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Gamified learning in higher education: A systematic review of the literature

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ABSTRACT

The ubiquitous presence of technology in classrooms has inspired a shift from traditional classroom lectures to integrated digital learning environments. These interactive learning environments present the opportunity to evolve the teaching process through the incorporation of game elements that have been shown to capture user attention, motivate towards goals, and promote competition, effective teamwork, and communication. Gamification and game-based learning systems aim to bring these benefits into the learning and teaching process. This paper presents a systematic literature review of game-based learning systems, frameworks that integrate game design elements, and various implementations of gamification in higher education. A systematic search of databases was conducted to select articles related to gamification in education for this review. The objective is to identify how gamified learning systems can be used and categorize its usefulness in higher education. The findings of this literature review allow higher education universities to employ and explore efficient gamified learning and teaching systems to improve student engagement, motivation, and performance.

1. Introduction

Games have been a source of enjoyment for several centuries and will continue to be so in the future (Sailer, Hense, Mayr, & Mandl, 2017). Games stir a number of positive emotions in humans such as feeling focused, engaged, and accomplished (Dias, 2017; Reeves & Read, 2009; Yee, 2006). People become more engaged and productive during games (Buckley & Doyle, 2016; Kim, 2012), and games have the potential to motivate individuals (Garris, Ahlers, & Driskell, 2002; Gee, 2007; Ryan, Rigby, & Przybylski, 2006; Sailer et al., 2017). The potential of games can be harnessed through the concepts of gamification. Gamification was first documented in 2008 but did not gain momentum until late 2010 (Deterding, Dixon, Khaled, & Nacke, 2011). Gamification can also be defined as the use of game design elements in non-game contexts (Deterding et al., 2011). Gamification can be applied in several contexts to influence the behaviors of individuals and has been used successfully in marketing and business contexts to influence consumer behavior (Zichermann & Cunningham, 2011). The main objective of gamification is to increase engagement (Kapp, 2012; Villagrasa, Fonseca, Redondo, & Duran, 2014). Poor student engagement and a lack of motivation are the major issues faced by teachers in schools (Lee & Hammer, 2011). For this reason, gamification has been applied mostly in educational contexts (De-Marcos, García-Cabot, & García-López, 2017; Hamari, Koivisto, & Sarsa, 2014). It is important to note that actual games do not need to be used when using gamification; rather, the game design elements from games are used in various contexts such as education and marketing.

Another aspect of gamification is the intentional use of games to fulfil learning objectives. The use of games in educational contexts as a part of learning objectives is defined as game-based learning (GBL) (Wiggins, 2016). Game-based learning has been found to have a positive effect on student engagement (Wiggins, 2016). Serious games (SGs), a form of game-based learning, have been used for learning in health, business, science, military, computer science, mathematics, and biology. A study by Connolly, Boyle, MacArthur, Hainey, and Boyle (2012) found improved knowledge acquisition, content mastery, and motivation to be the most common outcomes from using serious games for learning.

This paper presents a systematic literature review of gamified learning in higher education used in the form of both gamification and game-based learning. The sections below present the systematic literature review methodology, followed by the principle findings of this study and conclusions.

2. Systematic literature review methodology

A systematic review methodology was used to identify how gamified learning systems have been used and to categorize their use in higher education. The authors sought to identify the most widely recognized benefits and components of gamified learning. It is important to identify the contexts in which gamified learning systems thrive/succeed, and factors for their effective implementation. Peer-reviewed

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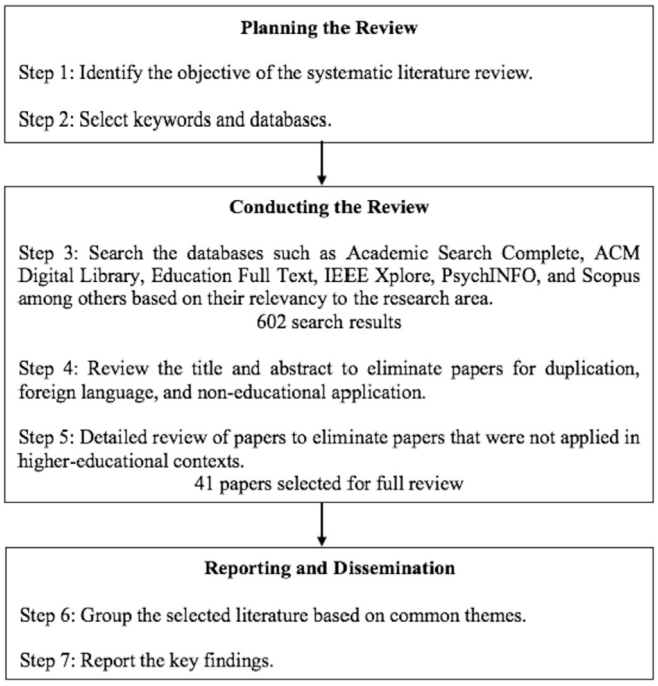

Fig. 1. Systematic review methodology.

journal articles published in English were considered for inclusion in the systematic literature review.

The systematic review methodology suggested by Materla, Cudney, and Antony (2017) was conducted to include papers published up to September 2017. Although the literature search was not confined to a specific starting time frame, all papers included in the literature review were published after 2012. The review methodology is illustrated in Fig. 1.

The papers included in the systematic literature review describe frameworks, concepts, and applications of gamification and game-based learning. The systematic review began by evaluating each of the A-Z databases relevant to the research area, with the preliminary search of keywords “Gamification” “AND” “Higher Education” in the “All Text” field of the advanced search for each database and limiting the search to include only peer-reviewed journal articles. The databases used include Academic Search Complete, ACM Digital Library, Education Full Text, ASEM Digital Collection, IEEE Xplore, PsychINFO, and Scopus. These databases were selected as they comprehensively cover the broad base of application areas of gamified learning. Some of the databases did not return any results that satisfied the review criteria. A total of 602 papers were identified in the first search.

Grey literature, repeated search results, and papers that did not contain full text in English were excluded. A detailed review of the title and abstract of the remaining papers was conducted to eliminate those that did not meet the inclusion criteria for this study/systematic review. Forty-one papers remained after this step. Only papers found in the databases through the authors' institutional library were included.

3. Literature review on gamified learning in higher education

During the literature review, three distinct themes emerged. The systematic literature review categorized the papers into frameworks in gamified learning, gamification in higher education, and game-based learning in higher education. The frameworks provide guidelines on designing and evaluating gamified learning systems in higher education. Existing literature on gamification and game-based learning provide an overview of the implementation, benefits, and challenges of gamified learning in higher education. Studies on frameworks that evaluated or proposed a design process for the implementation of gamification and game-based learning in higher education were categorized under the literature review on frameworks in gamified learning. Papers on gamification that focused on game elements and mechanics, but not the use of games themselves were categorized under gamification in higher education. These included studies evaluating the benefits of game elements in higher education classrooms, the use of game elements through learning management systems (LMS) such as Moodle, and the incorporation of game elements into other LMS platforms. Studies on games designed for higher education or used in the form of digital and non-digital applications in higher education settings were classified under game-based learning in higher education. Studies on role-play games, serious games, gamified applications, mobile-based learning games, and 3D simulation games for learning were grouped into this category. The inherent characteristic of game-based learning to utilize game-elements can be used to broadly classify studies on gamification in higher education. However, a clear distinction is made from the latter category as studies on gamification in higher education do not employ actual games. The reviews in each section are presented in chronological order.

3.1. Literature review on frameworks in gamified learning

A gamified framework to improve attendance and participation in an undergraduate computer game production module is presented in Caton and Greenhill (2014). A control group of 62 students was taught the course by the same instructor using the same assignment, and assessment methods as the trial group of 74 students, but without the gamified framework used in the following year. The gamified framework used awards and penalties to promptly identify and motivate disengaged students. The penalty system utilized yellow cards as a warning to students not participating in group-project activities, and red cards that deducted 25 points from their project grade were used for repeated violations. Awards for categories such as best programming, game of the year, and best design were presented at the end of the semester. One of the awards, best concept, was awarded in the 9th week of the semester. Attendance on the day of the best concept award was 16% higher than during the control year, which indicates that students were motivated by the chance of winning the award. A comparison of the grades between the groups showed that the trial group had a higher percentage of students performing well. The instructor also noticed that the trial group showed more interest in the class and produced superior final projects compared to the control group. The trial group was also more willing to complete difficult tasks with 10 out of 12 groups completing a game-concept-storyboard task, as compared to only 2 out of 12 teams from the control group. The penalty system proved to be effective in improving participation and attendance, with 13 out of the 18 students who received a yellow card penalty not engaging in any further infractions.

Mayer et al. (2014) sought to identify design requirements for game-based learning, the contributions games make to learning, and if learning from simulation games can be applied to the real world. The aim of this research study was to develop an evaluation methodology for simulation games used in advanced learning. The investigators developed their evaluation framework by administering a longitudinal study using 12 simulation games targeting would-be professional engineers. The efficacy of the games was measured through knowledge tests, self-reporting, and in-game performance measurements. The proposed framework serves as a tool for quasi-experimental design research into simulation games and game-based learning.

Serious games were presented by Mettler and Pinto (2015) as a credible method to disseminate research findings to not just the academic community, but also to nonscientific professionals. An in-depth review of SGs is provided, and it is highlighted that the current frameworks used to design them lack the pedagogical perspective needed to make SGs widespread educational tools. A framework is proposed

Table 1
Literature summary of frameworks for gamified learning.

Authors	Year	Study Focus	Key Findings
Caton & Greenhill	2014	Awards and penalties impact	• Identified that penalties deter students from violating attendance and participation requirements. • Showed that awards motivate students to produce higher quality outputs and attempt challenging tasks.
Mayer, Bekebrede, Harteveld, Warmelink, Zhou, van Ruijven, & Wenzler	2014	Framework for game-based learning	• Identified GBL design requirements. • Identified contributions of games to learning. • Identified weaknesses in current evaluation methodologies for GBL. • Developed a framework for the evaluation of simulation games.
Mettler & Pinto	2015	SGs use to disseminate research findings	• Proposed framework using an iterative design process and frequent testing to design SGs for knowledge transfer. • Identified learner-engagement as the key motive for the use of SGs.
Holmes & Gee	2016	Game framework	• Identified constraints to implementation of gamification. • Emphasized the importance of context in application of gamification. • Developed framework to classify the use of games in higher education.
Chang & Wei	2016	Game mechanics	• Identified game mechanics currently prevalent in the online course environment. • Identified poor game mechanics as the leading reason for failed learning objectives. • Developed hierarchical framework to improve student engagement.

that includes an iterative design process and frequent testing to design SGs for knowledge transfer. The framework is based on the feedback, ideas, expectations, and continuous participation of the target audience in the development of the game. The study concludes that learner engagement is the key motive for the use of SGs in professional education.

Holmes and Gee (2016) reviewed potential constraints to implementing gamification in a higher educational setting and presented a framework to address the concerns with gamification by providing a heuristic tool to categorize the use of games into frames. The framework was developed by analyzing literature on the use of game-based teaching and learning (GBTL), and different applications of games in higher education were identified. The frames were classified based on the method of application and type of tools used to integrate games into the classroom. The applications can be broadly categorized into four frames: action, structuring, bridging, and design. The frames can be used to analyze and develop GBTL solutions. The importance of implementing games in a contextual manner to demonstrate gamification as a legitimate and effective approach to teaching and learning was also outlined.

The research of Chang and Wei (2016) sought to identify and explore gamification mechanics prevalent in the massive online open course (MOOC) environment. A focus group interview of human–computer interaction experts was used to identify gamification mechanics in online courses and conduct an online survey of learners to gauge the relative level of engagement associated with the identified gamification mechanics. An overview of the different forms of interactivity used in the gamification of online courses is provided. In addition, poor game mechanics were identified as the reason for most MOOCs failing to achieve their learning objectives. Virtual goods, redeemable points, leaderboards, wordless pictures, and trophies and badges were ranked in order as the most engaging game mechanics. The hierarchical framework of gamification factors was developed to assist MOOC operators in improving student engagement.

The review of literature on frameworks of gamified learning in higher education found that the use of awards and penalties throughout the semester was effective in motivating disengaged students. It was observed that serious games can be effectively evaluated through knowledge tests, self-reporting, and in-game performance. An iterative design process using continuous feedback of target participants and frequent testing can be used to design serious games for knowledge transfer. It is important to consider the context of application when using educational games. A hierarchical framework of virtual goods, redeemable points, leaderboard, wordless pictures, and badges can assist online course designers in effectively engaging students. An overview of the key findings on papers on frameworks of gamified learning is presented in Table 1.

3.2. Literature review on gamification in higher education

Fisher, Beedle, and Rouse (2013) sought to evaluate the knowledge of, attitudes toward, and experience with gamification in higher education through a survey of 70 business faculty respondents. An overview of the potential of gamification applied to business education is provided, which points to increased engagement, inspiration, and interest among students as benefits of using gamification in classrooms. The research found that most of the study participants were familiar with gamification and agreed that gamification increases motivation. A majority also felt that gamification would be useful for increasing student learning. The sample was mixed on the effectiveness of gamification relative to traditional lectures; however, a statistically significant correlation was found between experience with gamification and a positive attitude towards it. The research found gamification as a useful teaching strategy, particularly for recruiting students to business education programs.

De-Marcos, Domínguez, Saenz-de-Navarrete, and Pagés (2014) tested the effects of social networking and gamification on academic achievement, engagement, and attitude. An empirical experiment was developed using a between-groups design to test the effectiveness of gamification. The study used a sample of 114 students for the gamified group, 184 students for the social networking group, and 73 students for the control group. The experiments showed that gamification promoted individual work over collaboration among students, while social networking promoted collaboration and increased participation from students. A comparison of gamification and social networking in an educational setting yielded results showing better performance that were statistically significant for both tools over a traditional e-learning approach in developing skills. However, both tools underperformed traditional e-learning in tests assessing knowledge. The benefits of both tools are presented; however, the importance of having clear objectives and context for integrating the tools into coursework was stressed.

The application of gamification and visual technologies to increase motivation and engagement of students in a university-level computer-animations course is presented in Villagrasa et al. (2014). A gamified learning management system (GLABS) that utilizes key game mechanics such as quests, badges, points, and avatars was developed, and a mixed-method study was carried out to identify the most positive and negative aspects of the system. The GLAB platform uses a LEGO® theme containing avatars, analytics, and points, missions, and adventure map to

provide students a social environment to compete, collaborate, and receive feedback on their tasks. A survey found that students were highly motivated to work in 3D with gamification, and positively perceived the gamification techniques and awards that were used in the platform.

Markopoulos, Fragkou, Kasidiaris, and Davim (2015) offered an introduction to the concepts of gamification with a special focus on its application to engineering education. Gaming practices used in education were reviewed to identify achievements, levels, points, quests, status, and collaboration as key elements of game mechanics that apply to engineering education. The types of games across various educational settings are discussed with examples of gamification applied to engineering training with an emphasis on manufacturing. The benefits of gamification in education such as students being in control of their learning, having the freedom to fail, and learning through different avenues were presented along with common criticisms of gamification such as not being effective for all learners and diminishing the role of intrinsic motivation through rewards were also discussed. The importance of scientifically approaching gamification research is addressed. The research points out that, while there is a considerable amount of theoretical research on gamification, there is a severe lack of empirical and experimental work.

The perceived benefits and results of using gamification and games in an undergraduate media theory class are evaluated in Leaning (2015). A leaderboard and scoring from fellow students on class presentations are used along with paper-based games such as crosswords and choose-your-own-adventure to gamify the course. The experimental group of 27 students was taught the course with the game elements and game included in the first module, and then taught a non-gamified version of the advanced module in the next semester. The control group of 35 students was taught the course with no games or game elements. Both the control group and experimental group had the same assessment method. Although a comparison between the groups found no statistical improvement in the final scores of the students, the students in the gamified course reported enjoyment of the course and motivation to work harder due to the game elements. The gamified group also reported deeper perceived learning and engagement when the game elements were used in the class.

The effectiveness of gamification on improving student performance in an undergraduate computer-graphics e-learning course is presented in Strmečki, Bernik, and Radošević (2015). Points, badges, customization, leaderboards, levels, challenges, quests, feedback, and freedom to fail are identified as gamification elements suitable for use in e-learning systems. These game elements are incorporated into the online learning platform: Moodle, designed using expert feedback, and the analysis, design, development, implementation, and evaluation framework proposed by Wongso, Rosmansyah, and Bandung (2014). A non-gamified version of the course that still used an online platform with discussion forums was simultaneously tested on control groups. Fifty-five students were split into two experimental groups and two control groups. A pre-test evaluating prior knowledge of both groups showed only a 0.63 point difference in favor of the experimental group. However, the experimental groups had 5.59 more points on average than the controls groups. An independent sample *t*-test on the post-test scores of both cohorts showed the higher scores to be statistically significant in favor of the gamified group.

Wiggins (2016) examined the use of game-based learning and gamification, and the recognition of game strategies by communication faculty at higher education universities. A clear distinction between GBL and gamification is made with the former recognized as the use of digital or non-digital games, and the latter identified as the use of game elements such as points and badges in an educational setting. Non-digital GBL options were found to be more prevalent and more likely to be used than their digital counterparts as non-digital options were perceived to be more accessible. While the concept of gamification was mostly unknown, gamification strategies were largely recognized by communication faculty. The current approach to gamification is criticized and its novelty questioned with gamification branded as just the repackaging of traditional teaching strategies.

The use of gamification to promote and disseminate online academic content is examined in Kuo and Chuang (2016). The focus of this study was to identify key game mechanics required in an academic context to engage faculty members, students, and visitors at a university level. A website incorporating gamification elements including points, leaderboard, discussion board, thematic activities, graphical incentives, levels, rewards, and invitations was developed to act as a research platform for the study. Users were awarded points for interacting with the online system and other users that could be exchanged for tangible rewards such as university souvenirs. A survey deployed through the online platform was used to gather the users' perception of game interface design elements. The survey found that graphical incentives, gamified thematic activities, and the discussion board were the most important factors to users. Data collected through google analytics showed that the gamified website exhibited favorable retention, bounce rate, time spent, and referral activity. This study revealed the positive influence of gamification applied to online content on improving user engagement and retention.

Empirical evidence supporting the use of game mechanics in the graduate-level course “Designing Questionnaires” from experimental and control group studies repeated over two consecutive semesters is presented in Hew, Huang, Chu, and Chiu (2016). The course was designed according to the self-determination theory (Ryan & Deci, 2000) that postulates humans' need for relatedness, autonomy, and competence. The first study randomly assigned 22 students between the experimental and control group, while the second study used a quasi-experimental design with 20 participants in the experimental group and 22 participants in the control group. The experimental group in both semesters employed points, badges, and a leaderboard during the course, whereas the control group used no game mechanics. Points were assigned in the experimental group according to the level of difficulty of assignments chosen by the students, and the final project of the course was evaluated by an expert for both groups. Both groups were presented with pre-tests to evaluate the level of knowledge before the lesson, and post-tests were employed to measure the knowledge gained at the end of the lesson. Analysis of the pre- and post-test scores showed no statistically significant difference between the groups. However, in both studies, the experimental group chose more difficult assignments and produced higher quality final questionnaires than the control group. A survey of the experimental groups revealed that it was the game elements that motivated the students to choose more difficult tasks. The results showed that using game mechanics improved both behavioral and cognitive engagement of students in the course.

Morillas Barrio, Muñoz Organero, and Sánchez Soriano (2016) conducted an experimental study to evaluate the perceived learning benefits of gamified student response systems (SRSs) over non-gamified SRSs. A review of the benefits of using SRS in classrooms is presented. The study tested if gamified SRSs lead to improved motivation, attention, engagement, and performance. A gamified SRS was developed by integrating game design elements of reward and competition into the SRS. The study found that the gamified SRSs increased motivation to attend classes, reduced disconnection from the lectures, and improved student confidence in the lesson materials. However, gamified SRSs did not significantly improve engagement over non-gamified SRSs, as students are already highly engaged when using SRSs.

The impact of gamification on 156 undergraduate students in a taxation course is investigated in Buckley and Doyle (2016). A review of existing literature on gamification revealed the key game mechanics needed in a gamified course as rules, reward, feedback, and competition. A web-based decision-making system incorporating these game mechanics was used in the course to motivate students to independently search for information that would enhance the students' learning outcomes. The students' motivation was measured through the Academic

Motivation Scale (AMS) at the beginning of the course, and their general knowledge on relevant course material was evaluated both before and after using the gamified system. The material evaluated in the pre- and post-test were not directly covered in the course. The results showed a statistically significant improvement in the students' general knowledge of the national taxation system after using the gamified platform. Comparing the pre-and post-test results with the AMS responses showed that the gamified learning system was particularly effective for intrinsically motivated students.

Yildirim (2017) aimed to determine if gamification-based teaching practices impact student performance and their attitudes towards lessons at a university level. A review of different teaching procedures and key gamification elements that need to be incorporated into the teaching process is provided. The study used a between group experimental design using pre- and post-test experimental and control groups with the experimental group receiving the gamified lessons. The students' improvement from pre-to post-test in the experimental group of 49 students was significantly higher than in the control group of 48 students. The results also indicated that gamified lessons had a statistically significant improvement in the students' attitude.

The effects of using gamification dynamics in a general science classroom of 36 students were presented by Sánchez-Martín, Cañada-Cañada, and Dávila-Acedo (2017). The study evaluated the relationship between the scores of students in a game-based scoring methodology and their respective academic performance in the final exam for the course. The research hypothesis was that students with higher scores in the game obtained higher academic grades in their final exam. During the course, the researchers observed that gamification caused students to become more competitive and separate into groups of similar academic performance with no interaction between the groups. The researchers introduced a game-index system that took the entire class scores into account to assign rewards in a bid to increase collaboration between students. However, the implementation of the game index was not sufficient to increase collaboration, and students were unable to recognize the opportunity to increase their own rewards by collaborating. This evidence is used to recognize that gamification without careful inclusion of measures focused on increasing collaboration can result in increased competition among students. The results of this experiment showed significant correlation between scores in the game to the grades on the final exam.

A social gamification approach designed to satisfy the situational motivational needs of students is applied to an undergraduate course and compared to a traditional e-learning approach in De-Marcos et al. (2017). The Elgg software was used as the social gamification tool to provide an interactive online environment with achievement badges, points, virtual shop, and leaderboard. The situational motivation needs of autonomy, competence, and relatedness were addressed by the social gamification tool using peer-assessed learning activities with clear goals, increasing difficulties, and a sense of progress. A quasi-experimental design is used to test whether the social gamified approach positively impacts learning performance and student attitudes. The results showed that students found the social gamification approach to be useful. The gamified group of 200 students outperformed the control group of 164 students on practical assignments but underperformed on the written final exam. It was concluded that while social gamification refined practical skills, it did not improve conceptual learning.

An industrial organizational psychology course incorporating meaningful gamification elements was designed and quantitatively evaluated against the traditional class for the same course in Stansbury and Earnest (2017). Meaningful gamification elements were integrated into the course through roleplay, social interaction, narration, and a gamified grading system using experience points (XP). The evaluation was conducted using a quasi-experimental design with the experimental group of 49 students receiving the gamified course and the control group of 44 students receiving the traditionally taught course. The results showed that the gamified group experienced higher motivation, engagement, and enjoyment, which resulted in an overall more positive course experience. The gamified group also gave more importance to team projects for their learning. While the experimental group did not show statistically significant improvement in performance, their perceived learning was significantly higher. It was further found that the students would like to see gamified instructional methods used in their other courses.

Psychological theories of motivation were explored by Sailer et al. (2017) to explain the motivational power of game design and explore the effects of certain game design elements on psychological need satisfaction. An overview of the potential of gamification and how gamification pairs psychological needs with key game design elements is provided. The need for competence, autonomy, and social relatedness is assessed within the self-determination theory (Ryan & Deci, 2000) in the context of gamification. The study found that game design elements such as badges, leaderboards, and performance graphs fostered competence-need satisfaction and autonomy need satisfaction regarding task meaningfulness, while avatars, meaningful stories, and teammates fostered social relatedness need satisfaction, which is the need for humans to belong to a social group. The findings indicate that gamification is a powerful motivational tool when well designed and implemented properly.

The effects of gamification elements on student engagement and the relationship between gamification, engagement, and academic achievement of 37 undergraduate students in an information and communication (ICT) course are investigated in Cakıroglu, Basıbüyük, Güler, Atabay, and Memis (2017). The instructor integrated a leaderboard showing the top five students in each quest with bonus points for extra participation and real gifts to the top student in the course each week. The top three students each week were given the additional responsibility of assisting other students. The students' engagement was measured at the beginning and end of the course. A Wilcoxon signed-rank test on the engagement scale scores found statistically significant improvement in student engagement. A gamification score was compiled for each student based on their evaluation of game elements used. It was found that most students who had high engagement scores also had high gamification and academic scores. Clinical interviews conducted on students selected across the class performance spectrum found that, with the exception of real gifts, gamification dynamics generally improved engagement, confidence, motivation, and academic effort.

An empirical study comparing the experiences of students taking a gamified course with those of students taking the non-gamified version measured over four semesters of an undergraduate operations research class taken by 150 first-year management students is presented in Dias (2017). The gamified version of the course used points, badges, and a leaderboard, as these are the easiest game elements to implement through online platforms for a large group of students. Students in both cohorts were given a choice between continuous assessment that included activities or only a final exam. Students in the gamified course earned points for each activity instead of marks as in the case of their non-gamified counterparts, which were aggregated to determine their final grade. The points system allowed students to make up for poor performance in some activities and receive participation points for some activities to keep students engaged. The gamified group showed a statistically higher mean score, pass percentage, participation, and class attendance than the non-gamified group. There was no difference in the assessment of the lecturer between the groups, thereby attributing the improvements to the gamified course design. However, the authors did acknowledge the possibility of some uncontrolled variables or the increased engagement of the lecturer in the gamified group influencing the results.

The effectiveness of points in improving student engagement and psychological profiles that can be engaged by this gamification element is evaluated in Song, Ju, and Xu (2017). Students made presentations on topics of interest, and the class earned points for asking questions.

Scenarios of the presenters earning points for the audience asking questions and the listeners earning points for asking the question are evaluated against not using any gamification element during the presentations. The study found that the presenters earning points resulted in the most engagement among the settings tested. It was also found that bashful and distracted students were more likely to be engaged in the gamified class. Feedback on the gamification design showed that most students found the use of gamification increased their engagement and enjoyment. A limitation of this study was that the same students were used for both experiments, and the social approach was more novel to the students.

The literature review on gamification in higher education found that points, badges, leaderboards, and levels were the most commonly used game elements with improved engagement, motivation, and attitudes being the most commonly cited benefits of using gamification in higher education. Although improved student performance was observed in some studies, others showed that gamification improved perceived learning and enjoyment but did not significantly improve performance. As the studies differed significantly in the contexts of their application, the results on student performance are not conclusive. The key findings of the papers on gamification are presented in Table 2.

3.3. Literature review on game-based learning in higher education

Giannetto, Chao, and Fontana (2013) developed a system for gamifying a social learning environment. An introduction to the concepts of gamification was provided and user engagement was stressed as its primary goal. The goal of developing the gamification system was to foster student engagement in the classroom. In addition, a detailed breakdown of the features and functionalities of the Qizbox gamification system, which acts as a comprehensive classroom tool, was discussed. The Qizbox system allows students to access lectures, quizzes, and a chatbox to interact with other students and the presenter. There is also a dedicated question area where students can ask questions anonymously and have their questions ranked by other students to highlight important questions. The researchers implemented gamification design elements such as experience points, levels, and achievement badges to maximize the students' social and collaborative experience during lectures.

A project carried out at the University of Deusto to design a serious game to enhance generic competences required by students for professional development is presented in Guenaga et al. (2013). The multidisciplinary project team identified making the game available across a variety of platforms and transitioning pedagogical goals to game mechanics as key challenges faced in developing the serious game. Entrepreneurship and problem solving were chosen as the competencies to be developed by the serious game for a target audience of final-year undergraduate students and first-year graduate students. The project was carried out in three phases with phase-I consisting of carrying out an analysis of the literature, current use of serious games in higher education, and existing SG products. Phase-II involved the design of two prototypes for the development of employment-oriented competencies and experimental use in engineering education. The prototypes developed in phase-II were tested and developed into serious games in phase-III. The SGs used clearly defined learning objectives, rules, challenges, and feedback mechanisms to create an immersive experience for the students.

Moncada and Moncada (2014) sought to illustrate the potential of using games in accounting courses using gamified adaptations of Hollywood Squares® and Connect Four®. A review of the evolution of games as a tool for university-level business education was provided. In addition, guidelines for designing educational games were presented. According to the research, games should clearly define educational objectives and any required prerequisite knowledge to be effective as pedagogical tools. The study also found that most accounting faculty lack the programming skills required to develop fully interactive games and showed that MS PowerPoint® can be used to develop dynamic gamification activities to enhance accounting and business teaching and learning.

Bonde et al. (2014) presented an empirical study of gamified laboratory simulations to test if they improved learning effectiveness and motivation of biotech students. The simulation laboratories used gamification elements such as interactive 3D animations, storytelling, and a scoring system providing feedback to optimize student learning. A survey of 149 biology students that used a crime-scene simulation lab found that 97% of students found it interesting to use, an equal percentage felt that the gamified simulations made the course more interesting, and 86% found the laboratory simulation to be more interesting than ordinary exercises. A separate survey of high school students found that the gamified laboratories improved their motivation to pursue higher studies in biotech. The investigators studied 91 students who were tested in two separate groups, one trained in the simulation lab for half the course and the other educated through traditional lectures, before switching the training methods. The results showed that while using gamified laboratory simulations significantly improved learning, a combination of gamified labs and traditional lectures yielded the most benefit to the students.

Knautz, Wintermeyer, Orszullok, and Soubusta (2014) sought to demonstrate the benefits of game-based learning on an information literacy course that was adapted into an interactive game. The game platform presented lessons through text adventures where students solved quests to move forward and collaborated with fellow students on guild quests. The game “The Legend of Zyren” used game mechanics such as experience points, leaderboards, levels, and a story. The game was evaluated for content quality, platform effectiveness, and the effect of game design elements. An overwhelming majority of students found the online platform to be useful, trustworthy, and fun, with 85.6% of the 91 students motivated by the story and quests. Competition to top the leaderboard motivated students, with 73% admitting to being more engaged by the challenge. The gameful design had a positive impact on content mastery and student performance with a positive correlation seen between players' XP and their final grades. The benefit of game-based learning was observed in raising the average GPA of students and reducing failure rate compared to the traditional class.

An empirical study evaluating the influence of gamification on students' cognitive engagement and performance in an undergraduate C-programming class is presented in Ibanez, Di-Serio, and Delgado-Kloos (2014). A gamified learning platform was developed for the study, where students gained points, badges, and leaderboard positions for introducing and assessing questions on C-programming. The Q-Learning gamified platform provided students with choices of work, planning, and social activities with a goal of reaching 100 points to accomplish the course's learning goal. Data on the 22 students' activities were collected using the system's log. After the lectures covering the basic concepts, students were administered a pre-test before using the gamified platform and a post-test at the end. Analyzing the log showed that students continued to use the platform and master unexplored topics after reaching 100 points. However, it was found that students changed their learning strategies after reaching the goal and shifted their focus to earn badges and consulting the leaderboard area. Focus group interviews also revealed that some students stopped using the system when they achieved all the badges. A comparison of the pre- and post-test scores showed a statistically significant improvement in the performance of the students, indicating an improvement in programming knowledge from using the gamified platform.

A detailed overview of serious games available on the market for teaching entrepreneurship and the associated benefits and issues with using them are presented in Bellotti et al. (2014). The games were selected for improving entrepreneurial competencies such as finance, marketing, business set-up and management, and spotting business opportunities. It was found that, while serious games for entrepreneurship provided a good simulation of company management,

Table 2
Literature summary of gamification use in the classroom.

Authors	Year	Study Focus	Key Findings	Benefits	Game Elements
Fisher, Beedle, & Rouse	2013	Gamification by business education faculty	• Identified increased engagement, motivation, inspiration, and interest among students as benefits of gamification. • Found significant correlation between experience with gamification and a positive attitude towards it.	Engagement, motivation, inspiration, and interest	Not specified
De-Marcos, Domínguez, Saenz-de-Navarrete, & Pagés	2014	Effects of social networking and gamification	• Showed that gamification promoted individual work and competition among students. • Found that gamification and social networking improved performance over traditional e-learning in developing skills.	Practical skill development, engagement, and attitude	Trophies, badges, levels, and leaderboard
Villagrasa, Fonseca, Redondo, & Duran	2014	Gamified learning management system	• Identified quests, badges, points, and avatars as key game mechanics. • Found that students were highly motivated by gamification. • Found that students positively perceived gamification.	Motivation and performance	Quests, badges, points, and avatars
Markopoulos, Fragkou, Kasidiaris, & Davim	2015	Gamification applied to engineering education	• Determined achievements, levels, points, quests, status, and collaboration as key game mechanics that apply to engineering education. • Recognized gamification has a positive effect on engineering education.	Motivation, interest, and knowledge	Achievements, levels, points, quests, status, and collaboration
Leaning	2015	Perceived benefits of games and gamification	• Found that students attributed higher enjoyment and motivation to the use of game elements. • Found that students reported higher perceived learning and engagement when game elements are used.	Enjoyment, motivation, engagement, and perceived learning	Leaderboard
Strmečki, Bernik, & Radošević	2015	Student performance	• Identified points, badges, customization, leaderboards, levels, challenges, quests, feedback, and freedom to fail as game elements suitable for e-learning systems. • Found that the gamified group showed higher improvement in test scores than the non-gamified group.	Improved student performance	Points, badges, customization, leaderboards, levels, challenges, quests, feedback, and freedom to fail
Wiggins	2016	Gamification and GBL in higher education	• Distinguished GBL and gamification. • Identified non-digital GBL to be more prevalent than digital GBL. • Found that communication faculty were largely unfamiliar with gamification concepts, but generally recognized game elements.	Not discussed	Not discussed
Kuo & Chuang	2016	Key game mechanics for online platform	• Identified graphical incentives, gamified thematic activities, and discussion board as the most important gamification elements for user engagement and retention. • Showed that a gamified website exhibited favorable retention, bounce rate, time spent, and referral activity.	Engagement and retention	Points, leaderboard, discussion board, thematic activities, graphical incentives, levels, rewards, and invitations
Hew, Huang, Chu, & Chiu	2016	Effects of game mechanics on student motivation and engagement	• Showed that the use of points, badges, and a leaderboard improved behavioral and cognitive engagement. • Found that game elements motivated students to choose more difficult tasks and produce higher quality end products.	Engagement, more effort, and higher quality work	Points, badges, and leaderboard
Morillas Barrio, Muñoz Organero, & Sánchez Soriano	2016	Gamified student response systems	• Developed a gamified SRS. • Found that gamified SRSs increased motivation, reduced disconnection from the lectures, and improved student confidence.	Motivation, confidence, engagement, and attention	Goal, challenges, illustration, and feedback
Buckley & Doyle	2016	Student motivation and learning	• Identified rules, rewards, feedback, and competition as the key game mechanics of a gamified course. • Found that students were more motivated to learn beyond the material covered directly in the class due to gamification. • Observed that intrinsically motivated students especially benefited from gamification.	Improved learning outcomes	Rules, reward, feedback, and competition
Yildirim	2017	Student performance and attitude	• Identified key gamification elements. • Showed that gamification improved student performance and their attitudes towards lessons.	Improved attitude and learning outcomes	Points, badges, leaderboard, and collaboration
Sánchez-Martín, Cañada-Cañada, & Dávila-Acedo	2017	Student performance and competitive-collaborative attitudes		Increased competition	Points and challenges

(*continued on next page*)

Table 2 (*continued*)

Authors	Year	Study Focus	Key Findings	Benefits	Game Elements
			• Observed significant correlation between scores in the game to the grades on the final exam. • Found that gamification caused students to become more competitive.		
De-Marcos, García-Cabot, & García-López	2017	Social gamification	• Found that the gamified group outperformed the control group on practical assignments. • Observed that students had a positive attitude towards social gamification.	Improved student performance	Badges, points, virtual shop, and leaderboard
Stansbury & Earnest	2017	Meaningful gamification	• Observed that the perceived learning of the gamified group was higher than that of the control group. • Found that the gamified group experienced higher motivation, engagement, and enjoyment.	Motivation, engagement, enjoyment, and perceived learning	Points, role-play, narrative, and feedback
Sailer, Hense, Mayr, & Mandl	2017	Game design elements	• Identified game design elements that fostered psychological need satisfaction. • Recognized gamification as a powerful motivational tool.	Psychological satisfaction	Badges, leaderboard, avatars, stories, and teammates
Cakıroglu, Basıbüyük, Güler, Atabay, & Memis	2017	Effect of gamification on student engagement	• Showed that the use of quests, bonus points, and a leaderboard improved student engagement. • Observed that there was a perceived improvement in the students' engagement, confidence, motivation, and academic effort.	Engagement, performance, confidence, motivation, and academic effort	Leaderboard, points (bonus), real gifts, and reputation
Dias	2017	Student performance and engagement in a gamified vs non-gamified course	• Identified that students in the gamified group showed higher mean scores, pass percentage, participation, and attendance than the non-gamified group. • Observed that benefits were attributed to the gamified course design as all other aspects of the course were identical to the non-gamified course.	Performance, engagement, and attendance	Points, badges, and leaderboard
Song, Ju, & Xu	2017	Effect of points on student engagement	• Identified that the use of points increased the students' engagement and enjoyment. • Observed that bashful and distracted students were most likely to be engaged in the gamified class.	Engagement and enjoyment	Points

they did not develop enough skills to innovate, find new solutions, or provide sufficient real-world simulation, scaling, and entertainment. A further study by Antonaci et al. (2015) provided an overview of issues in entrepreneurship education and explained the motivation behind the use of gamified courses as a part of the stimulating entrepreneurship through serious games (eSG) project. The eSG project was a collaborative effort between universities in Italy, Spain, and the Netherlands at gamifying entrepreneurship courses at non-business universities. The goal of the research was to identify the most appropriate games to enhance entrepreneurship education. Students welcomed the use of games and found them to be useful for introducing some difficult topics. Entrepreneurial motivation, business competence, and business acumen were identified as key entrepreneurial skills that can be developed using serious games. The study found that more than one game was needed to cover the key skills for each course.

Day-Black, Merrill, Konzelman, Williams, and Hart (2015) presented the use of serious games in two learning units of an undergraduate community health nursing course. Students expressing their difficulty in understanding the content and applications of the epidemiology and environmental health learning units motivated the course faculty to use two web-based games to supplement the learning process. The students were introduced to the game after the traditional lectures on the topics were completed. Students expressed being more comfortable with epidemiological principals after playing Outbreak at WatersEdge. The game EnviroRisk was utilized to train students in using problem-solving techniques to conduct environmental risk assessments. The students' feedback indicated that the serious games used in the class improved motivation and learning efficiency.

A game-based learning approach that was used in an undergraduate physical chemistry course was presented by Daubenfeld and Zenker (2015). The GBL approach was used to supplement the traditional lectures of the course. The digital learning environment used lecture screencasts for each chapter arranged as a learning pathway where the students would have to unlock subsequent chapters by passing a short exam on each chapter. Students earned a maximum of 35 bonus points through the in-game exams, which could be added to their final exam score. The students' assessment of the GBL system revealed higher self-study time compared to traditional lectures, and significantly more time spent learning in the game by female participants than male participants. The students rated lecture screencasts, online tests, and bonus points as indispensable elements of the GBL approach. The student feedback also identified graphical illustration of the learning pathway and background story as elements that can be eliminated if the instructor is faced with time and budget constraints. Although there was a reduction in failure rate for the course with the introduction of the GBL approach due to the bonus points, there was no significant improvement in the final examination results when compared to a previous non-gamified term for the same course.

A mobile-device-based serious game approach to teach and learn Java programming for first-year computer science students is proposed in Jordine, Liang, and Ihler (2015). A review of existing serious games for programming languages found that there were no serious games available for practicing Java programming on mobile devices. A survey completed by 98 students found that 60% of the respondents played games on their phones, and 40% expressed a desire to use a game to learn Java on their mobile phones. A majority of students who agreed that the mobile Java game would benefit them answered that they would use the game to learn during idle times. The survey also identified practical exercises, good usability, and current learning progress as desirable features for the mobile game. A prototype was developed to address the current void in serious games for teaching Java programming. The prototype was designed with levels that could be completed in under five minutes and incorporated mission screens, instant feedback, and high-scores. An authoring tool was also added to the prototype that would allow lecturers the ability to create and customize content of the mobile game.

A hybrid game-based learning application was evaluated in Berns, Isla-Montes, Palomo-Duarte, and Dodero (2016) for its effects on perceived usefulness and added value, learning outcomes, and student motivation. The VocabTrainerA1 Android app was developed to meet the learning needs of 104 German-language students. Game elements such as points, levels, clues, role-play, and time limit were integrated into the app that required students to complete individual levels before participating in collaborative game-play. A 90% score was required to pass each level, which ensured repeated play and, hence, reinforced learning. A technology-acceptance survey completed by 91 students and focus group interviews of 12 students revealed that students were highly motivated to learn and perceived high usefulness and added value from using the app. Students also found the app to be more effective, engaging, and fun than traditional learning tools such as flashcards. Comparing the performance of students on a pre-test before using the app with post-test scores at the conclusion of the experiment showed statistically significant improvement in learning outcomes from using the hybrid game-based learning app. Evaluating both scores against the scores of the same students on written tests in a previous semester for a lower-level German-language course showed that the average score of students increased after using the VocabTrainerA1 app.

Mathrani, Christian, and Ponder-Sutton (2016) presented a game-based learning experiment in a computing course to investigate its effectiveness. The use of games and current pedagogical approaches in information and communication technology (ICT) education was reviewed. The study used two different student cohorts. Cohort 1 consisted of 20 students who had not yet started the computing course and cohort 2 consisted of 24 students who had completed the course module but had not been assessed. Both student cohorts played the educational game Lightbot 2.0 in separate test settings, and data was collected through an online survey immediately after the game to gauge the students' perception of game engagement, difficulty, and learning efficiency. This was followed by a survey to assess the students' impression of game-based learning at the end of the course. Students perceived the game to support learning and application of programming concepts. The researchers found game-based learning to be effective both before and after the course was taught, supporting high levels of engagement.

Llorens-Largo et al. (2016) presented a gamified system to teach Logic to first year engineering students using the Prolog programming language. The proposed PLMan gamified system is comprised of programming the movements of a character in the game to navigate through mazes while eating dots and avoiding enemies. PLMan employs gamification mechanics such as allowing students to set difficulty, progressing through the game, and retrying failed attempts with corrective feedback. An overview of the benefits of video games and the use of gamification in education is provided. Motivation, autonomy, progressiveness, feedback, experimentation, and adaptation were identified as key features of gamification. The study also found that the most essential attribute of a gamified system is the fun component.

The effects of engagement, immersion, and flow conditions such as challenge and skill on perceived learning in a game-based learning environment are presented in Hamari et al. (2016). The relationship between challenge and skill with engagement and immersion also are examined alongside their mediating effects on perceived learning in game-based learning. The perceived level of engagement, challenge, skill, immersion, and learning experienced by 40 undergraduate mechanical engineering students playing Spumone throughout the semester was analyzed using a psychometric survey carried out before the final exam. Analysis of the survey results showed that the challenge of the game had a positive effect on perceived learning both directly and through increased engagement, which was also a factor that had a clear positive influence on perceived learning. While the skill of the player did not show a direct relationship with learning, it had a positive effect on engagement and immersion in the game. However, immersion itself showed no effect on learning, and had no mediating effect with the

Table 3
Literature summary of game-based learning.

Authors	Year	Study Focus (Game-Based Learning System)	Key Findings/Contributions	Benefits	Game Elements Used
Giannetto, Chao, & Fontana	2013	Qizbox gamification system	• Developed Quizbox, a gamified social learning environment. • Built Quizbox gamified system with gamification elements such as XP levels and achievement badges.	Engagement	Points, levels, and badges
Guenaga, Arranz, Florido, Aguilar, Guinea, Rayón, Bezanilla, & Menchaca	2013	Serious games to develop employment competencies	• Identified making the game available across various platforms and transitioning pedagogical goals to game mechanics as key challenges in developing serious games. • Developed serious games to improve entrepreneurship and problem-solving competencies.	Competencies and skills	Not specified
Moncada & Moncada	2014	Gamified adaptations of Hollywood Squares® and Connect Four®	• Established that games should identify educational objectives and prerequisite knowledge to be effective. • Found that most accounting faculty lack the programming skills required to develop fully interactive games. • Showed that MS PowerPoint® can be used to develop dynamic gamification activities.	Motivation and enjoyment	Illustration and role-play
Bonde, Makransky, Wandall, Larsen, Morsing, Jarmer, & Sommer	2014	Gamified biotech laboratory simulations	• Identified that gamified simulations made the courses more interesting. • Found that gamified laboratories improved students' motivation to pursue higher studies in biotech. • Showed that laboratory simulations significantly improved learning. • Observed that gamified labs combined with traditional lectures yielded the most benefit to the students.	Improved student performance and learning	Animations, story, and points
Knautz, Wintermeyer, Orszullok, & Soubusta	2014	The Legend of Zyren	• Found positive correlation between XPs gained in the game to final grades. • Showed that students were found to be motivated by story and quests. • Found that GBL improved average GPA and reduced failure rates.	Learning/performance, enjoyment, and engagement	Points, leaderboard, levels, and story
Ibanez, Di-Serio, & Delgado-Kloos	2014	Q-learning gamified platform	• Identified that students were motivated by badges and leaderboard. • Showed that students' knowledge and test performance improved after using the gamified platform.	Performance	Points, badges, and leaderboard
Bellotti, Berta, De Gloria, Lavagnino, Antonaci, Dagnino, Ott, Romero, Usart, & Mayer	2014	Serious games for entrepreneurship development	• Provided an overview of SGs for teaching entrepreneurship. • Found that SGs did not develop innovation and problem-solving skills.	Not specified	Not specified
Antonaci, Dagnino, Ott, Bellotti, Berta, Gloria, & Mayer	2015	Entrepreneurship through serious games	• Identified the key game elements to enhance entrepreneurship education. • Found that students welcomed the use of games and found them to be useful for introducing some difficult topics.	Not specified	Not specified
Day-Black, Merrill, Konzelman, Williams, & Hart	2015	Outbreak at WatersEdge and EnviroRisk	• Found serious games to be effective in teaching difficult aspects of a health nursing course. • Identified that serious games improved student motivation and learning efficiency.	Motivation and learning	Role-play and missions
Daubenfeld & Zenker	2015	Chemory, three-component game, and Labyrinth	• Observed that students who used GBL spent more self-study time than those in traditional lectures. • Identified lecture screencasts, online-tests, and bonus points as indispensable elements of GBL. • Found no significant improvement on final exam scores from using GBL.	Higher effort and reduced failure rate	Illustration, bonus points, and levels
Jordine, Liang, & Ihler	2015	Mobile-based serious game for Java	• Identified short levels, practice exercises, good usability, and progress indicators as important features of mobile-based learning. • Identified customizability by instructors as a vital feature of mobile-based serious games.	Engagement, interest, attitude, and customizability	Levels, missions, feedback, and leaderboard

(*continued on next page*)

Table 3 (*continued*)

Authors	Year	Study Focus (Game-Based Learning System)	Key Findings/Contributions	Benefits	Game Elements Used
Berns, Isla-Montes, Palomo-Duarte, & Dodero	2016	VocabTrainerA1	• Observed that students found the gamified app to be more engaging, effective, and fun than traditional learning tools. • Observed that students showed significant improvement in learning outcomes from using the GBL app.	Engagement and learning outcomes	Points, levels, clues, role-play, and time-limit
Mathrani, Christian, & Ponder-Sutton	2016	Lightbot 2.0 game system	• Found GBL improved student perception of learning and application of programming concepts. • Showed GBL to be effective before and after a course was taught.	Engagement and learning effectiveness	Role-play, quests, and graphical illustration
Llorens-Largo, Gallego-Durán, Villagrá-Arnedo, Compañ-Rosique, Satorre-Cuerda, & Molina-Carmona	2016	PLMan gamified system	• Developed PLMan gamified system. • Identified motivation, autonomy, progressiveness, feedback, experimentation, and adaptation as key features of gamification. • Identified fun as the most essential attribute of a gamified system.	Enjoyment, motivation, and psychological satisfaction	Levels, freedom to fail, feedback, and characters
Hamari, Shernoff, Rowe, Coller, Asbell-Clarke, & Edwards	2016	Spumone	• Identified that engagement in the game had a positive effect on learning. • Observed that challenge had a positive effect on learning both directly and mediated by engagement. • Found that skill of the player had only a mediated effect on learning through engagement.	Engagement and perceived learning	Simulation
Fotaris, Mastoras, Leinfellner, & Yasmine	2016	Gamified Python programming	• Observed that GBL increased attendance, assignment completion, engagement, and overall academic performance. • Found that students of the gamified course showed higher effort and interest in the course.	Attendance, assignment completion, engagement, performance, and more effort	Points, badges, instant feedback, role play, and leaderboard
Pechenkina, Laurence, Oates, Eldridge, & Hunter	2017	Gamified mobile application	• Showed higher achievement in students using the gamified app than those who did not. • Showed that the app improved student retention and engagement. • Observed positive correlation between high scores on the app to high academic achievement in the course.	Retention, performance, and engagement	Leaderboard, badges, push notifications, and feedback
Hamzeh, Theokaris, Rouhana, & Abbas	2017	Student perspective of simulation games and perceived learning	• Identified simulation games as a favorable teaching method among students. • Found improved perceived learning in topics that used simulation games.	Performance and student satisfaction	Simulation and collaboration

challenge of the game on perceived learning.

An empirical study comparing student engagement and performance in a gamified Python programming class with those of a control group who were taught the same course in a traditional format is presented in Fotaris, Mastoras, Leinfellner, and Yasmine (2016). The experimental group of 52 students used a classroom response system "Kahoot", a modified version of "Who Wants to be a Millionaire?" (WWTBAM) that utilized course relevant questions of increasing difficulty, and Codeacademy's interactive online platform to gamify the course. Kahoot was used to bring a gameshow feel with the instructor acting as a host and students as competitors. WWTBAM replaced the review seminars that were given to the control group of 54 students to prompt collaborative work among assigned groups in the experimental condition. Codeacademy employed game elements such as points, badges, instant feedback, and leaderboards to provide students with a gamified online platform to practice programming. Results of the experiment showed that the gamified group had much higher attendance, assignment completion, engagement, and overall academic performance than the control group. It was also observed that students in the gamified course put in more effort and showed more interest by downloading course material more consistently and more often than students in the control group.

The impact of a gamified mobile learning application on student retention, performance, and engagement was investigated by Pechenkina, Laurence, Oates, Eldridge, and Hunter (2017). A custom app, developed for both Android and iOS devices, was initially introduced in an accounting course and then extended to science classes. The usage of the app in the courses was completely optional for the students, and 55% opted to use the app. Gamification elements such as digital leaderboards and badges were used in the app to motivate students, and push notifications were used to deliver post-lecture and pre-tutorial multiple choice quizzes to heighten student engagement and satisfy their need for personalized education. It was also acknowledged that the immediate feedback provided by the gamified app could contribute to student engagement. The researchers sought to identify if introducing the app into the classroom improved student retention, performance, and engagement, and measured if the performance in the app correlated to the performance on academic tests. The results of their analysis showed that the introduction of the gamified app correlated with improved student retention, and app users on average achieved higher grades than those who opted out of using the app. A significant positive correlation was also observed between performing well on the app and achieving higher academic grades.

The effectiveness of hands-on team simulation games as a learning method for 65 graduate students in a lean construction class is examined by Hamzeh, Theokaris, Rouhana, and Abbas (2017). The instructor for the class received training on implementing the simulation games selected with the aim of providing students with a clear understanding of lean construction topics and their applications in the industry. Researchers sought to assess the change in student perception of the use of simulation games as a teaching method through surveys at the end of the first simulation and the course. The hypothesis tests conducted showed statistically significant improvement in student perception of simulation games as a favorable teaching method beyond 0.01 significance level, and significant improvement in students' perceived understanding of the topics that used simulation games at 0.05 significance level. Tests conducted to evaluate the students' grasp of concepts used in the game at the end of each simulation game on average showed high grades. Course evaluations at the end of the course also showed favorable assessment of the use of simulation games. The improved student satisfaction and learning make a promising case for the use of simulation games to teach lean construction concepts.

The literature review on game-based learning in higher education found that levels, graphics, points, leaderboard, and badges were the most used game elements in games for higher education. Improved student engagement, attitudes, and performance were the most significant benefits observed from the use of game-based learning applications. Enjoyment, increased motivation, and improved perceived learning were some of the other important benefits observed in studies on game-based learning. Gamified learning systems in the form of mobile and computer applications, serious games, and 3D simulation labs were used or developed in studies of this category. An overview of the findings of papers on game-based learning is presented in Table 3.

4. Principal findings of the systematic literature review

The systematic review of gamified learning in higher education revealed a number of key findings that show that the influence and acceptance of gamification and game-based learning in education is growing. Research in this field has increased in recent years with benefits in higher education settings becoming more established and recognized. Gamified learning in higher education only received attention since 2013 but grew rapidly thereafter. 2017 has already seen a number of publications for the period ending in September 2017. Fig. 2 shows the number of papers published each year during this period.

The subject area of a course can impact the approach to gamified learning. During this review, it was observed that a majority of studies were conducted in the field of computing. This can be attributed to the subject area presenting several opportunities to implement and study gamification and game-based learning through the development of gamified applications and platforms. However, a number of fields demonstrated that gamification and game-based learning can be applied in higher education across a variety of subject areas ranging from science to language (and communication). Fig. 3 shows the range of application areas and the corresponding number of papers published in each field. It can be observed that gamified learning is being increasingly studied or applied in business and science studies.

Cultural differences can cause the expectations and attitudes of students towards gamified learning to vary in different countries. Fig. 4 illustrates the number of papers published in different countries. This gives an impression of the regions' willingness to accept and experiment with evolving forms of teaching and learning tools. Spain can be seen as the region with the most studies in gamified learning in higher education, followed by the United States, Germany, and the United Kingdom.

Fig. 5 shows the game elements used in gamification and game-based learning. Points, badges, and leaderboard were the most frequently used game elements in gamification. These elements were also employed in game-based learning; however, graphical elements and levels were the most significant game elements incorporated into game-based learning. Badges in the form of achievement badges, virtual trophies and rewards, and points in the form of experience points,

Fig. 2. Number of papers on gamified learning in higher education published each year.

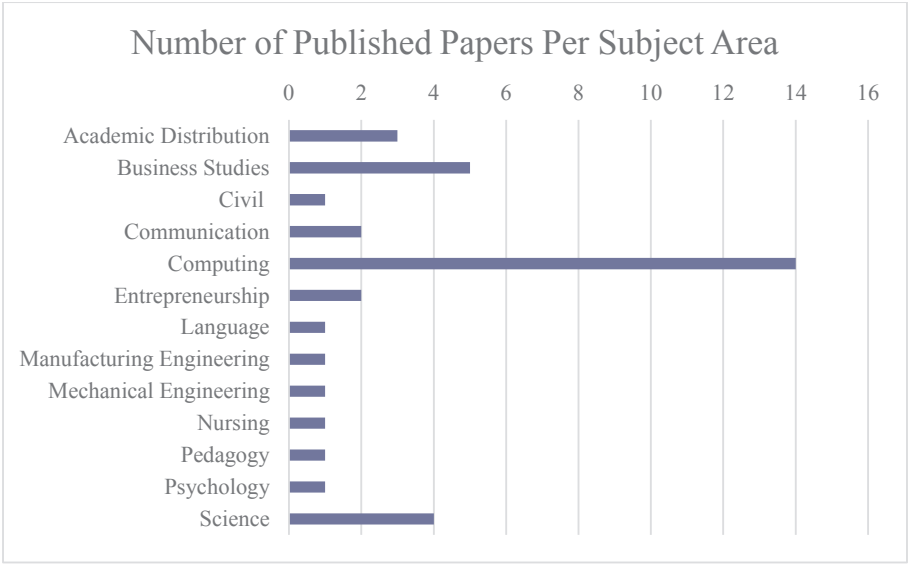

Fig. 3. Number of papers published on gamified learning in each higher education subject area.

bonus points, and earned points were used to gamify courses. Levels in the form of quests, missions, and challenges were also used to gamify a course. Instant feedback was also used in both gamification of courses and game-based learning applications. Graphical elements such as avatars, illustrations, and simulations were predominantly used in game-based learning as they are easily accessible in digital environments. Collaboration in the form of teammates and discussion boards was more commonly be used in gamification than in game-based learning.

Improved student attitude, engagement, and performance were observed as the most significant benefits of gamification and game-based learning in higher education. Both gamification and game-based learning offer very similar benefits as indicated in Fig. 6. Improved student motivation is also seen as an important benefit of gamified learning. Perceived learning is higher when using game-based learning applications. Whether an instructor decides to gamify the course or use a game-based learning approach, there are several possible benefits from their use.

This review found that gamification and game-based learning in higher education have overwhelming support for a number of benefits to both teachers and students in higher education. Student engagement, motivation, and enjoyment are widely cited as benefits of gamified learning. Although a few studies did not observe an improvement in the final exam scores, perceived learning was widely concluded as a positive effect of gamified learning. Improved learning was observed in the majority of students when compared to non-gamified groups. Student attitudes in the form of increased effort, participation, attendance, confidence, and interest in class was also an important benefit observed from using gamification and game-based learning. Improved student performance in the form of higher quality projects, improved learning outcomes, reduced failure rates, and higher average scores were also observed in gamified learning groups.

The systematic review found that a number of game mechanics can be successfully borrowed from games for use in higher education settings. The study also found that the game elements can be used in different combinations and across various approaches and applications

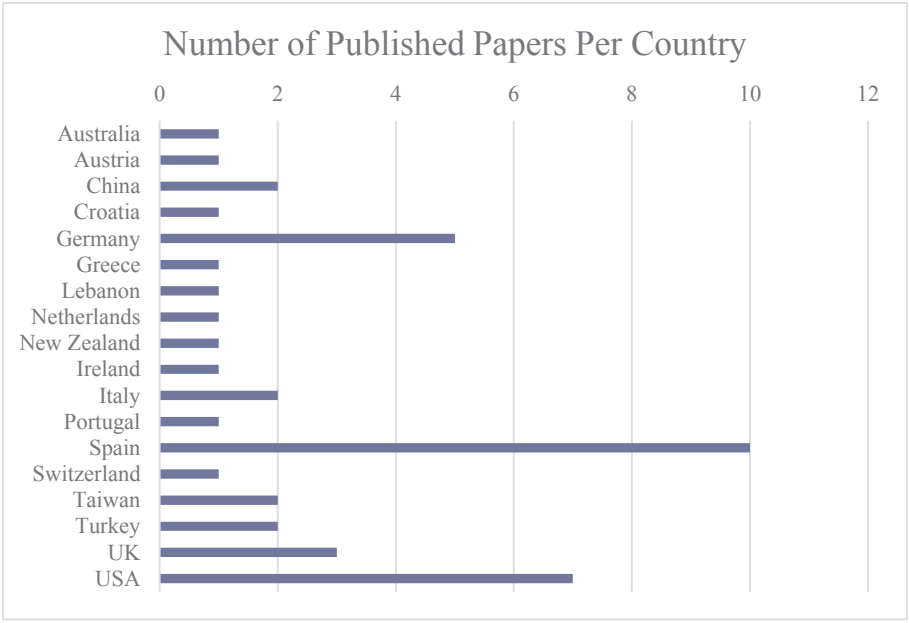

Fig. 4. Number of papers on gamified learning in higher education published per country.

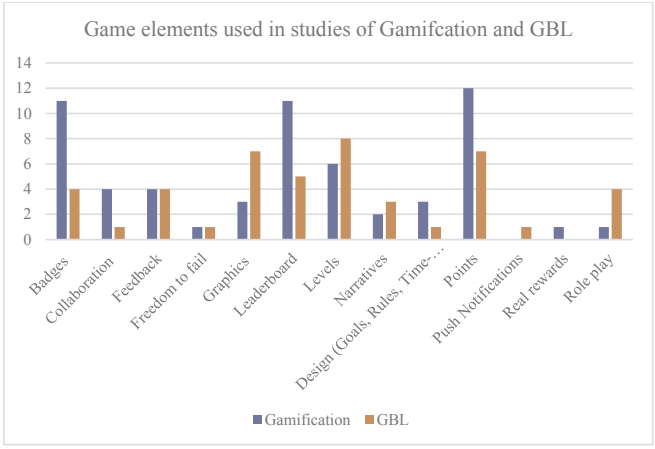

Fig. 5. Game elements used in studies on gamification and game-based learning.

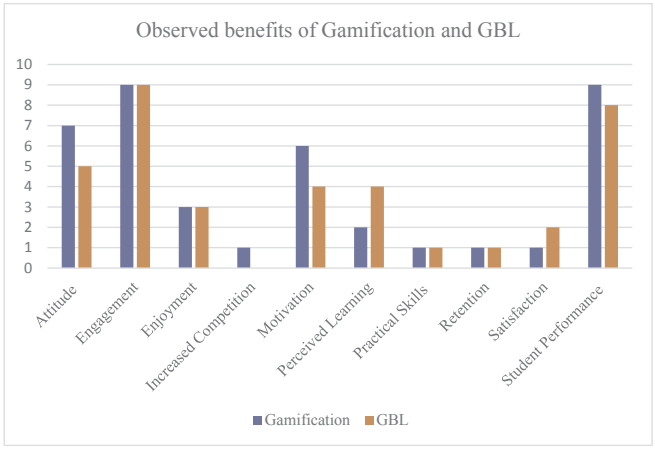

Fig. 6. Observed benefits in studies on gamification and GBL.

of gamification and game-based learning. In particular, points, badges, leaderboards, levels, missions/quests, and feedback were identified through the systematic literature review as important game elements. The systematic literature review found that gamification is gaining acceptance quickly and is being implemented across several countries. This review also recognized the most important game elements that can be used in both gamification and game-based learning. Gamified learning has been shown to improve several attributes of education resulting in benefits for both teachers and students.

5. Conclusions and limitations

This systematic literature review found encouraging support for gamified learning in higher education used in the form of gamification and game-based learning. The successful implementation of gamification and game-based learning give reason to be enthusiastic about their application in higher education across various country/student cultures, subjects, and formats. Spain can be seen as the country leading the research into gamified learning in higher education contexts, with research primarily being conducted in the field of computing. There is a lack of research on gamified learning in engineering disciplines; however, this review offers motivation to conduct further research on applying gamification and game-based learning to engineering education. The systematic literature review identified several benefits of using gamified learning, such as improved student-engagement, motivation, confidence, attitude, perceived learning, and performance. Improved student attitudes, engagement, and performance were the most significant benefits from using gamification and game-based learning applications. This makes a strong case for the application of gamification and game-based learning in higher education. This review also identified points, badges, leaderboard, levels, feedback, and graphics as important game elements that are suitable for use in higher education. While points, badges, and leaderboard were the most commonly used game elements for gamification of courses, graphics, points, and levels were the most frequently used game elements in game-based learning.

While this paper provides a comprehensive review, there are limitations. One limitation of this study that should be considered is that a number of studies used a quasi-experimental design where the assignment of students into experimental groups is not completely randomized. Therefore, the possible presence of some confounding variables in those studies cannot be discounted. In addition, only papers published in English in peer-reviewed journals available through the authors' institutional library were considered. As a result, studies on gamified learning published in other languages have been excluded. Additionally, grey literature, books, and dissertations were not considered for this study. This literature review focused on gamified learning only in higher education; therefore, frameworks that are not specific to higher education but still relevant to gamified learning in higher education may have been excluded. Further research in the application of gamified learning, and the development of frameworks suitable for students in higher education in engineering will be considered by the authors. Overall, there is a reason to be optimistic of the future of improved and innovative teaching and learning methods using gamification and game-based learning in higher education.

References

Antonaci, A., Dagnino, F. M., Ott, M., Bellotti, F., Berta, R., Gloria, A. D., ... Mayer, I. (2015). A gamified collaborative course in entrepreneurship: Focus on objectives and tools. *Computers in Human Behavior, 51*, 1276–1283.

Bellotti, F., Berta, R., Dagnino, F. M., Ott, M., Antonaci, A., Gloria, A. D., ... Mayer, I. (2014). Serious games and the development of an entrepreneurial mindset in higher education engineering students. *Entertainment Computing, 5*, 357–366.

Berns, A., Isla-Montes, J.-L., Palomo-Duarte, M., & Dodero, J.-M. (2016). Motivation, students' needs and learning outcomes: A hybrid game-based app for enhanced language learning. *SpringerPlus, 5*(1), 1–23.

Bonde, M. T., Makransky, G., Wandall, J., Larsen, M. V., Morsing, M., Jarmer, H., et al. (2014). Improving biotech education through gamified laboratory simulations. *Nature Biotechnology, 32*(7), 694–697.

Buckley, P., & Doyle, E. (2016). Gamification and student motivation. *Interactive Learning Environments, 24*(6), 1162–1175.

Cakıroglu, U., Basıbüyük, B., Güler, M., Atabay, M., & Memis, B. Y. (2017). Gamifying an ICT course: Influences on engagement and academic performance. *Computers in Human Behavior, 69*, 98–107.

Caton, H., & Greenhill, D. (2014). Rewards and penalties: A gamification approach for increasing attendance and engagement in an undergraduate computing module. *International Journal of Game-based Learning, 4*(3), 1–12.

Chang, J.-W., & Wei, H.-Y. (2016). Exploring engaging gamification mechanics in massive online open courses. *Educational Technology & Society, 19*(2), 177–203.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*, 661–687.

Daubenfeld, T., & Zenker, D. (2015). A game-based approach to an entire physical chemistry course. *Journal of Chemical Education, 92*(2), 269–277.

Day-Black, C., Merrill, E. B., Konzelman, L., Williams, T. T., & Hart, N. (2015). Gamification: An innovative teaching-learning strategy for the digital nursing students in a community health nursing course. *Official Journal of the Association of Black Nursing Faculty in Higher Education, 26*(4), 90–94.

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.

De-Marcos, L., García-Cabot, A., & García-López, E. (2017). Towards the Social Gamification of e-Learning: a Practical Experiment. *International Journal of Engineering Educadion, 33*, 66–73.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification". *MindTrek'11 proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp. 9–15). Tampere: ACM.

Dias, J. (2017). Teaching operations research to undergraduate management students: The role of gamification. *International Journal of Management in Education, 15*, 98–111.

Fisher, D. J., Beedle, J., & Rouse, S. E. (2013). Gamification: A study of business teacher educators' knowledge of, attitudes toward, and experiences with the gamification of

activities in the classroom. *The Journal of Research in Business Education, 56*(1).
Fotaris, P., Mastoras, T., Leinfellner, R., & Yasmine, R. (2016). Climbing up the Leaderboard: An empirical study of applying gamification techniques to a computer programming class. *The Electronin Journal of e-Learning, 14*(2), 94–110.
Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming, 33*(4), 441–467.
Gee, J. P. (2007). *Good video games and good learning: Collected essays on video games, learning, and literacy.* New York: Peter Lang International Academic Publishers.
Giannetto, D., Chao, J., & Fontana, A. (2013). Gamification in a social learning environment. *Issues in Informing Science and Information Technology, 10*, 195–207.
Guenaga, M., Arranz, S., Florido, I. R., Aguilar, E., Guinea, A. O., Rayón, A., ... Menchaca, I. (2013). Serious games for the development of employment oriented competences. *IEEE Journal of Latin-American Learning Technologies, 8*(4), 176–183.
Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification Work? A literature review of empirical studies on gamification. *Proceedings of 47th Hawaii international conference on system sciences* (pp. 1530–1605). Waikoloa: IEEE.
Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, 54*, 170–179.
Hamzeh, F., Theokaris, C., Rouhana, C., & Abbas, Y. (2017). Application of hands-on simulation games to improve classroom experience. *European Journal of Engineering Education, 42*(5), 471–481.
Hew, K. F., Huang, B., Chu, K. W., & Chiu, D. K. (2016). Engaging Asian students through game mechanics: Findings from two experiment studies. *Computers & Education, 92–93*, 221–236.
Holmes, J. B., & Gee, E. R. (2016). A framework for understanding game-based teaching and learning. *On the Horizon, 24*(1), 1–16.
Ibanez, M.-B., Di-Serio, A., & Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: A case study. *IEEE Transactions on Learning Technologies, 7*(3), 291–301.
Jordine, T., Liang, Y., & Ihler, E. (2015). A mobile device based serious gaming approach for teaching and learning Java programming. *International Journal of Interactive Mobile Technologies, 9*(1), 53–59.
Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education.* San Francisco, CA, USA: Pfeiffer.
Kim, B. (2012). Harnessing the power of game dynamics why, how to, and how not to gamify the library experience. *College & Research Libraries News, 73*(8), 465–469.
Knautz, K., Wintermeyer, A., Orszullok, L., & Soubusta, S. (2014). From know that to know how – providing new learning strategies for information literacy instruction. *Communications in Computer and Information Science, 492*, 417–426 (Springer, Cham).
Kuo, M.-S., & Chuang, T.-Y. (2016). How gamification motivates visits and engagement for online academic dissemination - an empirical study. *Computers in Human Behavior, 55*, 16–27.
Leaning, M. (2015). A study of the use of games and gamification to enhance student engagement, experience and achievement on a theory-based course of an undergraduate media degree. *Journal of Media Practice, 16*(2), 155–170.
Lee, J., & Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly, 15*(2), 1–5.
Llorens-Largo, F. J., Gallego-Durán, F. J., Villagrá-Arnedo, C., Compañ-Rosique, P., Satorre-Cuerda, R., & Molina-Carmona, R. (2016). Gamification of the learning Process: Lessons learned. *IEEE Journal of Latin-American Learning Technologies, 11*(4), 227–234.
Markopoulos, A. P., Fragkou, A., Kasidiaris, P. D., & Davim, J. P. (2015). Gamification in engineering education and professional training. *International Journal of Mechanical Engineering Education, 43*(2), 118–131.
Materla, T., Cudney, E. A., & Antony, J. (2017). The application of kano model in the healthcare industry: A systematic literature review. *Total Quality Management and Business Excellence,* 1–22.
Mathrani, A., Christian, S., & Ponder-Sutton, A. (2016). PlayIT: Game based learning approach for teaching programming concepts. *Educational Technology & Society, 19*(2), 5–17.
Mayer, I., Bekebrede, G., Harteveld, C., Warmelink, H., Zhou, Q., van Ruijven, T., ... Wenzler, I. (2014). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology, 45*(3), 502–527.
Mettler, T., & Pinto, R. (2015). Serious games as a means for scientific knowledge transfer—a case from engineering management education. *IEEE Transactions on Engineering Management, 62*(2), 256–265.
Moncada, S. M., & Moncada, T. P. (2014). Gamification of learning in accounting education. *Journal of Higher Education Theory and Practice, 14*(3), 9–19.
Morillas Barrio, C., Muñoz Organero, M., & Sánchez Soriano, J. (2016). Can gamification improve the benefits of SRSs in learning? *IEEE Transactions on Emerging Topics in Computing, 4*(3), 429–438.
Pechenkina, E., Laurence, D., Oates, G., Eldridge, D., & Hunter, D. (2017). Using a gamified mobile app to increase student engagement, retention and academic achievement. *International Journal of Educational Technology in Higher Education, 14*(31), 1–12 (2017) 14:31.
Reeves, B., & Read, J. L. (2009). *Total Engagement: Using games and virtual worlds to change the way people work and business compete.* Harvard Business Press.
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78.
Ryan, R. M., Rigby, C. S., & Przybylski, A. K. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion, 30*(4), 344–360.
Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior,* 371–380.
Sánchez-Martín, J., Cañada-Cañada, F., & Dávila-Acedo, M. A. (2017). Just a game? Gamifying a general science class at university Collaborative and competitive work implications. *Thinking Skills and Creativity, 26*, 51–59.
Song, D., Ju, P., & Xu, H. (2017). Engaged Cohorts: Can gamification engage all college students in class? *Eurasia Journal of Mathematics, Science and Technology Education, 13*(7), 3723–3734.
Stansbury, J. A., & Earnest, D. R. (2017). Meaningful gamification in an industrial/organizational psychology course. *Teaching of Psychology, 44*(1), 38–45.
Strmečki, D., Bernik, A., & Radošević, D. (2015). Gamification in e-learning: Introducing gamified design elements into e-learning systems. *Journal of Computer Sciences, 11*(12), 1108–1117.
Villagrasa, S., Fonseca, D., Redondo, E., & Duran, J. (2014). Teaching case of gamification and visual technologies for education. *Journal of Cases on Information Technology, 16*(4), 38–57.
Wiggins, B. E. (2016). An overview and study on the use of games, simulations, and gamification in higher education. *International Journal of Game-based Learning, 6*(1), 18–29.
Wongso, O., Rosmansyah, Y., & Bandung, Y. (2014). Gamification framework model, based on social engagement in e-learning 2.0. *2nd international conference on technology, informatics, management, engineering and environment* (pp. 10–14). Bandung: IEEE Xplore.
Yee, N. (2006). *The psychology of MMORPGs: Emotional investment, motivations, relationship formation, and problematic usage. Avatars at work and play: Collaboration and interaction in shared virtual environments, Vol. 34*, 187–207.
Yildirim, I. (2017). The effects of gamification-based teaching practices on student achievement and students' attitudes toward lessons. *Internet and Higher Education, 33*, 86–92.
Zichermann, G., & Cunningham, C. (2011). *Gamification by design.* Sebastopol, CA: O'Reilly.