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Underpinning Learning Theories of Medical Educational Games: A Scoping Review

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Abstract

Background: Gamification is the process of game thinking and game mechanics to attract learners and solve problems. It is a unique growing phenomenon in education and training programs. Educational games, by application of game design and game elements in learning environments, motivate students to learn and improve the teaching and learning process. Herein, this scoping review presents an overview of the theoretical underpinnings of gamification that is crucial in understanding the theoretical pillar of successful educational games.

Methods: This scoping review follows Arksey and O'Malley's stages of scoping review. In this review, the gamification in medical education articles that implicitly or explicitly presented underpinning learning theories of gamification in medical education was retrieved. So, keywords such as gamification, learning theories, higher education, and medical education were searched in Scopus, PubMed, WEB OF SCIENCE, EMBASE, ERIC, and Cochrane Library from 1998 to March 2019.

Results: The search indicated 5416 articles which were narrowed down by title and abstract relatedness. 464 articles entered the second phase of the study and after reviewing their full text, finally, 10 articles which were explicitly and implicitly reported the underpinning learning theories remained.

Conclusion: Gamification is a strategy using game design techniques for non-game experiences for more effective learning and provides a more attractive environment for teaching and learning. Designing gamification based on learning theories (behavioral, cognitive, and constructivist), makes them more efficient, and the application of learning theories in designing gamification is recommended.

Keywords: Gamification, Learning Theories, Higher Education, Medical Education

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Introduction

Education has assumed a new form and meaning in recent years. The traditional teacher-centered approach in which the teacher transferred information in educational settings has changed; now, numerous methods and tools, including gamification, facilitate teaching and learning (1). Games are product-oriented activities that progress based on predetermined rules and mostly comprise centralized decision-making. Also, games are activities with competition to promote learning and memorization (2). Gamification introduces the elements of games in a non-game situation (3).

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↑What is "already known" in this topic:
Gamification is the process of game thinking and game mechanics to attract learners and solve problems. It is a unique growing phenomenon in education and training programs.

→What this article adds:
Learning theories provide teachers and game designers with numerous techniques that can be selected based on the topic, situation, and learners to guarantee the best performance in a specific situation or a specific topic. Incorporating a combination of learning theories in the design of effective and efficient gamification will have beneficial teaching effects, leading to effective, efficient, and lifelong learning.

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Gamification is an effective educational tool that increases the quality of education and creates motivation and enthusiasm in learners (4). Learning through gamification is based on adding processing elements to learning activities, making it parallel to what takes place in games. Accordingly, it is assumed that by including the mechanics of the game in designing the learning process, learners can get involved with the learning experience, and their behavior can be optimally altered (5). In fact, gamification is not just a technology but a methodology that can be applied to different domains of education. Gamification involves the learner in a learning experience, which eventually leads to learning.

The acquisition, processing, and maintenance of knowledge during the learning process are described through learning theories. The cognitive, emotional, and environmental effects and prior experience all play a role in shaping how a person acquires, changes, or maintains knowledge and skills (6). Learning theories can be divided into three general groups: behaviorism, cognitivism, and constructivism (7). Behaviorism is mainly concerned with the observable and measurable aspects of human behavior (8). For behaviorists, learning results in a manifest change in behavior (9). Contrary to this view which emphasizes the role of the environment in changing behaviors and learning, cognitive theories attach more importance to learners in creating learning (10). In other words, according to cognitive theorists, learning is created in the learners in the form of potentials and is saved in their memory; as a result, whenever the learners desire --immediately after learning or later- they can use those potentials. Constructivism is a psychological and philosophical view according to which most people construct and shape most of what they learn and comprehend. Constructivism is a learning theory that emphasizes the active role of learners in knowledge and perception construction (11).

To the best of our knowledge of review of the literature showed no study examining fundamental learning theories in gamification in medical education. Gamification is growing as a research domain and practice (5). Gamification leads to learning, and how this learning is shaped is described by learning theories. Thus, the present study examined the fundamental learning theories in gamification in medical education. We hope that by using the results of this study, we can encourage the designers of gamification to design games based on sound theoretical foundations and theories of learning, thus contributing to the development of learning theories in gamification.

Methods

The scope of this scoping review was limited to studies on fundamental learning theories in gamification. This method follows five stages of the structure of scoping reviews, including the formulation of the research question, identification of relevant studies, selection of studies, charting and collecting the data, and summarizing and reporting the results, as expressed by Arksey and O'Malley (11).

Step 1: Identify the research question

The research question in this scoping review was:

What are the learning theories used for designing gamification in medical education?

Step 2: Identify relevant studies

Six databases were searched to find articles related to the fundamental learning theories in gamification: Scopus, PubMed, WEB OF SCIENCE, EMBASE, ERIC, and Cochrane Library. The search was limited from 1998 to March 2019. According to that educational games existed before Nick Pelling coined the term "gamification" in 2003, we considered the time limit for published articles from 1998 to 2019. The search strategy in terms of the selected keywords is provided in Table 1. The selected keywords used in the search strategies, after examination in MeSH, are as follows:

- "Gamification" OR "Educational Games" OR " Game-Based Learning" OR "GBL" OR " Serious Game" "Video Game" OR "Computer Game" OR " Digital Game"
- Higher education
- Education, professional
- Education, graduate
- Medical education
- Learning theory

Step 3: Study selection

The resources examined in each database included articles (and case reports), conference proceedings, book sections, books, and other items refined based on the search strategy and the study's objectives. The reviewed articles were screened and examined based on the PRISMA flowchart, and finally, eligible articles were selected (Figure 1). The inclusion criteria are as follows:

Table 1. Search strategies in databases

1-	("gamification" OR "educational game" OR " game-based learning" OR "GBL" OR "serious game" OR "video game" OR "computer game" OR "digital game") AND ("higher education")
2-	("gamification" OR "educational game" OR " game-based learning" OR "GBL" OR "serious game" OR "video game" OR "computer game" OR "digital game") AND ("higher education" OR education, profession OR education, graduate OR medical education)
3-	("gamification" OR "educational game" OR " game-based learning" OR "GBL" OR "serious game" OR "video game" OR "computer game" OR "digital game") AND ("learning theory")
4-	("gamification" OR "educational game" OR " game-based learning" OR "GBL" OR "serious game" OR "video game" OR "computer game" OR "digital game") AND ("higher education") AND ("learning theory")
5-	("gamification" OR "educational game" OR " game-based learning" OR "GBL" OR "serious game" OR "video game" OR "computer game" OR "digital game") AND ("higher education" OR education, profession OR education, graduated OR medical education) AND ("learning theory")

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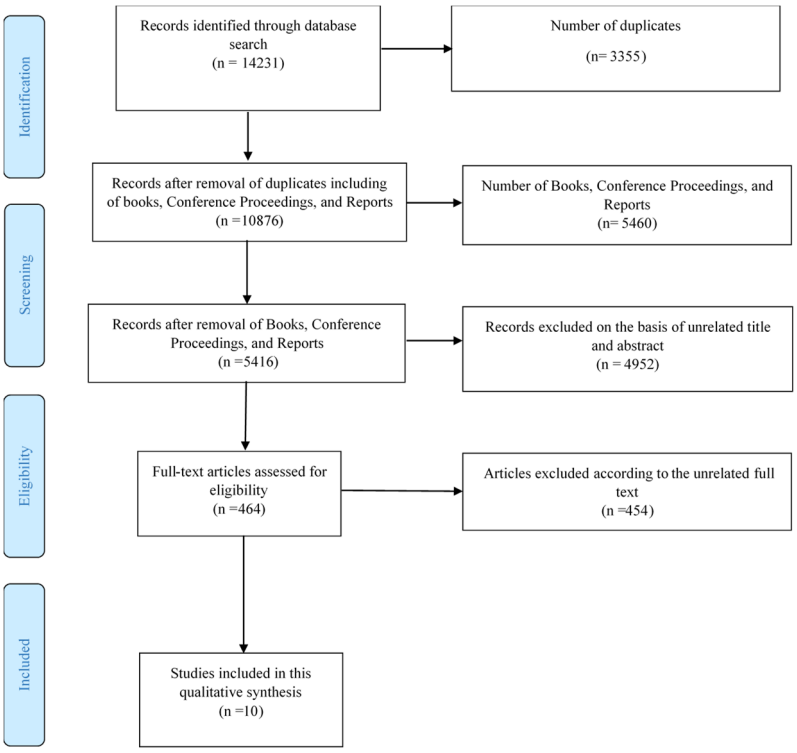

Figure 1. Prisma Diagram

- Samples have been extracted from the population that is based on learning theories in educational games and are representative of the community.
- Studies that are estimated to have the least possible bias and minimal variance.
-
- Studies in the field of education in medical sciences.
- The full text of the article is available.

Library articles included were read in full by two members of the research team, and cases of disagreement were discussed with a third researcher; discussions were continued until reaching a consensus. Then, the medical Education Research Study Quality Instrument (MERSQI) checklist was used for evaluating quantitative articles in the domain of education, and the PRISMA checklist was used for assessing systematic reviews. The quality of each article was assessed, and it was found that all the selected articles were eligible for inclusion.

Step 4: Charting the data

Charting the data is a valid descriptive-analytical method that utilizes a standard form for collecting and organizing data obtained from searching texts. Table 2 summarizes the data divided by year, author, country, type of study, participants, and database.

Table 2. The Bibliography of the reviewed articles

Row	First Authors	Database	Year	Study Type	Participants	Country
1	Adriana A. Beylefeld	PubMed	2007	Observational	Third-year medical students	South Africa
2	Konrad Bochennek	Web oF Science	2007	Review	-----	Germany
3	Thanakorn Jirasevijinda	EMBASE	2010	Observational	Residents with undergraduate medical degrees	U. S. A.
4	Alan Amory	Web oF Science	2011	Mixed-Method	Undergraduate B.Ed. students postgraduate students	South Africa
5	Andrew Tawfik	Scopus	2012	Mixed-Method	First-year health science students	U. S. A.
6	Brynjar Foss	Scopus	2013	Case-Report	Nurses	Norway
7	Joan Earle Hahn, Cheryl Bartel	Scopus	2014	Case-Report	Graduate students in nursing	California
8	Stephen M. Wiesner	PubMed	2017	Observational	Undergraduate students in a medical laboratory science	Minneapolis
9	Lamyae Sardi and Ali Idri	PubMed	2017	Systematic Review	------	Spain
10	Duncan Henry, Benjamin Orwoll	Scopus	2018	Prospective nonrandomized controlled	Nurses	California

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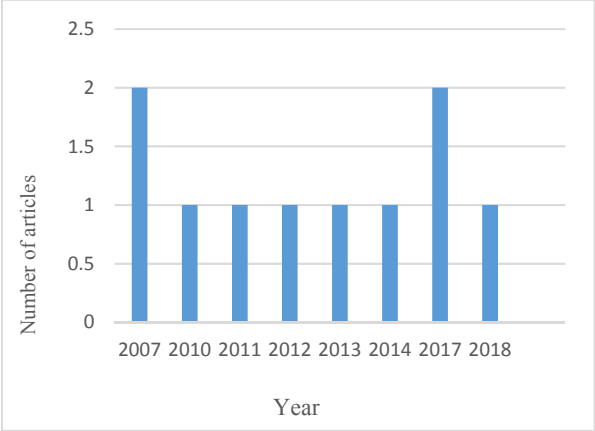

Figure 2. Number of articles found on educational games related to learning theories by year of publication

Step 5: Collating, summarizing, and reporting the results

All ten articles examined behaviorism. Of these, 6 mentioned cognitivism, three constructivism, two cognitive load theory, and one humanism and the adult learning theory (Figure 1). Figure 2 depicts the frequency of the ten articles on gamification, which examined learning theories in medical education, divided by the year of publication.

The number of studies on gamification in medical education also discussed learning theories was higher in 2007 than that in 2010-2015. No relevant research was found in 2008 and 2009. In recent years, attention to gamification based on learning theories has increased. The following discussion is based on the findings of these articles.

Discussion

The results of the examined articles demonstrated that attention to the use of learning theories in designing gamification has increased in recent years. The ten eligible articles have specified six learning theories: behaviorism, cognitivism, constructivism, cognitive load theory, humanism, and adult learning theory, which will be discussed below.

Behaviorism learning theory

According to behaviorism, learning is a "change in behavior in the desired direction," which occurs using different techniques such as rewards and incentives for shaping correct behavior. Learning is formed by repetition, feedback, and reinforcement which are utilized to modify the behavior stably. This system depends on constant repetition and "skill and practice". Learning occurs in small portions and leads to a change in behavior (10, 12). Today, the principles of behavioristic learning are commonly used in medical education. For instance, Joseph (13) states that university students must receive immediate feedback on incorrect concepts from experienced professors or other sources. Based on the principles of behaviorism, feedback works only if it is offered immediately, and this feedback can be easily identified after behavior and performance (14). For example, in a study by Bochennek et al., games were reviewed in the field of medical education on the PubMed database and stated that an oncology game as a combination of board and computer games had been designed for third-year medical students in four stages, the computer contains the data of all the patients, and the players choose the therapeutic elements and sequences (radiology, oncology, or surgery). When the patient visits the clinic, the computer gives feedback regarding the players 'choices and offers points for further treatment. The learners felt that their knowledge of oncology was enhanced during the gameplay (15, 16). The present study confirmed the findings of Foss et al., expressing that the reception of immediate feedback allows the learners to evaluate their progress in learning, which enhances their motivation and self-confidence. In addition to feedback, the reward is a significant aspect of games, offers information to the learners about their performance (17, 18), and creates competition and motivation in them. The feedback given to the learners during the game helps enhance their self-awareness and promotes interactions with peers (19). All the articles included in the current review indirectly discussed the behavioristic learning theory. According to the findings of the present study and about the mechanics of games, the reward and feedback the learners receive during the game can reinforce or shape the learned behavior. Accordingly, the behavioristic theory can be an inseparable component of educational games based on learning theories. As for the use of behaviorism in medical education, since behaviorists focus on observable behaviors, educational goals can be determined and transformed into more specific behavioral purposes specified by the game designers in the game design document. In general, for education offered through computers, the principles of behaviorism can be applied (20).

Cognitivist learning theory

The cognitivist approach is characterized by meaningful learning, through which the learners try to comprehend the structure of knowledge (10). In fact, this theory discusses the processes performed on the data entering the human brain that change, store, and retrieve these data and use them in different situations (20).

The findings suggest that the concepts proposed by Vygotsky in knowledge construction provide a practical framework for the use of video games in education. The use of mediation, a significant component of Vygotsky's theory, has provided a framework for contemporary educators which can be quickly adopted in any teaching situation, such as computer games (21). The study by Joan Earle Hahn et al. showed that, as an approach to education, educational games support Bandura's (1977) self-efficacy model, which states that an effective experience can serve as a source of information that affects self-efficacy (22). A systematic review by Lamyae Sardi et al. (2017) on gamification in e-health (23) provides evidence that games stimulate the brain and improve the acquisition of knowledge, thereby enhancing cognitive development. Different game mechanics that play potential roles in gamification are significant for players because they can ensure the flow of cognitive skills, such as developing concentration and problem-solving skills (23-25). Furthermore, Wiesner et al. conducted a study on a scenario-based learning environment (SBLE) through game theory. The students solved

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each scenario, received rewards and feedback, and moved on to the next level. According to the authors, the students were willing to repeat the scenarios and acquired a new experience upon each repetition. Reception of reward and feedback indicates the behavioristic learning theory. SBLE is designed to strengthen clinical thinking and integrate the topics for learners with a high level of prior knowledge. It attempts to cover different aspects of the cognitivist learning theory and education design, e.g., reducing the external cognitive load, purposeful learning, scheduling feedback, and game theory (26).

Another pertinent theory is the cognitive load theory. The present study confirmed the results of Tawfik's (27) study in which educational video games have been regarded as an opportunity for engaging learners with an all-encompassing experience of problem-solving. However, despite potential merits, educational video games may lead to excess cognitive load and, therefore, lack unofficial learning benefits for inexperienced individuals. According to Soler, the cognitive load theory states that the working memory required for meaningful learning has intrinsic limitations. In other words, people have a limited capacity for processing and constructing information received through visual and verbal channels (28). The limitations of working memory are exacerbated upon interaction with unknown information. Studies show that the cognitive load in educational video games in which the learner interacts with concepts may be exacerbated. Moreover, there are also elements of technology interaction (abnormal cognitive load) at play. As a result, attention must be paid to cognitive load theory in designing educational games so that more efficient games can be created. As for the use of cognitivist learning theories in medical education, one can mention Ausubel's meaningful learning theory. In this theory, an emphasis is made on the use of advanced organizers by the teacher. Progressive organizers aim to present concepts related to the topic at hand to the learners before teaching the details. As a result, one of the applications of this theory is the use of advanced organizers. Some gamification present vaster educational content before starting the game and, in this way, help the learners become familiar with the conceptual framework of the game. Another application of the cognitivist theory is the use of concept maps. Yet another application of said theory is learning through observation, a major principle in Bandura's social cognitive learning theory. This principle can find vast applications in medical education, especially in the clinical domain. There is prior information about the scientific topic of the game in the minds of learners; this information is changed at the end of the game in which learning is formed. As a result of new information, the cognitive structure in the learner's mind is altered, which leads to learning. Moreover, learning with educational games can create a concept map related to the topic in the learner's mind. The learner can use this concept map at any time, which is entirely compatible with the cognitivist learning theory.

Constructivist learning theory

Constructivism highlights the importance of the learners 'active participation in constructing knowledge for themselves. It is assumed that learners use background knowledge and concepts to access new information (29). The study by Tawfik (27) notes that the expansion of multimedia technologies provides creative opportunities for learning in which the learner is educated through participation in the process of learning. Video games are an ideal multimedia tool to present concepts interestingly and unofficially. In addition, educational video games allow learners to participate in learning and knowledge construction, thus promoting the principles of constructive learning. Since new knowledge is integrated with prior experience, teaching strategies should present the concepts to create problem-solving skills in learners. Research suggests that educational video games motivate learners to spend more time learning (27, 30, 31). As for the use of this theory in medical education, it is known that the constructivist theory emphasizes the active role of learners in the learning process, and thus its main application can be in learner-centered teaching methods. Another application of this theory is mentorship; based on Vygotsky's social constructivism, knowledge is constructed in society and interaction with others. In this method, the learners face real problems in a real environment and learn in interaction with the teacher and other learners. Education through gamification is learner-centered, and the player constructs a major part of the acquired knowledge during the game. When playing a game, the learner's knowledge resulting from learning is constructed by the learner and based on the facilitative factors in the game. Since, in the constructivist learning theory, the teacher only plays the role of a facilitator, the learning constructed through the educational game can be largely compatible with the constructivist learning theory.

Humanistic learning theory and adult learning theory

Humanistic learning theories are related to learners' emotions, thoughts, values, and experiences in relation to learning (32). Based on this theory, learners 'experiences promote learning (33). In a study by Konrad et al., the experiential learning cycle theory for medical games has been adopted to describe the complexities of a game as an educational process. Learning cycles describe the process of learning as a sequence of steps forming a cycle of repeated actions. As a result, games may be viewed as experiential learning cycles because the steps of learning are repeated in each gameplay or each game (34).

In an observational study by Thanakorn Jirasevijinda et al., a game format has been proposed for residents. In this game, the participants are tested on information about a broad spectrum of topics. Each clue containing the presented data is a "response". The clues have dollar values, and their values are increased based on the problem's difficulty level. At the end of the game, the participant with the highest number of wins is the winner. Based on a survey of the participants, most of them stated that they learned better and more in this way. The game used in this study was based on the adult learning theory, which is directly mentioned in the article. Adult learners actively participate in the learning process in a safe and supportive setting in the adult learning theory. In this setting, they receive immedi-

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ate feedback; interact and cooperate with one another; activate their prior knowledge and experience; pay attention to the relevant topics, and learn in the best way. This directly discusses the adult learning theory and the behavioristic and cognitivist learning theories (34).

The present study investigated fundamental learning theories in gamification in medical education to extract these theories from the existing games. It is suggested that games should be designed based on learning theories so that, by using this educational tool, more effective and efficient education can be provided. Table 3 presents the data resulting from the examined articles about learning theories in gamification.

One of the limitations of this study is that at the time of searching the databases, some articles may have been under publication, or may not have been indexed in the databases, or may have been neglected by the researchers and, as such, have not been included. Moreover, relevant articles may have been published in languages other than English and thus have not been included. Also, despite our efforts to access the full texts of all the articles, this was not possible in the case of some pieces.

Conclusion

Gamification is a strategy employing the techniques of game design for non-game experiences to direct the learners 'behavior. It can lead the learners towards more effective learning and make the learning environment more attractive. Since the goal of gamification goes beyond entertainment and tries to attract learners' attention and shape their learning, the development of such games should be based on learning theories. Based on the results of this study, the most frequently used learning theory in gamification is the behavioristic learning theory, directly or indirectly mentioned in the majority of the reviewed studies. This is because receiving rewards and feedback, which are behavioristic principles, exist in almost all games and are the principles of game design. An application of this theory in medical education is setting educational goals and turning these behaviors into precise behavioral purposes, a point that must be provided in the game design documented

Table 3. Learning theories mentioned in the retrieved articles

Row	Title	Study Type	Authors	Year	Learning Theories					
					Behaviorism	Cognitivism	Constructivism	Humanism	Cognitive load	Adult Learning
1	Pre-service teacher development: A model to develop critical media literacy through computer game-play	Mixed-Method	Alan Amor	2011	√	√	√			
2	More than mere games: a review of card and board games for medical education	Review	Konrad Bochennek, Boris Wittekindt and et.al	2007	√			√		
3	Teaching gaming with technology in the classroom: So you Want to be an Educator?	Case-Report	Joan Earle Hahn and Cheryl Bartel	2014	√	√				
4	Human-computer interaction factors in designing educational video games	Mixed-Method	Andrew Tawfik	2012	√		√		√	
5	A systematic review of gamification in e-health	Systematic Review	Lamyae Sardi, Ali Idri, José Luis Fernández-Alemán	2017	√	√				
6	Improving Critical Thinking Using a Web-Based Tutorial Environment	Observational	Stephen M. Wiesner, PhD, MT(ASCP) J.D. Walker, PhD Craig R. Creeger, BS	2017	√	√			√	
7	Jeopardy! An innovative approach to teach psychosocial aspects of pediatrics	Observational	Thanakorn Jirasevijinda a,*, Lauren C. Brown	2010	√	√				√
8	A gaming approach to learning medical microbiology: students' experiences of flow	Observational	Adriana A. Beylefeld D& Magdalena C. Struwig	2007	√	√	√			
9	Medication Calculation the Potential Role of Digital Game-Based Learning in Nurse Education	Case-Report	Brynjar Foss	2013	√					
10	microlearning for enuality improvement led digital intervention of central line–associream infection	Prospective nonrandomized controlled	Benjamin Orwoll,Shelley Diane, Duncan Henry,Lisa Tsang	2018	√					

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by the designers. The constructivist learning theory is also adopted in designing gamification because this type of education is learner-centered, and learning plays a central role in it; the teacher plays the role of a facilitator, and new knowledge is constructed by the learner. The applications of this theory in medical education include learner-centered teaching methods and mentorship. Education through gamification is learner-centered, and the player constructs a major part of the acquired knowledge during the game. In education through gamification, the cognitivist learning theory is also used. This could partly be because new learning occurs based on previous knowledge in this type of education. Of course, the cognitive load theory must be included in designing gamification because human memory can store a limited amount of information. The applications of the cognitivist learning theory include the use of advanced organizers, concept maps, and learning through observation. Learning theories provide teachers and game designers with numerous techniques that can be selected based on the topic, situation, and learners to guarantee the best performance in a specific situation or a specific topic. Incorporating a combination of learning theories in the design of effective and efficient gamification will have beneficial teaching effects, leading to effective, efficient, and lifelong learning.

Ethical Approval

The present study was part of the thesis submitted by Ms. Zohreh Hosseinzadeh for the partial fulfillment of the Master's thesis entitled "A Systematized Review of Underpinning Learning Theories of Educational Games (1998-2019)" which was approved by the Ethics Committee of Iran University of Medical Sciences (IUMS) in 2018 (Code of ethics: IR.IUMS.FMD.REC.1398.218).

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Conflict of Interests

The authors declare that they have no competing interests.

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