Improved Students' Performance within Gamified Learning Environment: A Meta-Analysis Study

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Abstract

Gamification is defined as the use of game-design elements in non-game contexts. This study aims to investigate the effect of gamification in education. A meta-analysis study was used and articles (21) published between 2012 and 2018 were analysed in several databases and digital libraries. Most of the selected articles were journal manuscripts (81%), including undergraduate students (57.1%), predominantly using the web-based technologies (33.3%), digital game-based learning (28.6%) and learning management system (28.6%) as a game delivery platform. The most gamified subjects were Languages (19%) and Information Technology (IT) (14.3%). It was observed that students at the post-secondary level (SMD=0.809, p=0.004) seem to benefit more from gamification than those from the post-graduate level (SMD=-0.930, p=0.000). Most of the subjects gamified showed positive effects, some of them statistically significant (Language, Maths and Science). In conclusion, the meta-analysis showed that students' performance can improve by 50% when the subject is gamified. Web-based technologies were the most widely used platform for gamification.

Keywords: Gamification; Education; Serious games; Meta-Analysis; Student Performance.

1. Introduction

Gamification is a relatively new concept that aims to improve people's motivation and engagement in different aspects of their lives. It is defined as the use of game design elements in non-game contexts, where the redesign of certain processes embeds characteristics that are more commonly found in games (Detering et al., 2011a) Usually, present game design elements have a pyramidal hierarchy composed of three layers; components, mechanics and dynamics (Werbach & Hunter, 2012).

Gamification builds on established game-based approaches and an understanding of the nature of humankind, founded on behavioural economics and psychology, to allow system designers to achieve objectives. Gamification is applied in various disciplines to promote and encourage certain behaviours (Wood & Reiners, 2015).

Considering that gamification is an informal umbrella term for the use of video game elements in non-gaming systems (Detering et al., 2011a), the recent introduction of gamified applications in the educational environment aims to improve students' performance by improving their motivation and engagement (Deterding et al., 2011b).

The concept of game thinking implanted in the educational environment, when content is gamified, creates opportunities for more innovative approaches and increases the sense of creativity. In addition, playful or game-based approaches stimulate a certain degree of learner autonomy and improve the student-teacher relationship (Davies et al., 2013).

Different educational organizations are using gamification practices, getting results on student performance, and publishing them. A meta-analysis is the appropriate method to statistically summarize these results and answer the main question: What is the impact of gamification on student performance?

In this sense, the aim of this study is to investigate the effect of gamification in education, using a meta-analysis study as a methodology.

2. Theoretical Background

The concept of gamification is fairly new and numerous forms of gamification are grounded in providing external rewards for tasks and thereby manipulating the users to engage in a real world setting in order to earn rewards. Reward-based gamification is used for short-term change as it can quickly create a spike in engagement, but if the rewards are stopped, the engaged behaviour will stop with it (Nicholson, 2015).

Thus, it is game mechanics that stimulate people to participate in and enjoy a game (Taspinar, Schmidt & Schuhbauer, 2016). Having this in mind, finding a way to satisfy the needs of every player will guarantee the success rate of a particular game.

Preferences and psychological perceptions of people influence the way they can be motivated and involved in a game. According to the meta-analysis conducted by Baptista and Oliveira, that considered 54 studies, the most relevant predictors of intention to use gamification are attitude, enjoyment, and usefulness (Baptista & Oliveira, 2019). Another study focused on one single element in the form of digital achievements, one cornerstone of gamification to gain unconfounded insights into the effects and working mechanisms of digital achievements using a controlled experimental environment. This study found that achievements also improved motivation, although this only happens when it comes to persistence, not self-reported interest and enjoyment (Groening & Binnewies, 2019). Therefore, in order to create a successful game, it is of utmost importance to know for which types of players it is intended for (Bartle, 1996).

However, the concept of gamification is related to the advance in the internet and social medias. The big social media revolution began around 2008, when Facebook®, Instagram®, and Snapchat®, reached almost one billion consumers' use. In the meantime, smartphone technology has become more attractive, the price is more affordable, and use increased. These events impacted directly in the way that people communicate and also in different systems, including, in the educational system (Phua, Jin & Kim, 2017).

Nowadays, learners are part of a generation describe as “Digital Natives” (Prensky, 2001). Faced this, teachers and educators were pressured to change their teaching strategies and thus, gamification came as a new component. Gamification has been used as an alternative to contribute to modern education.

3. Methodology

The success of implementing gamification within the educational sphere is debatable, due to contrasting findings from different studies. For this reason, the increase in publications regarding the topic has allowed for conducting a meta-analysis of recent literature, in order to shed light on the success rate of implementing such a system within an educational setting.

According to this, the main guiding question is ‘What is the impact of gamification on student performance?**’.**

Based on the main guiding question following questions were derived: (i) Does the implementation of a gamified learning system (or gamification elements) increase knowledge retention or acquisition of taught content? (ii) Are there additional ways in which the researchers measured the success rate of implementing a gamified system? (iii) Which gamification elements/techniques/designs are linked to a higher success rate?

3.1. Research Selection and Data Collection

The meta-analysis incorporates works indexed in key databases and digital libraries, including: Education Resources Information Centre (ERIC), ProQuest, ACM Digital Library, IEEE Xplore, ISI Web of Science, Scopus, Science Direct (Elsevier), Wiley Online Library, Springer Link, Jstor, Ebsco and Google Scholar. Peer-reviewed literature was exclusively included in the search, in order to ensure the quality of the results for the meta-analysis.

Despite the fact that grey literature can broaden the range of relevant studies and give a somewhat more representative picture of the available evidence, it can also contaminate the data due to inadequate research methodologies and participant recruitment strategies. In order to minimise the risk of biasing, it was decided to exclude non-peer-reviewed works. Despite this, articles in peer-reviewed non-indexed journals; handbooks and manuals pertaining to the relevant topic; graduate theses; and dissertations were not excluded from the search.

The literature review was carried out between September and October of 2018. The research sought out articles published between 2012 and 2018.

The relevant publications were classified using three levels of specificity, according to the search keywords used: Level 1 used the keyword ‘gamification’, Level 2 used the keyword ‘gamification’, the Boolean operator ‘AND’ together with ‘education’. Level 3 utilised the keywords ‘gamification’ and ‘education’ and ‘control’. The reason was to narrow down the search, with each level making it more specific and targeted towards the inclusion and exclusion criteria. In addition, the filtration process included an analysis of the articles based on the inclusion and exclusion criteria. These predefined criteria were as follows:

- Only empirical articles utilising a variety of study designs including triangulation or a quantitative analytic approach were to be included.
- The participants were to be over the age of 11 (e.g. students in secondary, post- secondary and higher education, including university).

- The resources were to consist of peer-reviewed journals and conference papers to ensure a high quality of material to be considered for analysis. The articles needed to be available in English.
- The articles needed to adhere to the objective of the study by utilising gamification or game-elements within an education setting and measuring an outcome.
- Review articles, existing meta-analysis and systematic reviews were not to be included but were to be used as a cross-validation of the articles included.
- Individual studies from reviews, meta-analysis or systematic studies could be included if the inclusion and exclusion criteria were met.
- The articles included games and simulations used in traditional and online teaching environments.
- The use of non-Game based learning (GBL) tools and entertainment games were excluded.
- Articles that could not be accessed as full texts were excluded.

3.2. Data Analysis

2.2.1 Descriptive Statistics

Initially, the data set characteristics were analysed, such as countries the studies were conducted in, subject discipline, type of gamification system used, game delivery platform, educational level of participants and type of article being analysed. Subsequently, these variations in data were analysed for any existing correlations between: (i) subject *vs* type of system used, (ii) subject *vs* game delivery platform, (iii) subject *vs* educational level, (iv) country *vs* type of system used, (v) country *vs* game delivery platform and (vi) game delivery platform *vs* year of publication. The descriptive statistical analyses were conducted using Excel (Microsoft Office version 16.0, 2016).

2.2.2 Meta-Analytic Model

A meta-analysis is the quantification of the results of various scientific papers for a statistical model, which is usually expressed by the size of the effect (Hedges & Pigott, 2004).

A meta-analysis was conducted on different types of data extracted from the articles. A meta-analysis provides a highly accurate method to compute and visually represent the effect that gamification or gaming elements have on students' performance, attention, engagement and motivation. It allows the combination of results from several works studying similar phenomena. All the statistical computations and graphical representations for the meta-analysis were conducted using Comprehensive Meta-Analysis (CMA) software package (USA, Version 3.3.070, November 20, 2014). CMA allows for the insertion of different data sizes to compute the effect size. It automatically computes the standardized difference in means, Hedge's G and correlation, together with the standard error and variance for each statistic.

In addition, CMA modifies the weights to be taken into account and corrects the study-specific faults, such as measurement reliability. Any chosen method for conducting a meta-analytic computation includes at least two different models, namely to account for fixed and random effects. In principle, a fixed effects model should be used when the studies share identical data collection conditions and a single value for the true effect is assumed. Thus, using a fixed effect generally produces less variance as well as tighter confidence intervals.

On the other hand, a random effects model should be used when the study conditions are expected to vary and the distribution of the true effect is assumed. One cannot assume that identical study conditions exist between the articles. Moreover, as the data suggests there are dissimilar conditions with different variables, different cultures and demographics among the respondents and therefore random effects meta-analysis was employed.

2.2.2.1 Test of heterogeneity

Tests for heterogeneity were applied and confirmed the assumption that a random-effects model is preferred to a fixed-effects model. Prediction intervals from random-effects meta-analyses are a useful device for presenting the extent of between-study variation. The heterogeneity of the data was tested with Q-statistics and I^2 values. The Q-statistic is the classical measure for heterogeneity. The Q statistic is defined as follows:

$$Q = \sum_{i=1}^{k} Wi(Yi - \beta F)^2$$

Where $\beta_F = \sum (wi\ k\ i{=}1\ yi) / \sum wi\ k\ i{=}1$ and wi= 1/vi are the estimated common effect and the weight (and precision), respectively.

The I^2 value, which can be interpreted as the proportion of the total variation of the effect size due to the between-study heterogeneity. The minimum of 0% indicates that all variability is instead due to sampling error within trials (Higgins & Thompson, 2002). The p-value is statistically significant and the I^2-value is above 90%. Therefore, with these statistics assumed, a high heterogeneity and the random-effects model is indeed the most appropriate approach for conducting this meta-analysis.

2.2.2.2 Power Analysis

Power is directly related to the Type II error level (β) and is defined as: Power = 1- β. It is common practice to set the Type I error level (α) to 0.05, and thus assume that the Type I error is four times as grave as the Type II error. This means that falsely finding an effect while there is no effect in reality is four times as bad as not finding an effect whilst there is one in reality. The type II error is, therefore, set at β = 0.20, and the power should therefore be: 1-β= 1- 0.20 = 80%. For power analysis under the random-effects models, the formula used to calculate the variance of the true mean effect is as follows:

$$V^*\delta = \frac{V_Y + \tau^2}{k}$$

According to (Hedges & Pigott, 2004), the following formula may be used to calculate the power in the random-effect model assuming high heterogeneity (I^2=92.881).

$$V^*\delta = 2 \times \frac{VY}{k}$$

The programming language 'R' (version 2.11, 2010) was used to calculate the power in the meta-analysis, assuming random-effects high heterogeneity.

2.2.2.3 Effect interpretation & Publication Bias

Correlation effect sizes were interpreted using Cohen's (1988) method as: small, medium and large thresholds. The three classes for interpreting effect sizes were: Small (for values between 0.10 – 0.30); Medium (for values between 0.30 – 0.50); Large (for values between 0.50 – 1.00).

To address the problem of the publication bias, several tests were carried out using CMA. The basic issue underlying the publication bias is that not all completed studies are published, and the selection process is not random (hence the bias). Rather, studies that report relatively large treatment effects are more likely to be submitted and/or accepted for publication than studies which report more modest treatment effects. Since the treatment effect estimated from a biased collection of studies would tend to overestimate the effect, it is important to assess the likely extent of the bias and its potential impact on the conclusions.

2.2.2.4 Moderator Analysis Tests

Study characteristics such as year of publication, countries of participants, subjects gamified and level of education can be used as moderators. The difference between the correlation estimates is examined by way of a Q-test, which tests the homogeneity and significance of variance between groups (Borenstein, Hedges, Higgins & Rothstein, 2009).

Similar to the actual meta-analysis, the test also requires some decisions regarding the calculation model to be used. First, one must choose a fixed or random effects model, depending on how the within group estimates are to be calculated. Similar to the main meta-analysis, there is no reason to believe that even studies within the same group categories would have such identical research conditions, therefore, a random effects model was assumed. As a second issue, one must decide whether to assume true between-studies variance for both subgroups or to estimate separate variances.

4. Results

4.1. Descriptive Analysis

Implementing the first search level across all aforementioned databases and digital libraries returned a total of 8042 unique works. These articles unequivocally addressed gamification. The second search criterion, reduced the total number of articles by 44.16% to a total of 4491 articles. The third search criterion further reduced the number of articles by 49.19%, resulting in a total of 2282 articles.

All results are summarized in Table 1.

Table 1

Results of the library and online database search showed according to the keywords.

	Level 1	**Level 2**	**% Drop**	**Level 3**	**% Drop**
ERIC	180	148	-17.78%	19	-87.16%
ProQuest	724	609	-15.88%	319	-47.62%
ACM DL	693	223	-67.82%	2	-99.10%
AISEL	391	5	-98.72%	0	-100.00%

IEEE Xplore	787	324	-58.83%	31	-90.43%
Science Direct / Scopus	1016	663	-34.74%	474	-28.51%
Springer link	2461	1506	-38.81%	952	-36.79%
Wiley Online Library	702	437	-37.75%	340	-22.20%
EBSCO	804	382	-52.49%	32	-91.62%
Jstor	284	194	-31.69%	113	-41.75%
Total	**8042**	**4491**	**-44.16%**	**2282**	**-49.19%**

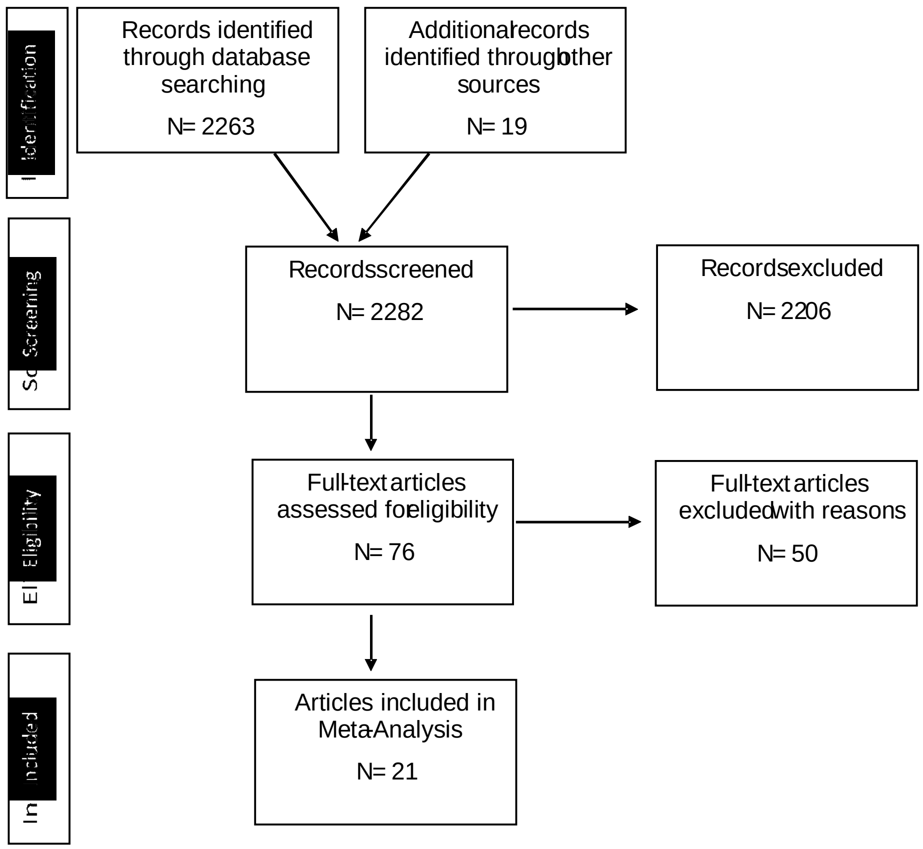
Note. *According to the keywords the levels were classified in: Level 1: gamification; Level 2: gamification and education; and Level 3: gamification and education and control. The data are represented in absolute and relative numbers (percentage).

A total of 2282 articles were than screened thoroughly against the inclusion and exclusion criteria and a total of 2206 articles were rejected due to not meeting the pre-determined requirements. Seventy-six full-text articles were assessed for eligibility and, out of these, a further 50 articles were excluded on the basis of: (i) having participants younger than the age of 11, (ii) having no control group or the control group incorporated wasn't compatible with researchers' expectations, (iii) insufficiently reported results, unclear study methodology and variable definitions (iv) articles that didn't fit the purpose of the literature review. Duplicates were continuously removed throughout the whole screening process

The search process resulted in 21 relevant articles which were included in the quantitative analysis. The majority of selected articles were journal manuscripts (81%) and 19% were conference papers.

Figure 1 shows all the search processes and selection of studies, and they are presented according to PRISM Flow Diagram based on Moher, Liberati, Tetzlaff & Altman (2009).

Figure 1
Search and selection process of studies according to previously established eligibility criteria.

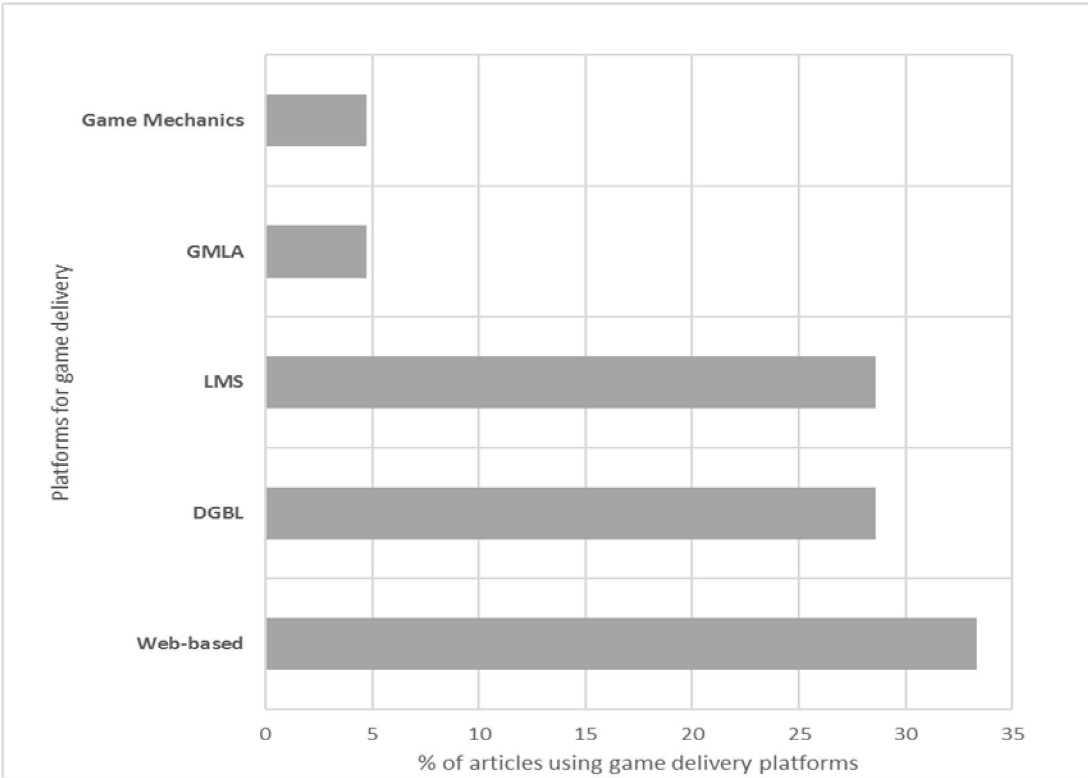


The majority of the articles included was composed by undergraduate students (57.1%), followed by secondary students (14.3%), post-secondary students (14.3%), primary students (9.5%) and post-graduate students (4.8%).

The types of gamified systems utilized were also taken into consideration and divided into two different categories: standard systems (57%) and custom systems (43%). Standard systems included games already out on the market such as *Kahoot!*® and Minecraft®, for example, whilst custom systems included personalized systems developed for a particular educational institution, and also shows the type of technology used for the integrated gamified environments. Amongst the selected articles, the most commonly used platform for game delivery was web-based (33.3%) (Figure 2).

Figure 2

Percentage of platforms chosen for game delivery according to the studies included in this research.



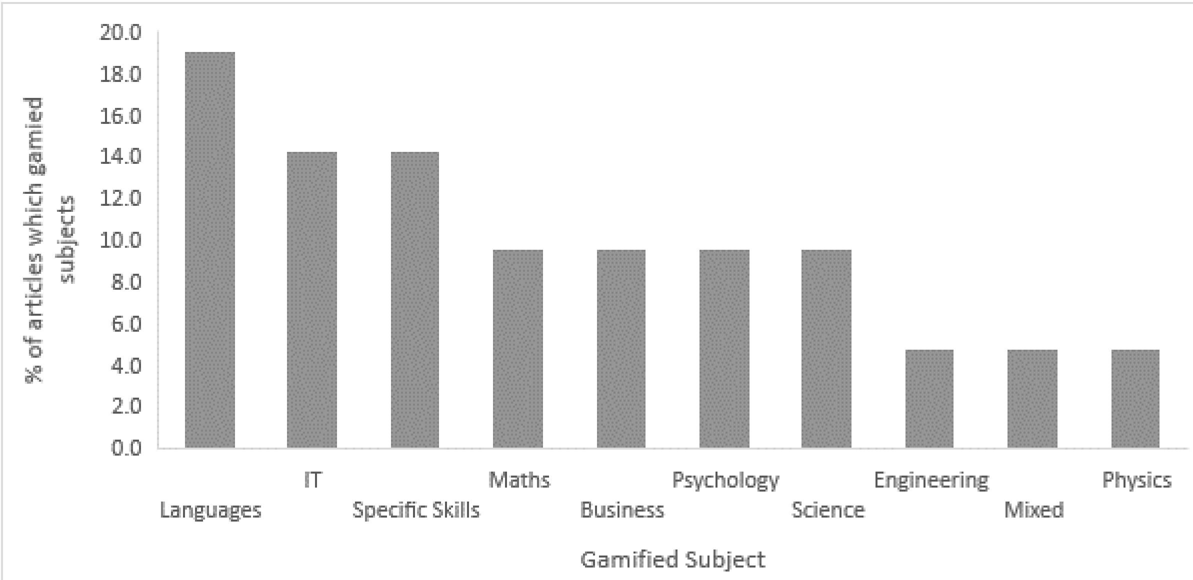
Note. DGBL, Digital Game-Based Learning; LMS, Learning Management System; GMLA, Gamified Mobile Learning Application.

The largest quantity of studies was from the United State (5 studies), followed by 3 studies from Taiwan, 2 from Hong Kong, and 2 from Thailand. One article in Jamaica, Spain, Netherlands, Japan, Indonesia, India, and Australia.

The most gamified subjects were Languages (19%), followed by Information Technology (IT) (14.3%), and Specific Skills (14.3%). Figure 3 shows all the results.

Figure 3

Percentage of subjects gamified according to the studies included in this research.



Note. IT, Information Technology. The subject classified as 'Mixed' represents two articles that gamified more than one subject.

4.2. Meta-Analytic Model

Research showed that the impact of gamification within an educational setting has mixed results on students' performance levels. In order to consolidate the results from the different studies, a basic meta-analysis test was run using CMA.

Table 2 shows a random-effect meta-analysis based on the difference between the results of the pre- and post-test comparing traditional and gamified teaching approaches. The effect size is the standard difference in means. A standard difference in mean of less than 0 indicates that gamification had a negative decrease on students' performances, a standard mean difference of 0 indicates no effect, and a standard mean difference higher than 0 indicates an increase on students' performances. The pooled random effect is 0.466 with a 95% confidence interval of 0.111 and 0.822 (p=0.010).

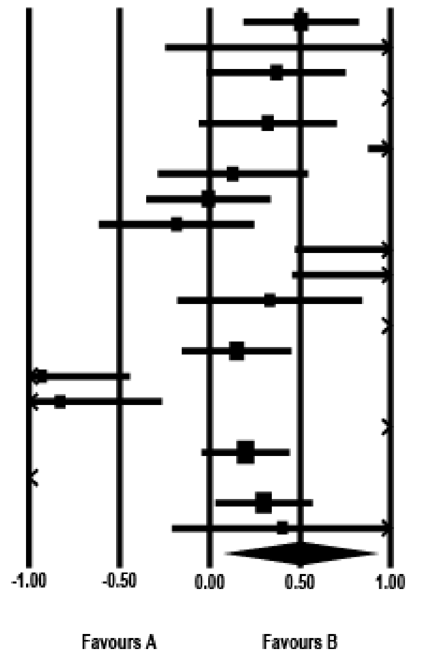
Thus, there is evidence that gamification does improve students' performances by approximately 50%. Equally important, however, is the variation in the treatment effect, with the standard means difference in individual studies ranging from -4.013 (indicating a 400% decrease in student's performance) to 4.074 (indicating a 400% increase in student's performance). While some of the observed variance in effects is probably due to sampling error, a substantial amount of the variance reflects real differences in the treatment effect (gamification). In order to understand why gamification was more effective in some studies when compared to the others, four moderators were included in the meta-analysis: country of publication, level of education, subjects that were gamified and year of publication.

Table 2

Meta-analysis results on differences in effect size for student performance according to the studies included in this research.

Study name	SMD	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
de-Marcos, Dominguez, Saenz-de-Navarrete & Pagés, 2014	0.506	0.159	0.025	0.195	0.818	3.183	0.001*
Naik & Kamat, 2015	1.038	0.650	0.423	-0.237	2.312	1.595	0.111
Goehle & Wagaman, 2015	0.369	0.192	0.037	-0.008	0.745	1.919	0.055*
Gressick & Langston, 2017	1.483	0.233	0.054	1.026	1.940	6.359	0.000*
Buhagiar & Leo, 2018	0.320	0.191	0.036	-0.053	0.694	1.681	0.093
Wichadee & Pattanapichet, 2018	1.382	0.254	0.064	0.884	1.879	5.447	0.000*
Stansbury & Earnest, 2016	0.128	0.208	0.043	-0.279	0.536	0.616	0.538
Canton & Greenhill, 2014	-0.007	0.172	0.030	-0.344	0.331	-0.040	0.968
Frost, Matta & MacIvor, 2015	-0.183	0.215	0.046	-0.604	0.238	-0.852	0.394
Lam, Hew & Chiu, 2018	1.066	0.300	0.090	0.479	1.653	3.560	0.000*
Fan & Xiao, 2015	1.155	0.352	0.124	0.465	1.846	3.280	0.001*
Wang, 2016	0.332	0.257	0.066	-0.172	0.835	1.292	0.196
Pan, 2017	4.074	0.392	0.154	3.306	4.843	10.391	0.000*
Saez-Lopez et al., 2015	0.149	0.150	0.023	-0.146	0.444	0.990	0.322
Abdool et al., 2017	-0.930	0.246	0.060	-1.411	-0.448	-3.785	0.000*
Zainuddin, 2018	-0.829	0.283	0.080	-1.384	-0.274	-2.928	0.003*
Kaneko et al., 2015	2.781	0.496	0.246	1.808	3.754	5.603	0.000*
Stapinski et al., 2017	0.199	0.120	0.014	-0.036	0.433	1.658	0.097
Asiksoy, 2017	-4.013	0.594	0.353	-5.176	-2.849	-6.757	0.000*
Kolovou, Heuvel-Panhuizen & Köller, 2013	0.299	0.133	0.018	0.039	0.559	2.250	0.024*
Hew et al., 2016	0.403	0.308	0.095	-0.201	1.007	1.309	0.191
Pooled Random Effect	0.466	0.181	0.033	0.111	0.822	2.570	0.010*

SMD and 95% CI



Note. SMD, Standardized Mean Difference; CI, Confidence Interval. *Statistically significant if p-value is <0.05.

In table 3, the country of publication was included as a moderator in the meta-analysis. The pooled random effect is 0.216 with a 95% confidence interval of 0.107 and 0.325 was statistically significant (p=0.000). Thus, there is evidence that the country of publication has an effect on the variance in the students' performance effect size (Standardized Mean Difference, SMD). The effect in Japan (SMD=2.781, p=0.000), Thailand (SMD=1.382, p=0.000), Hong Kong, China (SMD=0.739, p=0.026), Spain (SMD=0.506, p=0.001) and the Netherlands (SMD= 0.299, p=0.024) were significantly positive. On the other hand, research conducted in Turkey (SMD=-4.013, p=0.000), Jamaica (SMD= -0.930, p=0.000) and Indonesia (SMD= -0.829, p=0.026) showed that gamification had a significant negative effect.

When the level of education was used as a moderator, it was observed that students at the post-secondary level (SMD=0.809, p=0.004) seem to benefit more from gamification than those from the post-graduate level (SMD=-0.930, p=0.000).

Considering the subject gamified as a moderator, the effects were positive for gamification in the disciplines of Languages (SMD= 1.688, *p*=0.013), Maths (SMD= 0.321, *p*=0.003) and Science (SMD= 1.155, *p*=0.001). Negative effect was observed for the Engineering (SMD= -0.930, *p*=0.000) and Physics (SMD= -4.013, *p*=0.000) subjects.

Research published in 2013 (SMD= 0.299, *p*=0.024) and 2015 (SMD= 0.747, *p*=0.014) showed significant positive effects. All results are summarized in Table 3.

Table 3
Results of random effects, considering the study characteristics such as participants' countries, level of education, subject gamified and year of publication used as moderators.

Moderators	Covariate	SMD	Standard Error	Variance	CI 95%		Z-value	*p*-value
					Lower	Upper		
Country	***Overall***	*0.216*	*0.056*	*0.003*	*0.107*	*0.325*	*3.888*	*0.000**
	China	0.739	0.332	0.110	0.089	1.389	2.228	0.026*
	India	1.038	0.650	0.423	-0.237	2.312	1.595	0.111
	Indonesia	-0.829	0.283	0.080	-1.384	-0.274	-2.928	0.003*
	Jamaica	-0.930	0.246	0.060	-1.411	-0.448	-3.785	0.000*
	Japan	2.781	0.496	0.246	1.808	3.754	5.603	0.000*
	Mixed	0.149	0.150	0.023	-0.146	0.444	0.990	0.322
	Netherlands	0.299	0.133	0.018	0.039	0.559	2.250	0.024*
	Spain	0.506	0.159	0.025	0.195	0.818	3.183	0.001*
	Taiwan	1.839	1.080	1.167	-0.278	3.957	1.702	0.089
	Thailand	1.382	0.254	0.064	0.884	1.879	5.447	0.000*
	Turkey	-4.013	0.594	0.353	-5.176	-2.849	-6.757	0.000*
	UK	-0.007	0.172	0.030	-0.344	0.331	-0.040	0.968
	USA	0.417	0.257	0.066	-0.086	0.920	1.625	0.104
Level of Education	***Overall***	*0.006*	*0.125*	*0.016*	*-0.239*	*0.251*	*0.048*	*0.961*
	Post-graduate	-0.930	0.246	0.060	-1.411	-0.448	-3.785	0.000*
	Post-Secondary	0.809	0.279	0.078	0.262	1.356	2.899	0.004*
	Primary	2.168	1.888	3.563	-1.531	5.868	1.149	0.251
	Secondary	-0.089	0.236	0.056	-0.552	0.375	-0.375	0.071
	Undergraduate	0.393	0.248	0.062	-0.093	0.880	1.585	0.113
Subject Gamified	***Overall***	*0.156*	*0.071*	*0.005*	*0.017*	*0.296*	*2.193*	*0.028**
	Engineering	-0.930	0.246	0.060	-1.411	-0.448	-3.785	0.000*
	I.T.	0.341	0.242	0.058	-0.133	0.814	1.410	0.159
	Languages	1.688	0.681	0.463	0.354	3.022	2.480	0.013*
	Maths	0.321	0.109	0.012	0.107	0.536	2.942	0.003*
	Mixed	0.149	0.150	0.023	-0.146	0.444	0.990	0.322
	Physics	-4.013	0.594	0.353	-5.176	-2.849	-6.757	0.000*
	Psychology	0.801	0.677	0.459	-0.526	2.129	1.183	0.237
	Science	1.155	0.352	0.124	0.465	1.846	3.280	0.001*
	Specific Skills	0.549	0.491	0.241	-0.414	1.512	1.117	0.264
	Business	0.078	0.252	0.063	-0.415	0.571	0.312	0.755

Year of Publication	***Overall***	*0.318*	*0.085*	*0.007*	*0.151*	*0.485*	*3.736*	*0.000**
	2013	0.299	0.133	0.018	0.039	0.559	2.250	0.024*
	2014	0.254	0.257	0.066	-0.249	0.757	0.990	0.322
	2015	0.747	0.303	0.092	0.153	1.341	2.466	0.014*
	2016	0.251	0.143	0.020	-0.030	0.531	1.751	0.080
	2017	0.215	0.782	0.612	-1.318	1.748	0.275	0.783
	2018	0.485	0.451	0.204	-0.400	1.370	1.075	0.282

Note. SMD, Standardized Mean Difference; CI, Confidence Interval; UK, United Kingdom; USA, United States of America; IT, Information Technology. *Statistically significant if *p-value* is <0.05.

5. Discussion

This research was carried out in 2018, including 21 articles published between 2012 and 2018, using the keywords "gamification" and "education" and "control". In general, the articles examined the effects of the type of game delivery platform (web-based, digital game-based learning, gamified mobile learning applications, learning management systems, and game mechanics) in "experimental situations", on gamification of the subject matter and evaluate the cognitive or/and behavioural engagement, and other components.

Game Elements as an important part of gamification should include an Epic meaning, i.e. when the game is actually identified by users as a game; a Narrative, as the powerful tool, so users get involved in the plot; a Progress and feedback, sometimes called progression tracking or feedback looping; and Points, badges, and leader boards (PBL), usually represented by prizes or rewards. Thus, a customized gamification process can be developed according to the subject to be gamified and the characteristics of the users (Chou, 2015).

Among all the articles included in this meta-analysis, the study developed in Japan by Kaneko et al. (2016), showed positive effects (SMD= 2.781; *p*=0.000). This study used a Gamified Mobile Learning Application designed to run on mobile platforms such as iOS and Android, to evaluate the learning process related to library instruction (a specific skill). The study population was 32 participants divided into two groups: 15 from the experimental group and 17 from the control group. The study was published as a conference proceedings article, presented in 2015 at the "IIAI 4th International Congress on Advanced Applied Informatics".

Another article included in the current meta-analysis that showed positive effect (SMD= 1.382; *p*=0.000) was performed in Thailand (Wichadee & Pattanapichet, 2018). This was a quasi-experimental study with two groups of students (77 students in total), whereby, the experimental group (38 participants) was taught using the digital game *Kahoot*® whereas the control group (39 participants) was taught with the conventional method. The results of the survey indicated that students in the experimental group had positive attitudes towards the application of digital games in English language learning.

According to the four moderators used for the evaluation of this meta-analysis (country of publication, level of education, subjects that were gamified and year of publication), the study performed by Kolovou et al. (2013) was statistically significant for "country", "year" and "subject". The study was conducted with a convenience sample consisting of 236 sixth grade students from schools located in the city of Utrecht, Netherlands (SMD= 0.299; *p*=0.024), developed in 2013 (SMD= 0.299; *p*=0.024), and the subject gamified was Maths (SMD= 0.321; *p*=0.003). Statistical analyses showed a significant positive effect of the intervention on post-test performance when controlling for pre-test performance, mathematical ability, and gender.

Considering country as moderator, Taiwan compared with the other countries was not significant (SMD= 1.839; *p*= 0.084). However, when the three studies developed in Taiwan are analysed individually, it is observed that in the two of them (Fan, Xiao, & Su, 2015; Pan, 2017) results were statistically significant for the gamified subject.

With regards to the study by Fan, Xiao and Su (2015) the meta-analysis showed that the gamified subject (Science) was statistically significant (SMD= 1.155; *p*= 0.001). The aim of this study was to explore correlations between the learning styles, meaningful learning and learning achievement. By random distribution, the class was divided into an experimental group, composed of 12 male and 11 female students, and a control group, composed of 13 male and 10 female students. The platform used for game delivery was designed according to the principles of Digital Game-Based Learning model combined with a Mobile Meaningful Learning System for gamification. The research findings exposed divergences in mobile game-based learning styles. Although, students with different learning styles revealed significant variance in learning achievement, students in the experimental group scored significantly higher on the post-test than the students in the control group, whose scores barely differed from pre-test to post-test.

In Pan's study (2017), Language was the gamified subject and showed a significant difference (SMD=1.668; p=0.013). One hundred and twenty participants were chosen from an elementary school. The students were divided into three groups: a group using Kinect Motion Sensor Interactive System (KMIS), a group using a computer mouse and a control group. Students in the KMIS and computer mouse groups scored higher on both post-test and one-month-delayed test when compared to the control group. However, there was no significant difference between the KMIS and computer mouse groups. This implies that the motion-sensing interface of the KMIS did not have a key effect on short-term or long-term learning retention.

The study performed in Spain (De-Marcos, Domínguez, Saenz-De-Navarrete & Pagés, 2014) showed to be statistically significant in this meta-analysis (SMD: 0.506; *p*= 0.001). This study was designed with three groups. The Blackboard gamification plugin was used on a group of 114 first-year undergraduate students, the social networking site was delivered to a group of 184 first- and second-year undergraduate students, and the control group included 73 first- and second-year undergraduate students. Both, the gamification group and the social networking group outperformed the control group on practical assignments. Contrastingly, students in control group outperformed both experimental groups in written exam. Furthermore, although students in experimental groups had positive attitudes towards learning tools, participation rates and scores remained low.

The article published by Gressick and Langston (2017) discusses theory-driven classroom gamification innovations implemented in an undergraduate educational psychology course and uses a case study approach to understand how these changes impacted students' in-class learning experiences in positive ways. This was the only study where the authors used guild reports to calculate the average for each individual's scores obtained from peer rating and the average across group members for each guild in addition to considering final student course averages when comparing gamified with previous, traditionally-taught semester to assess students' knowledge acquisition in the gamified course. Student survey data and comments indicate that, from a student perspective, the innovations to the course were valued and encouraged learning, collaboration, and peer contacts. From an instructor perspective, the gamification elements promoted student learning and fostered a positive, collaborative classroom environment. The student's performance was effective (SMD= 1.483; p=0.000), tallying with this meta-analysis (Gressick & Langston, 2017).

Hew et al. (2016) reported the effects of game mechanics on student cognitive and behavioural engagements through two experiment studies conducted in an Asian university (Hong Kong). The authors found that the use of game mechanics had a positive effect on motivating students to engage with more difficult tasks, and that the quality of artefacts produced by participants in the experimental groups were higher than those in the control groups. The meta-analysis revealed that game mechanics improve students' performance (SMD= 1.066; p= 0.000) (Hew, Huang, Chu & Chiu, 2016).

In contrast, studies performed in Jamaica (Abdool et al., 2017), Indonesia (Zainuddin, 2018) and Turkey (Aşıksoy, 2018) showed negative effects related to student.

The study performed in Indonesia (Zainuddin, 2018) included students in the secondary level. The students' learning performance and perceived motivation in gamified flipped-class instruction related to Science were evaluated. This study employed a mixed-method research approach, using three formative assessments or post-tests design to examine students' learning achievement. The results reveal that while on the assessment 1 there was no significant difference between the the gamified flipped and non-gamified flipped classroom instruction (t=1.68, p=474), while assessment 2 and 3 were significantly different (t=5.54, p=.007 < .05) and (t=10.17, p=.001 < .05). The authors partially attributed results of the test 1 to the fact that, at the beginning of the intervention students were not familiar with a new instruction and initial assessment. On the other hand, the significant differences on the two subsequent post-tests were attributed to an iterative instructional cycle or formative assessment that students received.

Abdool et al. (2017) used a Data-RPG (Role-playing games) to improve student motivation in data science through game elements. The authors concluded that a further study is needed to ascertain whether this translates as an impact on end performance, and to rule out cohort specific effects.

The effects of the gamified flipped classroom environment (GFCE) on students' motivation, learning achievements and perception in a physics course were evaluated by Aşıksoy (2018), and the experimental results indicate that the students from the experimental group had a significantly increased motivation for the physics course and learning achievements in comparison to the students in the control group.

Overall, video games affect general cognitive domains, such as spatial cognition (Leong & Tang, 2017) and probabilistic learning (Schenk, Leich & Suchan, 2017). However, there is not yet much evidence for the effectiveness of games in science instruction or learning. The impact of games has been limited to particular components of education and there is little evidence that games, on their own, promote the development of scientific skills, the understanding of science content or an understanding of the nature of science. Surely the games will not replace teachers and classrooms, but they might replace some textbooks and laboratories (Morris, Croker, Zimmerman, Gill & Romig, 2013). The games may work best when coupled with other pedagogy models. For example, Wang (2016) concluded that introducing an interactive response system with the game-based competitive strategy, served as a positive contribution to the flipped classroom pedagogy; Lem, Hew and Ciu (2018) found a considerable improvement in students' writing using the blended learning approach and Pan suggests that employing interactive games with a questioning strategy promotes students' long-term English vocabulary retention (2017).

The advancement and popularity of computers and multimedia technologies have encouraged researchers to develop digital content and systems for mathematics courses (Hung, Huang & Hwang, 2014). In their study, Goehle and Wagaman (2016) found that despite the clear lack of evidence of overall improvement by students that participated in the gamified pedagogy, findings did offer preliminary evidence that the weak students can benefit from achievement system, especially in mathematics. Researchers have recognized advantages of integrating interactive mechanisms and higher media richness to support easier immersion in learning (Wu, 2016; Fan, Xiao & Su, 2015) as well as the importance of closely aligning specific game elements with the expected learning outcomes of a course (Hew et al., 2016).

The application of gamification in a pedagogical context provides some remedy for many students who find themselves alienated by traditional methods of instruction. In two articles that were analysed, gamified learning instruction has led to an improvement in quality and execution of the assigned practical tasks (Hew, Huang, Chu & Chiu, 2016; Marcos, Dominguez, Saenz de-Navarrete and Pages, 2014). Additionally, students within gamified settings, spent more time working on group projects and completed a wider variety of tasks (Pan, 2017). Still, longitudinal studies need to be conducted in order to develop a full understanding of the effect of gamification on the learners' engagement and motivation (Kyewski & Krämer, 2018; Alsawaier, 2018).

Table 5 summarizes the significant positive results among the studies included in this research. It is possible to add that the DGBL platform seems to be the most efficient in the gamification process.

Table 5

Profile of the studies with statistically significant results (positive effects) in the meta-analysis.

Articles	Summary Type	Level	Country	Subject	Game Platform	Participants
de-Marcos, Dominguez, Saenz-de-Navarrete & Pagés (2014)	Journal	Undergraduate	Spain	IT	LMS	371
Gressick & Langston (2017)	Journal	Undergraduate	US	Psychology	DGBL	117
Wichadee & Pattanapichet (2018)	Journal	Undergraduate	Thailand	Languages	Web-based	77
Lam, Hew & Chiu (2018)	Journal	Post-Secondary	Hong Kong	Languages	Web-based	72
Fan, Xiao & Su (2015)	Journal	Post-Secondary	Taiwan	Science	DGBL*	46
Pan (2017)	Journal	Primary	Taiwan	Languages	DGBL	160
Kaneko *et al.* (2015)	Conference	Undergraduate	Japan	Specific Skills	GMLA	32
Kolovou *et al.* (2013)	Journal	Primary	Netherlands	Maths	DGBL	225

Note. IT, Information Technology; US, United States; DGBL, Digital Game-Based Learning; LMS, Learning Management System; GMLA, Gamified Mobile Learning Application. * The design followed the principles of Digital Game-Based Learning model combined with a Mobile Meaningful Learning System for gamification.

Four of the eight articles with statistically significant positive results in the meta-analysis utilised DGBL platform. Digital Game-based Learning (DGBL) refers to the development and use of computer games for educational purposes (Prensky, 2001). A DGBL activity engages students in the process of problem solving or knowledge acquisition when facing the challenges presented by the game (Huang, Huang & Tschopp, 2010).

However, learning management systems (LMS) and web-based technologies seem to be efficient. In both articles with statistically significant positive results that have been using web-based technologies as a game delivery platform, the subject that was gamified was second language. Whereas, in one of the studies *Kahoot!*® quizzes were used to assess students understanding of grammar and vocabulary, while in the other study students used *Edmondo* platform for online discussions on the argumentative topic what was expected to help them to learn how think more argumentatively. Only one article that had statistically significant positive result utilized LMS as a platform for delivery of gamified instruction. Namely, gamification plug in of Blackboard system was used and seven badges were designed and included in the system. Some of the badges were hidden so they could trigger a sense of surprise or an emotion.

Many researchers have taken a great deal of effort to promote high quality game-based learning applications, such as educational games, animations, simulations, animated or interactive simulation mechanisms in learning management system (LMS), (Giuffra Palomino, Azambuja Silveira & Nakayama, 2014; Kuk, Rančić, Pronić-Rančić & Ranđelović, 2016). Hwang, Wu, and Chen developed an online game in the form of a competitive board game for carrying out web-based problem-solving activities (2012).

6. Limitations

This study was restricted by design because it did not perform meta-regression analysis. Meta-regression consists of a form of sensitivity analysis in meta-analysis, allowing to evaluate the impact of covariates on the meta-analysed results.

This study did not analyse the possible side-effects or negative outcomes related to gamification in education.

Overall, more research on gamification is needed to ascertain the learning benefits and also the side effects potentially related to this process.

7. Recommendations

The potential of gamification to improve learning achievement is not direct, but it lies in its ability to increase student motivation to learn and therefore improves students' engagement with the learning material.

This study recommends the gamification of the content with caution, considering that the School/Institution should first assess the students' profile (age, educational level, social and psychological factors, and access to electronic devices, for example), characteristics of the content to be gamified, assessment or follow-up to be employed and tools for controlling gamification-related side effects.

8. Conclusion

The meta-analysis showed that students' performance can improve by 50% with a gamified teaching environment, however, there is a big amount of variance in the students' results possibly due to sampling errors or confounding covariates. When level of education was included as a moderator, results indicated that gamification is most likely to produce positive results when introduced at a post-secondary level of education.

With regards to subjects tested, the meta-analysis indicated that languages had the highest positive results in students' performance when they were gamified, together with science and maths.

Web-based learning, learning management system (LMS) and digital gaming-based learning (DGBL) were the most widely used platforms for gamification, however, DGBL seemed to be the most efficient considering the number of studies with positive results.

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Conflict of Interest

None.

References

Abdool, A., Ringis, D., Maharajh, A., Sirju, L., & Abdool, H. (2017). DataRPG: Improving student motivation in data science through gaming elements. *Proceedings - Frontiers in Education Conference, FIE*, *2017-October* (October), 1–5. https://doi.org/10.1109/FIE.2017.8190442

Alsawaier, R. S. (2018). The Effect of Gamification on Motivation and Engagement. *International Journal of Information and Learning Technology*, *35*(1), 56–79. file:///C:/Users/flaviacmp/Downloads/The_Effect_of_Gamification_on_Motivation_and_Engag.pdf

Aşıksoy, G. (2018). The effects of the gamified flipped classroom environment (GFCE) on students' motivation, learning achievements and perception in a physics course. *Quality & Quantity*, *52*(S1), 129–145. https://doi.org/10.1007/s11135-017-0597-1

Baptista, G., & Oliveira, T. (2019). Gamification and serious games: A literature meta-analysis and integrative model. *Computers in Human Behavior*, *92*, 306–315. https://doi.org/10.1016/j.chb.2018.11.030

Bartle, R. (1996). Hearts, clubs, diamonds, spades: Players who suit MUDs. *MUSE Ltd, Colchester, Essex*, p. 28. https://www.researchgate.net/publication/247190693%0D

Borenstein, M., Hedges, L. V, Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction To Meta Aalysis*.

Chou, Y. -K. (2015). Actionable gamification: Beyond points, badges and leaderboards https://www.nima.today/wp-content/uploads/2018/11/Actionable-Gamification-Beyond-Points-Badges-And-Leaderboard.pdf

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education-A systematic literature review. *Thinking Skills and Creativity*, *8*(1), 80–91. https://doi.org/10.1016/j.tsc.2012.07.004

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

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011a). From game design elements to gamefulness. *From Game Design Elements to Gamefulness: Defining "Gamification". Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11*, 9. https://doi.org/10.1145/2181037.2181040

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011b). Gamification: Using Game Design Elements in Non-Gaming Contexts. *CHI, 2011 Conference on Human Factors in Computing Systems*, 5–8. http://dl.acm.org/citation.cfm?id=1979575

Fan, K. K., Xiao, P., -W, & Su, C. H. (2015). The effects of learning styles and meaningful learning on the learning achievement of gamification health education curriculum. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 1211–1229. https://doi.org/10.12973/eurasia.2015.1413a

Giuffra Palomino, C. E., Azambuja Silveira, R., & Nakayama, M. K. (2014). *An Intelligent LMS Model Based on Intelligent Tutoring Systems*. https://doi.org/10.1007/978-3-319-07221-0_72

Gressick, J., & Langston, J. B. (2017). The Guilded Classroom: Using Gamification to Engage and Motivate Undergraduates. *Journal of the Scholarship of Teaching and Learning*, *17*(3), 109–123. https://doi.org/10.14434/v17i3.22119

Groening, C., & Binnewies, C. (2019). "Achievement unlocked!" - The impact of digital achievements as a gamification element on motivation and performance. *Computers in Human Behavior*, *97*, 151–166. https://doi.org/10.1016/j.chb.2019.02.026

Hedges, L. V., & Pigott, T. D. (2004). The Power of Statistical Tests for Moderators in Meta-Analysis. *Psychological Methods*, *9*(4), 426–445. https://doi.org/10.1037/1082-989X.9.4.426

Hew, K. F., Huang, B., Chu, K. W. S., & Chiu, D. K. W. (2016). Engaging Asian students through game mechanics: Findings from two experiment studies. *Computers and Education*, *92–93*, 221–236. https://doi.org/10.1016/j.compedu.2015.10.010

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine*, *21*(11), 1539–1558. https://doi.org/10.1002/sim.1186

Huang, W.-H., Huang, W.-Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. *Computers & Education*, *55*(2), 789–797. https://doi.org/10.1016/j.compedu.2010.03.011

Hung, C.-M., Huang, I., & Hwang, G.-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education*, *1*(2–3), 151–166. https://doi.org/10.1007/s40692-014-0008-8

Hwang, G.-J., Wu, P.-H., & Chen, C.-C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, *59*(4), 1246–1256. Retrieved from https://www.learntechlib.org/p/50289/

Kaneko, K., Saito, Y., Nohara, Y., Kudo, E., & Yamada, M. (2016). A Game-Based Learning Environment Using the ARCS Model at a University Library. *Proceedings - 2015 IIAI 4th International Congress on Advanced Applied Informatics, IIAI-AAI 2015*, 403–408. https://doi.org/10.1109/IIAI-AAI.2015.285

Kolovou, A., Van Heuvel-Panhuizen, M. Den, & Koller, O. (2013). An intervention including an online game to improve grade 6 students' performance in early algebra. *Journal for Research in Mathematics Education*, *44*(3), 510–549. https://doi.org/10.5951/jresematheduc.44.3.0510

Kuk, K., Rančić, D., Pronić-Rančić, O., & Ranđelović, D. (2016). Intelligent Agents and Game-Based Learning Modules in a Learning Management System. *Agent and Multi-Agent Systems: Technology and Applications*, 233–245. https://doi.org/10.1007/978-3-319-39883-9_19

Kyewski, E., & Krämer, N. C. (2018). To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course. *Computers & Education*, *118*(1), 25–37. https://doi.org/https://doi.org/10.1016/j.compedu.2017.11.006

Leong, S., H. & Tang, H., E. (2017). Gamification for Non-Majors Mathematics: An Innovative Assignment Model. *Journal of Education and Practice*. 8(35, 201. https://files.eric.ed.gov/fulltext/ED579509.pdf

Moher D., Liberati A., Tetzlaff J., Altman D.G. (2009) The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *Open Med*. 3(2),123-13.

Morris, B. J., Croker, S., Zimmerman, C., Gill, D., & Romig, C. (2013). Gaming science: the "Gamification" of scientific thinking. *Frontiers in Psychology*, *4*, 607. https://doi.org/10.3389/fpsyg.2013.00607

Nicholson, S. (2015). A Recipe for Meaningful Gamification. *Gamification in Education and Business*, p. 16. http://scottnicholson.com/pubs/recipepreprint.pdf

Pan, W. F. (2017). The effects of using the kinect motion-sensing interactive system to enhance English learning for elementary students. *Educational Technology and Society*, *20*(2), 188–200.

Phua, J., Jin, S. V., & Kim, J. (2017). Gratifications of using Facebook, Twitter, Instagram, or Snapchat to follow brands: The moderating effect of social comparison, trust, tie strength, and network homophily on brand identification, brand engagement, brand commitment, and membership intentio. *Telematics and Informatics*, *34*(1), 412–424. https://doi.org/10.1016/j.tele.2016.06.004

Prensky, M. (2001). The Digital Game-Based Learning Revolution. *Learning*, *1*(1), 1–19. https://doi.org/10.1016/j.iheduc.2004.12.001

Schenk, S., Lech, R. K. & Suchan, B. (2017). Games people play: How video games improve probabilistic learning. *Behavioural Brain Research*. *335*, 208-214. https://www.sciencedirect.com/science/article/pii/S016643281730390X

Taspinar, B., Schmidt, W., & Schuhbauer, H. (2016). Gamification in Education: A Board Game Approach to Knowledge Acquisition. *Procedia Computer Science*, *99*, 101–116. https://doi.org/10.1016/j.procs.2016.09.104

Werbach, K., Hunter, D. (2012). *For the Win How Game Thinking Can Revolutionize Your Business*. Philadelphia: Wharton School Press (October 30, 2012).

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.

Wood, L. C., & Reiners, T. (2015). Gamification. In *Encyclopedia of Information Science and Technology, Third Edition* (pp. 3039–3047). https://doi.org/10.4018/978-1-4666-5888-2.ch297

Zainuddin, Z. (2018). Students' learning performance and perceived motivation in gamified flipped-class instruction. *Computers & Education*, *126*(1), 75–88. https://doi.org/10.1016/j.compedu.2018.07.003