control group, the number of participants, M and SD were used to calculate the standardised mean difference (SMD). SMD was used as the measure of analysis because most of the selected studies assess the same outcomes, but they were measured differently.

A fixed effect would be used if the studies were homogeneous. However, random effect was applied in case heterogeneity was detected. In studies where the random effect was applied and did not resolve heterogeneity, a sensitivity analysis was used as a next step. In addition, Cohen's principle was used to define the magnitude of SMD: <0.2 indicates a trivial magnitude; between 0.2 and 0.5 indicates a trivial magnitude; 0.5 and 0.8 indicates a moderate magnitude; >0.8 indicates a large magnitude (Cohen 1988).

The I^2 measure was analysed as a statistical marker to avoid possible errors when applying the Q-statistic to measure heterogeneity. I^2 values are represented between 0 % and 100 %: (1) small inconsistency and heterogeneity between 25-50; medium heterogeneity is between 50-75; high heterogeneity when the percentage is greater than 75 % (Higgins et al. 2008). Finally, the main analysis tools used were the forest plot and funnel plot for a better imaging of data (Chen et al. 2018; Gillette et al. 2018).

3. Results

In this section, the 16 articles included in the meta-analysis will be analysed. First, a general description of the characteristics of the studies (time course, research designs and samples) will be presented. Then, the results extracted from the meta-analysis will be analysed and interpreted.

3.1 General Description of the Studies

Most of the studies selected for the meta-analysis were published between 2015 and 2020, although the literature search focused on the last 10 years. In this five-year period (2015-2020), a steady pace is observed in the number of publications, reaching a maximum of six studies in the last year. In this sense, while 62.5% (n=10) of the total production corresponds to the first years (2015/2019), only 2020 accounts for 37.5% of the production generated.

The most commonly used methodological designs were quasi-experimental with CG and EG with pre-test and post-test (25 %); and experimental with CG and EG with pre-test and post-test (25 %). Other designs used in the studies are the quasi-experimental with CG and EG only post-test (18.75 %); the experimental with CG and EG only post-test (18.75 %); and the quasi-experimental with a non-equivalent control group design with pre-test and post-test (12.5 %). Finally, we also found two other studies with quasi-experimental designs with more than one CG or EG (Su, 2016; Dziob, 2020). In the meta-analysis, all possible alternatives for comparison between the groups in these studies have been considered and are reflected in the forest plot as Dziob (2020a), Dziob (2020b), Su (2016a) and Su (2016b).

In short, research has focused on comparing the results obtained by groups to which no intervention was applied (CG) with those to which it was applied (EG). The intervention used in these studies consisted of the use of different forms of gamification. In this sense, there is a clear predominance in the use of applications or digital media as the main tool both for the assessment of learning and for the development, explanation and acquisition of contents (87.5 %). Among the most characteristic examples are the use of *Kahoot* (Alharti, 2020; Wichadee and Pattanapichet, 2018); the development of role-playing or strategy games (Frost, Matta, and MacIvor 2015; Ferriz-Valero, Østerlie, García-Martínez, and García-Jaén 2020); the use of virtual reality (Su 2016); or the employment of specific learning apps and software such as Concept Review Bingo, Jeopardy Exam Review, Peer Wise or Minibool educational software (Bernik, Bubas, and Radosevic 2015; Chen and Chiu 2016; Chen et al. 2018; Frącz 2015; Jiménez-Hernández et al. 2020; Khaleel, Ashaari, and Wook 2019; Ortiz-Rojas et al. 2019; Pozo, López, Fuentes and López 2020).

On the other hand, there are also studies that either do not use apps or digital media, or use them as a complementary element. Clear examples of this aspect are the research conducted by Standsbury and Earnest (2017), which uses a traditional role play; that of Dziob (2020a, 2020b), which applies a physical game board for knowledge reinforcement; and that of Segura-Robles, Fuentes-Cabrera, Parra-González and López-Belmonte (2020a), which uses a Scape Room design-based game. However, regardless of the type of gamification used in the studies, most of them are usually complemented with competitive dynamics (62.5 % of the total). These are characterised by the use of points, internal leagues, rankings, or competition tables, among other aspects.

With regard to the duration of the interventions (gamification), there is variation between studies ranging from two weeks (Bernick et al. 2015) to one academic year (Chen et al., 2018; Standsbury and Earnest 2017). However, most studies comprise a maximum period of one month coinciding with the development of a particular unit (Frącz 2015; Ortiz-Rojas et al. 2019; Dziob 2020a, 2020b; Segura-Robles et al. 2020a; Ferriz-Valero et al. 2020; Pozo et al. 2020). There are also studies with a duration of one semester (Frost et al. 2015; Alharti, 2020; Jiménez-Hernández et al. 2020), and others with a length of two to three months (Chen and Chiu 2016; Su 2016; Wichadee and Pattanapichet 2018).

In terms of the samples, two fundamental aspects are worth highlighting. Firstly, the clear predominance of samples made

up of students from the university stage (75%). Secondly, the wide variety of subjects involved in the studies. Among these, STEM subjects stand out (56.25%), followed by language teaching (18.75%), health-related subjects and PE (12.5%).

In relation to the outcomes analysed, all studies examine either motivation (Segura-Robles et al. 2020a; Pozo et al. 2020; Stansbury and Earnest 2017; Ferriz-Valero et al. 2020), or performance (Chen and Chiu 2016; Bernick et al. 2015; Chen et al. 2018; Dziob 2020a, 2020b; Khaleel et al. 2019; Alharti 2020), or both (Frost et al. 2015; Wichadee and Pattanapichet 2018; Ortiz-Rojas et al. 2019; Jiménez-Hernández et al. 2020; Su 2016; Frącz 2015). However, there is a small group of studies that also consider other outcomes such as the degree of effectiveness, participation, autonomy, satisfaction or the level and quality of interactions, among others.

Finally, by way of summary, table 3 shows the relationship between the different characteristics of each of the studies selected for the meta-analysis.

Table 3. Main characteristics of the studies analysed

Study	**Educational Stage**	**Subject**	**N**	**Methodological design**	**Duration***
Alharti (2020)	University	Languages	36	R CG $O_1 - O_2$ EG O_1 X O_2	6
Bernik et al. (2015)	University	STEM	55	R CG $O_1 - O_2$ EG O_1 X O_2	0.5
Chen et al. (2018)	University	Languages	80	R CG $O_1 - O_2$ EG O_1 X O_2	6
Chen and Chiu (2016)	Elementary Education	STEM	58	R CG $O_1 - O_2$ EG O_1 X O_2	12
Dziob (2020a)	Secondary education	STEM	73	R CG – O_2 EG X O_2	1
Dziob (2020b)	Secondary education	STEM	57	R CG – O_2 EG X O_2	1
Ferriz-Valero et al. (2020)	University	Physical Education (PE)	127	NE CG $O_1 - O_2$ EG O_1 X O_2	1
Frącz (2015)	University	STEM	70	R CG – O_2 EG X O_2	1
Frost et al. (2015)	University	STEM	80	CG – O_2 EG X O_2	6
Jiménez-Hernández et al. (2020)	University	STEM	62	R CG $O_1 - O_2$ EG O_1 X O_2	6
Khaleel et al. (2019)	University	STEM	60	CG $O_1 - O_2$ EG O_1 X O_2	Not mention
Ortiz-Rojas et al. (2019)	Universidad	STEM	89	CG $O_1 - O_2$ EG O_1 X O_2	1
Pozo et al. (2020)	Secondary education	Languages	60	CG – O_2 EG X O_2	1
Segura-Robles et al. (2020a)	Secondary education	Physical Education (PE)	64	CG $O_1 - O_2$ EG O_1 X O_2	1
Standsbury and Earnest (2017)	University	Health (Psychology)	93	R CG – O_2 EG X O_2	12
Su (2016a)	University	Health (Nursing)	68	CG $O_1 - O_2$ EG O_1 X O_2	2
Su (2016b)	University	Health (Nursing)	68	CG $O_1 - O_2$ EG O_1 X O_2	2
Wichadee and Pattanapichet (2018)	University	Languages	77	CG $O_1 - O_2$ EG O_1 X O_2	3

Note: *Duration in months; R = Randomisation; NE = Non-Equivalent Design; O1=Pre-test; O2=Post-test; CG = Control Group; EG = Experimental Group; X = Intervention.

Correlation of each study with the analysed variables

3.2 Meta-Analysis Results

3.2.1 Gamification Effects on Learner Motivation (Meta-Analysis)

In this section, the general effects of gamification on students' motivation are analysed. To this end, Figure 2 shows the results of the eleven studies (858 participants) included in the meta-analysis that measure this effect (Ferriz-Valero et al. 2020; Frącz 2015; Frost et al. (2015); Jiménez-Hernández et al. 2020; Ortiz-Rojas et al. 2019; Pozo et al. 2020; Segura-Robles et al. 2020a; Standsbury and Earnest 2017; Su 2016a, b; Wichadee and Pattanapichet 2018).

Overall, most studies show a significant effect ($p < 0.05$) in favour of EG (Su, 2016a, b; Standsbury and Earnest, 2017; Wichadee and Pattanapichet, 2018; Ortiz-Rojas et al., 2019; Jiménez-Hernández et al., 2020; Pozo et al., 2020; Segura-Robles et al., 2020a). The diamond image to the right of the no effect line confirms that the difference between groups is statistically significant ($p < 0.05$), confirming, a priori, that gamification exerts a positive effect on motivation. In fact, the overall effect estimate of the investigations considered verifies this difference between the EG (n = 437) and the CG (n = 421) (SMD = 0.51; 95% CI [0.29, 0.73]; $p < 0.00001$), showing an oscillation of the effects between .02 and 1.37. The meta-analysis reported a medium heterogeneous pooled result ($p=0.006$, $I^2= 59\%$) in accordance with Cohen (1988) and Hattie (2015) principles. This shows that there are moderate inconsistencies between studies due to possible differences in samples, experimental conditions or even in the measures used. However, heterogeneity could be resolved by performing sensitivity of analysis ($p=0.45$, $I^2= 0\%$), with the exclusion of two studies (Ferriz-Valero et al., 2020; Segura-Robles et al., 2020a), after which the overall effect estimate would still show a statistically significant difference (SMD=0.49; 95% CI [0.33, 0.64]; $p < 0.00001$). Therefore, this analysis determines that Ferriz-Valero et al. (2020) and Segura-Robles et al. (2020a) cause moderate heterogeneity among the studies analysed in the meta-analysis.

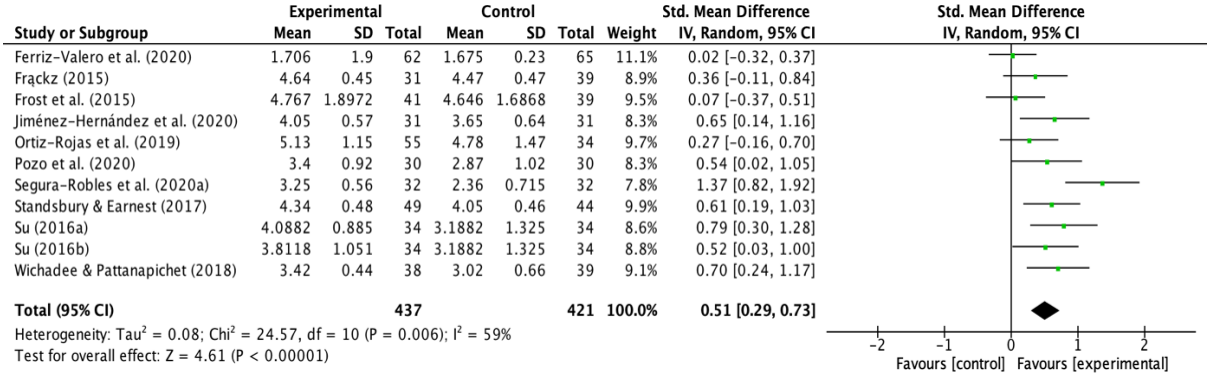

Figure 2. Forest plot with all the results (A)

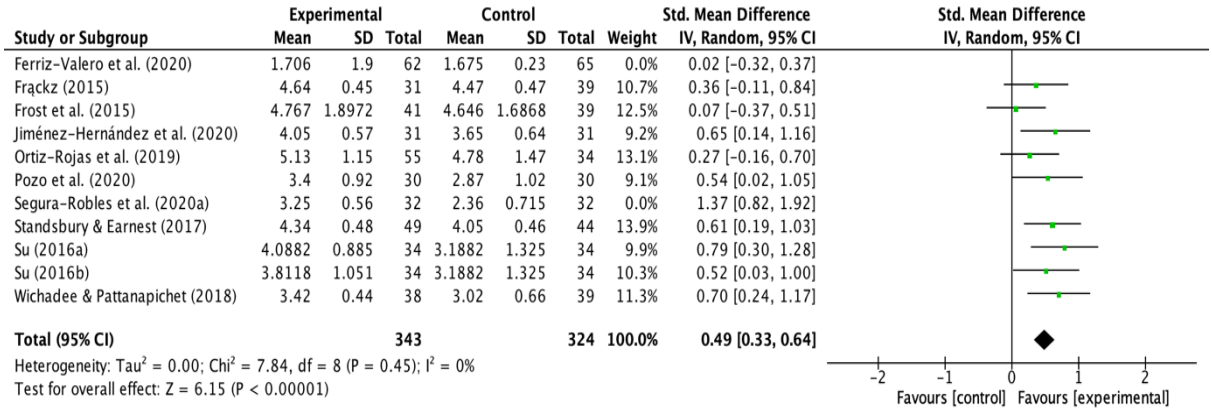

Figure 3. Forest plot after sensitivity analysis (B)

Regarding publication bias, Figure 3 shows the distribution of interventions according to the significance of the effect and precision of the studies on student motivation. The funnel plot shows the size (Y-axis) and effect (X-axis) of the studies included in this meta-analysis. The distribution of the studies shows a majority clustering in the middle part of

the Y-axis, therefore, the interventions included in this quantitative analysis are of moderate precision. Additionally, the distribution of studies in terms of effect size reflects symmetry on the X-axis, with only one study falling outside the parameters of the clustering of research, possibly due to the presence of heterogeneity. On the other hand, the funnel plot shows the presence of a larger number of publications with smaller effect size results located on the right side of the effect line. Therefore, fewer studies show statistically favourable results, which could mean that there is no publication bias in the research on the effect of gamification on student motivation.

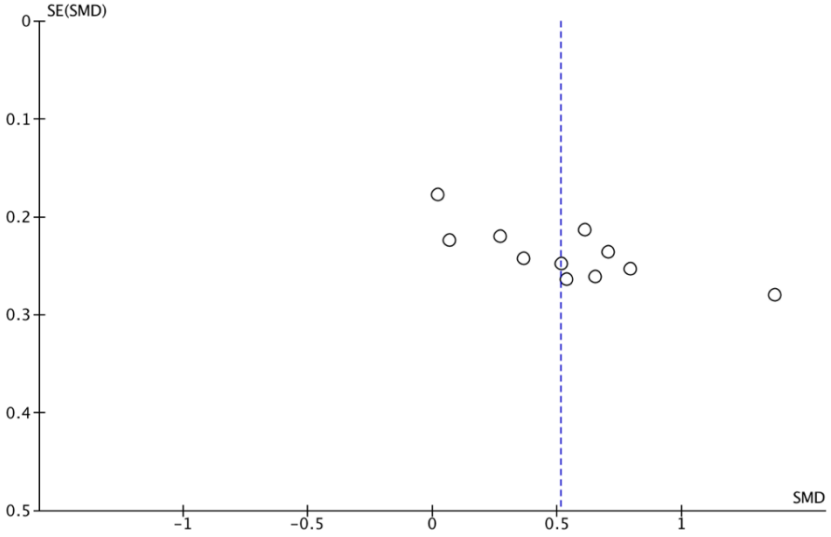

Figure 4. Funnel Plot on the distribution of the analysed gamification studies and their impact on motivation

3.2.2 Effects of Gamification on Student Performance (Meta-Analysis)

This section shows the effects that gamification can have on student performance. To this end, Figure 5 shows the results of the fourteen studies (933 participants) included in the meta-analysis that measure this variable (Bernik et al. 2015; Frącz 2015; Frost et al 2015; Su 2016a, b; Chen and Chiu 2016; Chen et al. 2018; Wichadee and Pattanapichet 2018; Ortiz-Rojas et al. 2019; Khaleel et al. 2019; Dziob 2020a, b; Alharti 2020; Jiménez-Hernández et al. 2020).

The forest plot shows that the overall effect estimate of the results verifies that EG produces a significant effect (n = 482) with respect to the CG (n = 451) (SMD = 0.89; 95% CI [0.45, 1.32]; $p < 0.0001$), showing an oscillation of the effects between -.53 and 3.91. Regarding heterogeneity, the meta-analysis reported large heterogeneous pooled results ($p < 0.00001$, $I^2 = 90\%$) according to the principle of Cohen (1988) and Hattie (2015). To resolve the high degree of heterogeneity, a random effect and sensitivity analysis was applied, however, the heterogeneity could not be solved. This shows that there is substantial inconsistency between studies due to possible differences in samples, experimental conditions and, above all, the use of different measurement instruments for the variables.

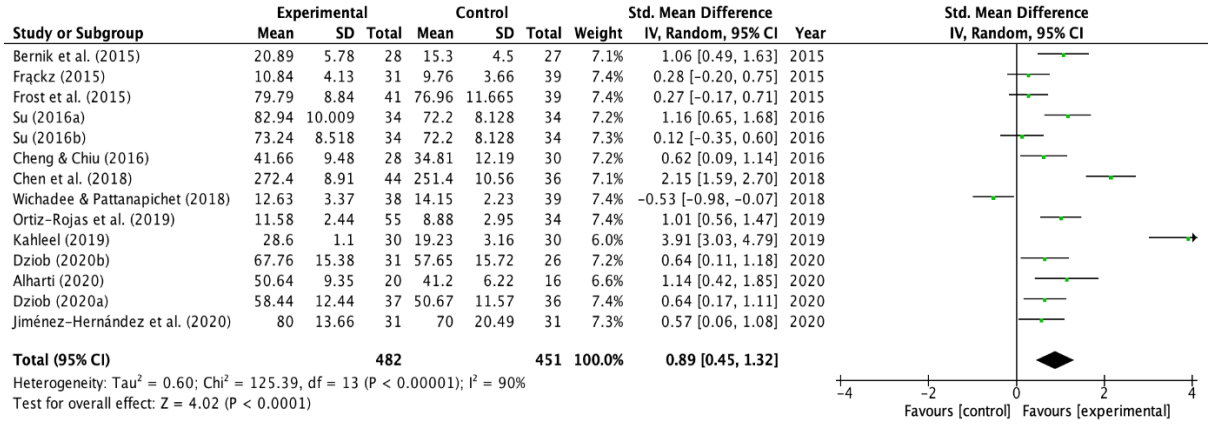

Figure 5. Forest plot of gamification publications analysing the impact on students' academic performance

Regarding publication bias, Figure 6 shows a heterogeneous distribution of studies and, in this case, concentrated on the left side of the central axis. This shows the existence of a larger number of studies with favourable results for

gamification. Furthermore, the dispersion of several studies on the right side of the no effect line shows an asymmetric distribution in terms of effect size (X-axis) and precision (Y-axis) of the studies, which could be caused by the existence of high heterogeneity among the investigations. Therefore, these characteristics indicate a possible existence of publication bias in research on the effect of gamification on student achievement. However, as mentioned above, it should be noted that the high heterogeneity ($p < 0.00001$, $I^2 = 90\%$) could be the cause of this asymmetric distribution of studies, and therefore the existence of a false positive publication bias.

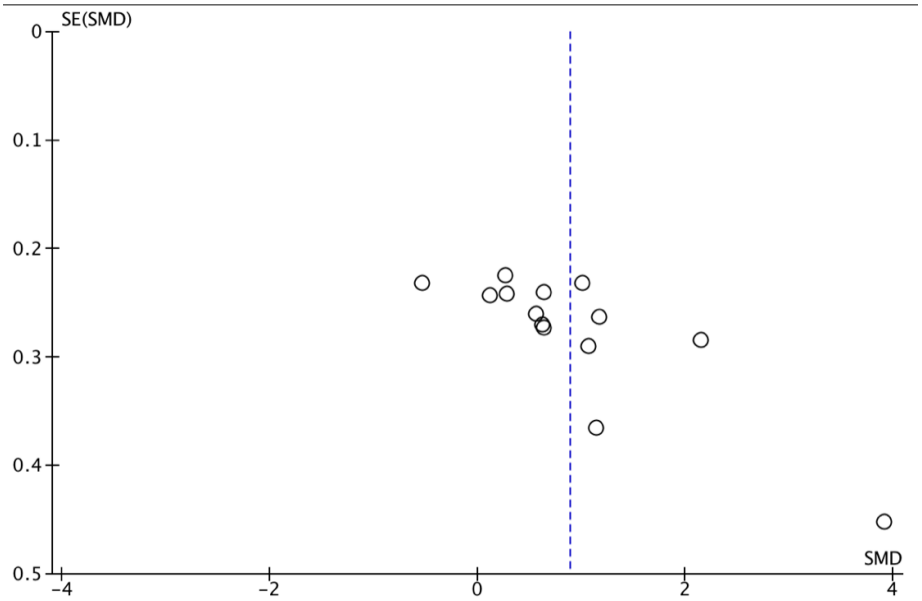

Figure 6. Funnel Plot on the distribution of the analysed gamification studies and their impact on performance

4. Discussion

The aim of this meta-analysis was to investigate the effects of gamification on motivation and academic performance in educational context. A total of 16 intervention studies carried out between January 2010 and the end of January 2022 met the inclusion criteria. The majority of selected studies were from 2015 to 2020. The last year this area increased remarkably, with 6 research (37,5% of the total). The samples were mostly formed by students from university programs (75%). Moreover, the areas involved in the studies were STEM (56.25%), foreign language (18.75%), and subjects associated with health and PE (12.5%). In general, the interventions are based on apps or digital means as main instrument to perform the gamification. For example, the use of *Kahoot*, role-playing or strategy games, or specific learning apps and software (*Classcraft*®). In addition, other proposals use traditional role play or Scape Room designs. Independently of the type of gamification, most of them are usually accompanied by competitive dynamics (62.5% of the total). The duration was from 2 weeks to 1 academic year, although the most of studies use a period of 1 month (coinciding with 1 teaching unit). General findings show that gamification positively effect on motivation and academic performance in educational context. It is suggested to use this kind of active methodology to potentiate a good atmosphere and learning during the learning-teaching process.

Our results show that gamification can positively affect motivation and academic performance in educational context, mostly in university. So far, not conclusive meta-analysis on the effects of gamification in motivational or academic variables together had yet been provided (Sailer and Homner 2020). Dicheva, Dichev, Agre and Angelova (2015) conducted a review of 34 empirical studies published between 2010 - 2014. Their findings revealed that most of the interventions (n=18) showed positive effects of gamification on various cognitive, motivational and behavioural variables. Two years later, Dicheva and Dichev published another literature review, and identified 51 additional studies, where 12 interventions reported positive results and three negative results. It can be seen that most of the analysed studies were inconclusive (n = 26) (Dichev and Dicheva 2017). In line with this, reviews such as Seaborn and Fels (2015), or Hamari et al. (2014), found mixed results in studies published between the time period 2008- 2013. These findings are in line with those found in the present study, which highlights a moderate inconsistency and precision between studies. This could be due to gamification contexts or methodology, differences regarding to samples, the experimental conditions or even the measures used or the confounding variables (Ferriz-Valero et al. 2020; Segura-Robles et al. 2020a).

The present meta-analysis found that the kind of outstanding intervention is based on apps or digital means as main

instrument to carry out the gamification, for the evaluation of learning as well as for the development, explanation and acquisition of contents (87.5%). For example, the use of *Kahoot* (Alharti, 2020; Wichadee and Pattanapichet 2018), the development of role-playing or strategy games (Frost et al. 2015; Ferriz-Valero et al. 2020), the use of virtual reality (Su 2016) or the use of specific learning apps and software (Bernik et al. 2015; Chen and Chiu 2016; Chen et al. 2018; Frącz 2015; Jiménez-Hernández et al. 2020; Khaleel et al. 2019; Ortiz-Rojas et al. 2019; Pozo et al. 2020). Studies are also observed in which either no applications or digital media are used, or they are used as a complementary element. For instance, Standsbury and Earnest (2017) used a traditional role play, Dziob (2020) a physical game board for knowledge reinforcement, and Segura-Robles et al. (2020a), which employed a design of Scape Room. The most of studies are accompanied by competitive dynamics (62.5% of the total). These are characterized by the use of points, internal leagues, rankings, or competition tables. All these components engage participants, motivates action and promotes learning, with its subsequent effect on the academic performance (Sailer and Homner 2020).

4.1 Gamification and Motivation

Even though some studies provided different results and have not shown an increase in student motivation after a gamified programme (Domínguez et al. 2013; Hanus and Fox 2015; Joo, Johnsen, and Ball 2019), the findings of this meta-analysis show that gamification enhances motivation in educational context (Su 2016a, b; Standsbury and Earnest 2017; Wichadee and Pattanapichet 2018; Ortiz-Rojas et al. 2019; Jiménez-Hernández et al. 2020; Pozo et al. 2020; Segura-Robles et al. 2020a), above all in university. In this line, Charles et al. (2011) found that university students enjoyed more the gamified experience. Similarly, Bellotti et al. (2013) reported higher engagement, interest and commitment among participants. Gamification could positively affect the four psychological needs from self-determination theory (Ryan and Deci 2002). Among them, novelty can be an important component of a gamified intervention in the short and long term, through fostering the interest for the activities (González-Cutre et al. 2016) and maintain the intrinsic motivation (Fernández-Río et al. 2020), in favour of learning and academic performance (Ryan and Deci 2002). This motivational effect of novelty could be due to the continuous use of tasks that involved active student participation and learning (Lim, Carpio, and Ong 2019). A study also added that effects of competition together with collaboration during gamification, might affect to motivational outcomes (Sailer and Homner 2020). Gamification increases the enjoyment, friendship and learning (Fernández-Río et al. 2020). All this produces a sense of well-being, happiness and positive emotions associated with the achievement of challenges, and engagement due to the attraction felt by the proposed dynamics (Hamari et al. 2014). Therefore, the combination of the components of the active gamification methodology, together with the novelty, the feedback, and the climate of progressive goal attainment promoted intrinsic motivation to a greater extent than extrinsic motivation, which is usually more ephemeral and dependent on those external factors outside the participant (Fernández-Río et al. 2020).

In this regard, several studies indicated that challenging tasks, narratives, and tangible rewards, are considered key variables in the gamified interventions to promote students' intrinsic motivation (Dichev and Dicheva 2017; Werbach and Hunter 2012). Pérez-López, Rivera-García, and Trigueros-Cervantes (2019), carried out a proposal based on the TV Show "*Game of Thrones*" at the university context. The study concluded that gamification as a methodological strategy increases student's motivation, which leads to higher involvement in learning. One year later, Fernández-Río et al. (2020), found that students' intrinsic motivation significantly improved with extrinsic rewards as points or badges during "*MarvPE*", a gamification based on the Marvel universe of super heroes (15 weeks, 2 sessions per week/50 min each), and they justified it according the self-determination theory of motivation. These authors indicate that the students enjoyed the experience and showed feelings like happiness and excitement, because of the novel pedagogical approach, where the narrative is a key motivating aspect. Perhaps, the dynamics with varied and playful tasks allowed a positive perception of the participants. For example, many teenagers may be working on content or carrying out an exercise related with Ironman while they are thinking that are involved in a competition to obtain a badge related to the dynamic. Other interesting gamified proposal could be the "*$ in TIME*" project using a mobile app (Mora-Gonzalez, Pérez-López, and Delgado-Fernández, 2020), "*The Matrix rEFvolution Program*" (Mora-Gonzalez, Pérez-López, Esteban-Cornejo, and Delgado-Fernández 2020) or "*The Seneb's Enigma*", an educational hybrid program based on gamification and teaching personal and social responsibility strategies, with a double history and health objective (Melero-Cañas et al. 2021). However, teachers sometimes showed concern for the workload of this new pedagogical approach (Fernández-Río et al. 2020). In summary, this meta-analysis shows that the experimental groups enrolled in gamification programmes had more motivation and enjoyed the learning process more, and provides important information to determine the positive effect of gamification on motivation, bearing in mind that more studies are still needed to determine the most appropriate stimuli to obtain the best benefits. The motivational power of gamification has become an especially promising method for instructional contexts (Sailer and Homner 2020). If motivation grows, learning becomes meaningful (Melero-Cañas et al. 2021).

4.2 Gamification and Academic Performance

The features and component of gamification are key to raise the motivation and, consequently, the academic performance (Sailer and Homner 2020). In this concern, studies analysing the effect of gamification in academic performance have shown clear benefits (Bernik et al. 2015; Frącz 2015; Frost et al. 2015; Su 2016a, b; Chen and Chiu 2016; Chen et al. 2018; Wichadee and Pattanapichet 2018; Ortiz-Rojas et al. 2019; Khaleel et al. 2019; Dziob 2020a, b; Alharti 2020; Jiménez-Hernández et al. 2020). However, the meta-analysis estimated a substantial inconsistency between studies for the differences in samples, the experimental conditions or, above all, due to the variability in the programs and variables used. The results also show a high heterogeneity in the effect of gamification on academic performance, indicating possible bias in the findings in the funnel plot.

Recent experimental studies show that gamification increases student achievement (Huang, Hew, and Lo 2018; Marín, Frez, Cruz-Lemus, and Genero 2018). A recent meta-analysis conducted by Yıldırım, and Şen (2020), studied the size of educational gamification and its effect on academic performance covering 45 experimental studies composed of 3487 students from different countries. The heterogeneity of the effect values obtained promoted the use of the random effects model and the mean value of the effect size was 0.557. Hedges' omega-squared value was 0.072. This score indicates that gamification has a positive effect of 7.2% on academic performance. Along these lines, Hamari et al. (2014) examined the results of experimental studies on gamification as a review and presented results showing the positive effects of gamification. Majuri, Koivisto, and Hamari (2018) reviewed experimental studies on gamification and described that the substantial majority of investigation reports positive learning outcomes. In this regard, Ferriz-Valero et al. (2020), suggest that gamified application is favourable for academic performance at the university stage, although intrinsic motivation does not change. The use of *Classcraft*® as a software for gamified educational intervention allows intervention and control groups to receive just the same content with the same methodology (grouping, design of activities, or feedback). Charles et al. (2011) found that university students learned more with the gamified experience and improved their academic performance. Domínguez et al. (2013) showed an increase in academic performance, but the students performed poorly on written tasks and were less engaged in class. In a similar way, other gamified programmes showed that participants showed lower satisfaction and final academic performance (De Marcos et al. 2014; Hanus and Fox 2015). Therefore, the results demonstrate that perhaps performance depends on the variety of assessment instruments and may be affected by other confounding variables. More research is needed to evaluate the impact of gamification on student motivation and academic performance on larger sample sizes, unifying the programs' criteria, using clear procedures and employing common validated instruments of measure.

5. Limitations and Strengths

This meta-analysis shows inaccuracy in some gamification programmes as the main weakness. Gamification applications and instruments of evaluation can be very diverse. Some studies do not describe in depth the type of gamification that was used, duration nor internal organisation. Also, some studies do not take into account contextual and situational factors nor other variables undertaken by students during their daily habits, which may bias the results. These moderating factors could be important to explain the conceptual heterogeneity in gamification. In this regard, it would be interesting to included contextual, situational, and methodological moderators in future proposal. These limitations difficult to know the most effective gamified programme. In spite of the above, it is the first time that a meta-analysis classifies and analyse the effects of gamification on motivation and academic performance across the educational stages (from primary school to university). The scope of this work was limited to intervention studies and we have provided educational implications on the use of gamification within educational context, to improve student's motivation and academic performance.

6. Conclusions and Educational Implications to Use Gamification Within Educational Context

This meta-analysis has shown that active strategies based on gamification have a high potential that was previously unrecognised. To incorporate the active methodology of gamification, consisting of dynamics (progressive and striking narrative), mechanics (challenges, cooperation, competition, rewards or continuous feedback) and components (avatars, points, badges or levels), increase the motivation for the learning process and academic performance in the educational context. For this reason, we consider that one of the main educational implications of this study should be the increased use of gamification programmes in schools. In this sense, encouraging educational legislation to introduce these methodologies in the classroom would be a great step forward. Gamification could be used such as guiding thread within the teaching planning and teaching units. Teachers who are not specialists in this active methodology should be instructed to incorporate all the mechanism and the correct structure in their subjects. One recommendation is to use the technology and active learning through the gamification proposals.

There is a need for more scientific production oriented towards the analysis of the duration, frequency and type of stimuli suitable for structuring gamified programmes in the school context. Furthermore, little is known about possible

age and sex differences in the effects of gamification, so these outcomes should be considered with caution. It would also be necessary to clarify the possible impact of non-analysed confounders such as daily study hours or socioeconomic level. Finally, it is suggested to depth in the possible effects of gamification on other potential variables such as educational values, emotional intelligence, executive functions, creativity or key competences.

Acknowledgments

This work has been funded by the Ministry of Universities of Spanish Government under grant number FPU19/00942.

References

Alharti, A. S. (2020). Assessings Kahoot's Impact on EFL Students' Learning Outcomes. *Tesol Internationl Journal, 15*(5), 31-64.

Bai, S., Hew, K. F., & Huang, B. (2020). Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. *Educational Research Review*, *30*, 100322. https://doi.org/10.1016/j.edurev.2020.100322

Bellotti, F., Berta, R., De Gloria, A., Lavagnino, E., Antonaci, A., Dagnino, M. F., & Ott, M. (2013). *A Gamified Short Course for Promoting Entrepreneurship among ICT Engineering Students*. IEEE 13th International Conference on Advanced Learning Technologies. Beijing, China. https://doi.org/10.1109/ICALT.2013.14

Bernik, A., Bubas, G., & Radosevic, D. (2015). *A pilot study of the influence of gamification on the effectiveness of an e-Learning Course*. Central European Conference on Information and Intelligent Systems. Faculty of Organization and Informatics Varazdin, Croatia.

Charles, D., Charles, T., McNeill, M., Bustard, D., & Black, M. (2011). Game-based Feedback for Educational Multi-User Virtual Environments. *British Journal of Educational Technology, 42*(4), 638–654. https://doi.org/10.1111/j.1467-8535.2010.01068.x

Chen, C. C., Huang, C., Gribbins, M., & Swan, K. (2018). Gamify Online Courses with Tools Built into Your Learning Management System (LMS) to Enhance Self-Determined and Active Learning. *Online Learning*, *22*(3), 41-54. https://doi.org/10.24059/olj.v22i3.1466

Chen, C. H., & Chiu, C. H. (2016). Employing intergroup competition in multitouch design-based learning to foster student engagement, learning achievement, and creativity. *Computers & Education*, *103*, 99-113. https://doi.org/10.1016/j.compedu.2016.09.007

Codina, L. (2018). *Revisiones bibliográficas sistematizadas: Procedimientos generales y Framework para Ciencias Humanas y Sociales*. Barcelona: Máster Universitario en Comunicación Social.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd Edition). Hillsdate, NJ: LEA.

Conn, V. S., Valentine, J. C., Cooper, H. M., & Rantz, M. J. (2003). Grey Literature in Meta-Analyses. *Nursing Research*, *52*(4), 256–261. https://doi.org/10.1097/00006199-200307000-00008

De Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers & Education, 75*, 82–91. https://doi.org/10.1016/j.compedu.2014.01.012

Deci, E. L., & Ryan, R. M. (2000). "The ''What'' and ''Why'' of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry, 11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education*, 1–36. https://doi.org/10.1186/s41239-017-0042-5

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: a systematic mapping study. *Educational Technology & Society, 18*(3), 75–88.

Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J.J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, *63*, 380–392. https://doi.org/10.1016/j.compedu.2012.12.020

Dziob, D. (2020). Board game in physics classes—A proposal for a new method of student assessment. *Research in Science Education*, *50*(3), 845-862. Fernández-Río, J., de las Heras, E., González, T., Trillo, V., & Palomares, J. (2020). Gamification and physical education. Viability and preliminary views from students and teachers. *Physical Education and Sport Pedagogy*, *25*(5), 509–524. https://doi.org/10.1007/s11165-018-9714-y

Ferriz-Valero, A., Østerlie, O., García-Martínez, S., & García-Jaén, M. (2020). Gamification in physical education:

Evaluation of impact on motivation and academic performance within higher education. *International Journal of Environmental Research and Public Health*, *17*(12), 4465. https://doi.org/10.3390/ijerph17124465

Frącz, W. (2015). *An empirical study inspecting the benefits of gamification applied to university classes*. 7th Computer Science and Electronic Engineering Conference (CEEC). Conference Proceedings. Piscataway: IEEE. https://doi.org/10.1109/CEEC.2015.7332713

Frost, R. D., Matta, V., & MacIvor, E. (2015). Assessing the efficacy of incorporating game dynamics in a learning management system. *Journal of Information Systems Education*, *26*(1), 59-70. Retrieved from https://aisel.aisnet.org/jise/vol26/iss1/6

Garland, C. M. (2015). Gamification and implications for second language education: a meta-analysis (Master's thesis). St. Cloud State University, St. Cloud.

Gillette, C., Rudolph, M., Kimble, C., Rockich-Winston, N., Smith, L., & Broedel-Zaugg, K. (2018). A Meta-Analysis of Outcomes Comparing Flipped Classroom and Lecture. *American Journal of Pharmaceutical Education*, *82*(5), 433-440.

González-Cutre, D., A. Sicilia, A. C., Sierra, R. F., & Hagger, M. S. (2016). Understanding the Need for Novelty from the Perspective of Self-Determination Theory. *Personality and Individual Differences*, *102*, 159–169. https://doi.org/10.1016/j.paid.2016.06.036

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? - a literature review of empirical studies on gamification. In R. H. Sprague Jr. (Ed.), Proceedings of the 47th Annual Hawaii International Conference on System Sciences (pp. 3025–3034). Washington, DC: IEEE. https://doi.org/10.1109/HICSS.2014.377

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education*, *80*, 152–161. https://doi.org/10.1016/j.compedu.2014.08.019

Hattie, J. (2015). The applicability of Visible Learning to higher education. *Scholarship of teaching and learning in psychology*, *1*(1), 79. https://doi.org/10.1037/stl0000021

Higgins, J., White, I. & Anzures-Cabrera, J. (2008). Meta-analysis of skewed data: combining results reported on log-transformed or raw scales. *Statistics in Medicine*, *27***,** 6072-6092. https://doi.org/10.1002/sim.3427

Huang, B., Hew, K. F., & Lo, C. K. (2018). Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement. *Interactive Learning Environments*, 1–21. https://doi.org/10.1080/10494820.2018.1495653

Jiménez-Hernández, E. M., Oktaba, H., Díaz-Barriga, F., & Piattini, M. (2020). Using web-based gamified software to learn Boolean algebra simplification in a blended learning setting. *Computer Applications in Engineering Education*, *28*(6), 1591-1611. https://doi.org/10.1002/cae.22335

Joo, S., Johnsen, K., and Ball, C. (2019). Point based reward systems in gamification impact children's physical activity strategies and psychological needs. *Health Education & Behavior, 46*, 417–425. https://doi.org/10.1177/1090198118818241

Kapp, K. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. Pfeiffer. https://doi.org/10.1145/2207270.2211316

Khaleel, F. L., Ashaari, N. S., & Wook, T. S. M. T. (2019). An empirical study on gamification for learning programming language website. *Jurnal Teknologi*, *81*(2), 152-162. https://doi.org/10.11113/jt.v81.11133

Lim, M., Carpio, G. A. C., & Ong, C. M. (2019). Evaluation of Engagement in Learning Within Active Learning Classrooms: Does Novelty Make a Difference? *Journal of Learning Spaces*, *8*(2), 1–11.

Majuri, J., Koivisto, J., & Hamari, J. (2018). *Gamification of education and learning: A review of empirical literature.* Proceedings of the 2nd International GamiFIN Conference, GamiFIN 2018. CEUR-WS.

Marczewski, A. (2013). Gamification: A simple introduction and a bit more (2nd ed.). (Kindle edition self-published on Amazon Digital Services).

Marín, B., Frez, J., Cruz-Lemus, J., & Genero, M. (2018). An empirical Investigation on the Benefits of gamification in Programming courses. *ACM Transactions on Computing Education (TOCE)*, *19*(1), 1–22. https://doi.org/10.1145/3231709

Melero-Cañas, D., Morales-Baños, V., Manzano-Sánchez, D., Navarro-Ardoy, D., & Valero-Valenzuela, A. (2021). Effects of an Educational Hybrid Physical Education Program on Physical Fitness, Body Composition and

Sedentary and Physical Activity Times in Adolescents: The Seneb's Enigma. *Frontiers in psychology*, *11*, 629335. https://doi.org/10.3389/fpsyg.2020.629335

Mora-Gonzalez, J., Pérez-López, I. J., & Delgado-Fernández, M. (2020). The "$ in TIME" gamification project: using a mobile app to improve cardiorespiratory fitness levels of college students. *Games for health journal*, *9*(1), 37-44. https://doi.org/10.1089/g4h.2019.0001

Mora-Gonzalez, J., Pérez-López, I. J., Esteban-Cornejo, I., & Delgado-Fernández, M. (2020). A gamification-based intervention program that encourages physical activity improves cardiorespiratory fitness of college students: 'The Matrix rEFvolution Program'. *International journal of environmental research and public health*, *17*(3), 877. https://doi.org/10.3390/ijerph17030877

Ortiz-Rojas, M., Chiluiza, K., & Valcke, M. (2019). Gamification through leaderboards: An empirical study in engineering education. *Computer Applications in Engineering Education*, *27*(4), 777-788. https://doi.org/10.1002/cae.12116

Pérez-López, I. J., Rivera-García, E. R., & Trigueros-Cervantes, C. (2019). 12+1. Sentimientos del alumnado universitario de educación física frente a una propuesta de gamificación: "game of thrones: La ira de los dragones". *Movimento: revista da Escola de Educação Física*, (25), 1-15. https://doi.org/10.22456/1982-8918.88031

Pozo, S., López, J., Fuentes, A., & López, J. A. (2020). Gamification as a methodological complement to flipped learning—an incident factor in learning improvement. *Multimodal Technologies and Interaction*, *4*(2), 12-24. https://doi.org/10.3390/mti4020012

Ruiz-Ariza, A., Casuso, R.A., Suarez-Manzano, S., & Martínez-López, E.J. (2018). Effect of augmented reality game Pokémon GO on cognitive performance and emotional intelligence in adolescent young. *Computers & Education, 116*, 49-63. https://doi.org/10.1016/j.compedu.2017.09.002

Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: an organismic dialectical perspective. In R. M. Ryan & E. L. Deci (Eds.), *Handbook of self-determination research* (pp. 3–33). Rochester, NY: University of Rochester Press.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development and Wellness*. New York: Guilford Press. https://doi.org/10.1521/978.14625/28806

Sailer, M., & Homner, L. (2020). The Gamification of Learning: a Meta-analysis. *Educational Psychology Review*, *32*, 77–112. https://doi.org/10.1007/s10648-019-09498-w

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, *74*, 14-31. https://doi.org/10.1016/j.ijhcs.2014.09.006

Segura-Robles, A., Fuentes-Cabrera, A., Parra-González, M. E., & López-Belmonte, J. (2020a). Effects on personal factors through flipped learning and gamification as combined methodologies in secondary education. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01103

Segura-Robles, A., Parra-González, M., & Gallardo-Vigil, M. (2020b). Bibliometric and collaborative network analysis on active methodologies in education. *Journal of New Approaches in Educational Research (NAER Journal)*, *9*(2), 259-274. https://doi.org/10.7821/naer.2020.7.575

Stansbury, J., & Earnest, D. (2017). Meaningful gamification in an industrial/organizational psychology course. *Teaching of Psychology*, *44*(1), 38-45. https://doi.org/10.1177/0098628316677645

Su, C. (2016). The effects of students' learning anxiety and motivation on the learning achievement in the activity theory based gamified learning environment. *EURASIA Journal of mathematics, science and technology education*, *13*(5), 1229-1258. https://doi.org/10.12973/eurasia.2017.00669a

Tomporowski, P. D., Davis, C. L., Miller, P. H., & Naglieri, J. A. (2008). Exercise and children's intelligence, cognition, and academic achievement. *Educational Psychology Review, 20*(2), 111-131. https://doi.org/10.1007/s10648-007-9057-0

Werbach, K., & Hunter, D. (2012). *For the win: how Game Thinking can Revolutionize Your Business*. Philadelphia: Wharton Digital Press.

Wichadee, S., & Pattanapichet, F. (2018). Enhancement of performance and motivation through application of digital games in an English language class. *Teaching English with Technology*, *18*(1), 77-92.

Yıldırım, İ., & Şen, S. (2019). The effects of gamification on students' academic achievement: A meta-analysis

study. *Interactive Learning Environments*, 1-18. https://doi.org/10.1080/10494820.2019.1636089