DIGITALEDUCATIONREVIEW

# All Work and No Play Makes Jack a Dull Boy – A Systematic Review on Effectiveness of Game-based Learning in Dental Education

Rahul Mohandas [1], Subhashree Mohapatra [2*]

[1] Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth (Deemed to be University), Pune, India, rahuldas1192@gmail.com, https://orcid.org/0000-0002-0609-8219

[2] Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth (Deemed to be University), Pune, India, subhashreesdc@gmail.com, https://orcid.org/0000-0002-8068-7249

## ABSTRACT

Game-based learning (GBL) is an effective learning tool for medical and dental undergraduates in enhancing knowledge and skills as well as gaining student engagement and motivation. Educational games can create a social constructivist learning environment, where learners can construct their knowledge through interactions with their peers and instructors. This concept is promising for learners to self-direct their learning. However, there is no clear evidence yet to support their effectiveness over traditional approaches in terms of competence improvement. The present systematic review aimed to assess and compare all the available literature on the effect of game-based learning on dental education. The PubMed, Scopus, Cochrane, Science Direct, Lilac, and Web of Science databases were searched using the predetermined MeSH terms and eligibility criteria. The search yielded a total of eight articles. The studies included applications like Kahoot, GoDental, DentalByte, Skills-o-mat, and Playdent for GBL and compared their effectiveness to conventional methods. It was found that overall student satisfaction, motivation and interest was higher in GBL methods compared to the conventional methods of learning. GBL seems to be an effective tool for knowledge acquisition among dental students. However, further research should be conducted to compare the effectiveness of GBL against other learning methods. Newer games can also be tailor-made for specific learning objectives.

KEYWORDS: Teaching; Teaching effectiveness; Dental education; Game-based learning; Dental curriculum

## 1 INTRODUCTION

Learning is an active process in which students and facilitators must collaborate to make this knowledge-sharing process entertaining and easy to comprehend (Nguyen et al., 2022). Conventional learning employs simple delivery of knowledge in the form of textbooks, didactic lectures, and tutorials. Despite conventional preferences due to its simplicity, appropriateness for crowded classes, and the ability to communicate vast volumes of theoretical subject, students are exposed to large amounts of information in conventional learning, making it difficult to retain, remember, and interpret (Tuma, 2021).

E-learning, web-based learning, computer-based simulators, mobile devices, virtual reality modalities, and games are increasingly being used to supplement simulation strategies and traditional curricula as technology advances and a variety of information technologies and multimedia resources are integrated into the educational context (Bankar et al., 2023). To catch up with the recent advancements in medical and dental education, it is critical to closely monitor the developments and changing information in medical education technology (Guze, 2015). Due to the inability of traditional learning to respond adequately to educational needs, the quest for newer learning models has begun (Coman et al., 2020).

Lack of motivation is a major obstacle in medical and dental education (Dhawan, 2020). Students with a higher interest rate and enjoyment scores tend to perform better (Harackiewicz et al., 2016). Modern medical education and teaching must motivate students by using innovative techniques and technologies to help them achieve better results (Moran et al., 2018). With the rapid development of modern technologies and the iterations of educational concepts, the array of unconventional educational practices is gradually widening its horizon (Coman et al., 2020). Among the various arrows in the quiver of modern healthcare education, game-based learning (GBL) is fast developing as an interesting and innovative teaching approach (Xu et al., 2023).

Unlike the traditional teaching methodologies, the core modality of GBL is to incorporate varied game components into non-game regions to enhance participant involvement, engagement and motivation (Abdul Jabbar & Felicia, 2015). GBL has a broad scope that includes both non-technical and technology integration of games within the educational activity (Pan et al., 2021). Using games in education can boost player engagement and consequently their willingness to study, thereby supporting knowledge acquisition (Nadeem et al., 2023). Games incorporated usually in GBL can be either commercial off-the-shelf games and their modifications, or serious games (Wang et al., 2023). Bergeron has defined serious games as ‘‘an interactive computer application, with or without a significant hardware component, that has a

challenging goal, is fun to play with, incorporates some concept of scoring, and imparts in the user a skill, knowledge or attitude which can be applied in the real world' (Gorbanev et al., 2018). Both off-self games and serious games have shown effectiveness.

Game-based learning (GBL) is an effective learning tool for medical and dental undergraduates in enhancing knowledge and skills as well as gaining student engagement and motivation. Educational games can create a social constructivist learning environment, where learners can construct their knowledge through interactions with their peers and instructors. This concept is promising for learners to self-direct their learning. However, there is no clear evidence yet to support their effectiveness over traditional approaches in terms of competence improvement. Hence, the present systematic review was conducted to compare the available literature on the effectiveness of GBL in dental education.

## 2 MATERIALS AND METHODS

The present systematic review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

### 2.1 Protocol registration

The review was registered in the PROSPERO database (the International Prospective Register of Systematic Reviews hosted by the National Institute of Health Research, University of York, Centre for Reviews and Dissemination) according to the guidelines, with the identification number CRD42023461406.

### 2.2 Review Question

Is Game-based learning more effective than conventional learning in dental education?

### 2.3 PICO analysis

The population included postgraduate and undergraduate dental students. The intervention was GBL in dental education. The comparator was conventional learning methods in dental education. The outcome assessed was knowledge attainment and student satisfaction/ perception of GBL.

### 2.4 Search strategy

Two authors (RM and SM) performed an exhaustive literature search to evaluate the efficacy of GBL in dental education in improving knowledge attainment and student satisfaction. Online electronic databases like PubMed, Scopus, Cochrane, Lilac, ScienceDirect, and Web of Science were searched from the earliest available data until 31st September 2023. A combination of appropriate keywords and Medical Subject Heading (MeSH) terms like 'game-based learning', 'gamification', 'education, dental', and 'dental curriculum' was used in different permutations and combinations using appropriate Boolean operators. A hand search was also done to obtain additional articles. In the case of unpublished articles, the authors were contacted. A detailed manual search for relevant articles was also performed to ensure a thorough screening process. A detailed search strategy is illustrated in Figure 1.

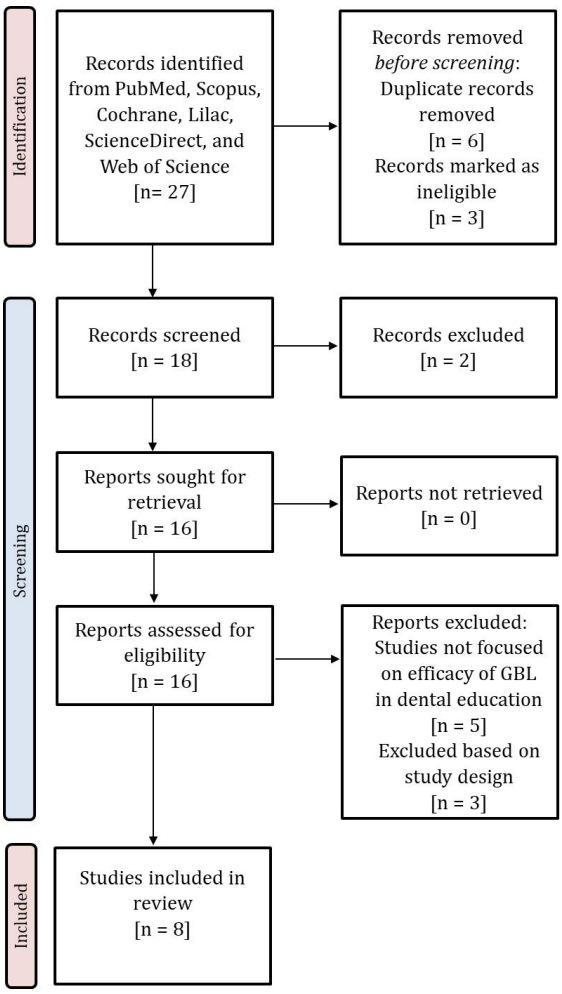


Figure 1. PRISMA flowchart

## 2.5 Inclusion and Exclusion Criteria

Studies assessing the efficacy of GBL among dental undergraduate and postgraduate students and comparing it with conventional learning were included. Randomized controlled trials, non-randomized interventional studies, and experimental studies were included without any date or language restriction.

Articles assessing the effectiveness of GBL among other health science students were excluded from the review. Letter to the editor, review articles, animal studies, technical notes, and correspondence were also excluded.

## 2.6 Screening and selection

All the searched data was imported into an Excel spreadsheet (MS Excel 2020). The titles and abstracts of the included studies were screened from the above-mentioned databases independently by two reviewers (RM and SM). The papers were selected for full-text reading if the search keywords were present in the title and the abstract. Articles without abstracts but titles related to this review's objectives were also chosen to screen the full text for eligibility. After selection, two reviewers read the full-text papers in detail (RM and SM). Those papers that fulfilled all selection criteria were processed for data extraction. Two reviewers (RM and SM) searched the reference lists of all selected studies for additional relevant articles. Disagreements between the two reviewers were resolved by discussion.

## 2.7 Data extraction

Two reviewers (RM and SM) used a standardized form to extract the relevant data. Any disagreement was resolved by discussion between the authors. Information curated for data extraction included author/year of publication, study setting, name of the game-based learning platform/ technology, application in dental education, objective outcome of knowledge attainment through pre-test and post-test assessment, subjective outcome of student satisfaction and perception through questionnaire/ survey, and conclusion. Disagreements between individual judgments in data extraction were resolved by mutual discussion. The extracted data were recorded using an Excel spreadsheet (MS Excel 2020).

### 2.8 Risk of Bias Assessment

Risk of bias assessment of the included studies was carried out by two reviewers independently (RM and SM). Any disagreements between individual judgments in risk of bias assessment were resolved by mutual discussion. The Medical Education Research Study Quality Instrument (MERSQI) was used to assess the quality of each publication (Cook & Reed, 2015). The tool consists of 10 items that address the following six areas of research quality: study design, sampling, type of data, validity of instrument, data analysis, and outcomes. Each domain has a maximum score of 3, permitting a maximum total score of 18. The authors of the instrument advise reviewing individual items and domain-specific scores even though they do not provide a precise cut-off score to distinguish between low- and high-quality researches. It has been determined that the tool is trustworthy for evaluating the methodological quality of publications in medical education (Cook & Reed, 2015).

## 3 RESULTS

### 3.1 Search Selection

The PubMed, Scopus, Cochrane, Science Direct, Lilac, and Web of Science databases using the pre-determined MeSH terms and hand-searched articles yielded a total of twenty seven articles, of which six were duplicates. Eighteen titles and abstracts were identified as the related subjects of inclusion criteria. After analyzing those eighteen abstracts, sixteen publications were finalized for full article screening. Finally, eight articles were acknowledged to meet the review criteria (Akaltan et al., 2023; Arayapisit et al., 2023; Borit & Stangvaltaite-Mouhat, 2020; Felszeghy et al., 2019; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023). PRISMA flowchart (figure 1) was developed to summarise the selection of included studies.

### 3.2 Characteristics of Included Studies

Six articles (Akaltan et al., 2023; Arayapisit et al., 2023; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023) used randomized controlled trial as their study design (75%). One study employed a questionnaire-based study (Borit & Stangvaltaite-Mouhat, 2020), while another study adopted a quasi-experimental study design (Felszeghy et al., 2019). The games were developed for the following applications in dental education: basic life support training, removable partial denture design, orofacial space infection tracing, oral rehabilitation of edentulous patients, flipped classroom, histology whole slide imaging, alginate mixing and improvement of learning performance, with one game each. Among the included studies, four studies (50%) assessed the knowledge and perception of the students (Arayapisit et al., 2023; Felszeghy et al., 2019; Mahrous et al., 2023; Pisal et al., 2022), while two studies (25%) assessed the knowledge, skill and perception (Akaltan et al., 2023; Tuil et al., 2023). Only one study each assessed perception (Borit & Stangvaltaite-Mouhat, 2020), and skill along with perception (Hannig et al., 2013) respectively. Table 1 depicts the description of the included studies.

| Sr no | Authors | Institution | Study design | Population | No of Participants | Intervention/ Name of GBL app/ technology | Application | Assessment |
|---|---|---|---|---|---|---|---|---|
| 1 | Akaltan, KF et al | Ankara University Faculty of Dentistry | Randomized Controlled trial | All 5-year dental students | 91 | Serious game learning | Basic life support training | Knowledge + Skill + Perception |
| 2 | Mahrous, A et al | University of Iowa College of Dentistry | Randomized Controlled trial | Pre-clinical second-year dental students | 73 | AiDental software group | Removable partial denture design | Knowledge + Perception |
| 3 | Tawepong et al | Mahidol University Faculty of Dentistry | Randomized Controlled trial | Fourth-year dental students | 32 | Trace the Spread: An educational board game for orofacial spaces | Orofacial space infection tracing | Knowledge + Perception |

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|---|---|---|---|---|---|---|---|---|
| 4 | Pisal et al | Krishna Institute of Medical Sciences, KIMSDU, Karad | Randomized Controlled trial | 2nd and 3rd BDS students | 120 | TAO GBL software | Improvement of students learning performance | Knowledge + Perception |
| 5 | Tuil et al | Faculty of Dental Surgery, University of Paris | Single-blind RCT | 3rd BDS students | 89 | Playdent project | Oral rehabilitation of edentulous patients | Knowledge + Perception + Skill |
| 6 | Borit et al | UiT The Arctic University of Norway (Tromsø, Norway) | Questionnaire | All 5-year dental students | 50 | GoDental based Flipped Classroom | Flipped classroom | Perception |
| 7 | Felszeghy et al | University of Eastern Finland (UEF) | Quasi-experimental design | first year medical and dentistry students | 418 | Whole-slide imaging platform + Kahoot | Histology whole slide imaging | Knowledge + Perception |
| 8 | Andreas Hannig et al | RWTH Aachen University & Medical School | Parallel-group randomized controlled trial | 2nd year of study | 55 | Skills-O-Mat | Alginate mixing | Skill + Perception |

Table 1. Description of included studies

### 3.3 Evidence on the effectiveness of GBL in dental education

Objective outcome like knowledge attainment was assessed using pre- and post-test assessment. The subjective outcomes like perception, satisfaction and overall usability of the game were assessed using questionnaires and open-ended surveys. Seven out of the eight included studies (87.5%) employed pre-test and post-test assessments to judge the knowledge gained using GBL (Akaltan et al., 2023; Arayapisit et al., 2023; Felszeghy et al., 2019; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023). In all seven studies, there was a significant increase in knowledge attainment in the GBL group compared to the control or conventional learning group.

Four studies (50%) assessed the perception of dental students towards GBL in dental education (Akaltan et al., 2023; Arayapisit et al., 2023; Felszeghy et al., 2019; Mahrous et al., 2023). In all four studies, a generally positive perception was reported by the students regarding improvement in learning, exam performance and decision making. Three studies (25%) assessed student satisfaction after using GBL, with all three studies reporting a significantly higher satisfaction among the students in the GBL group compared to the conventional learning group (Borit & Stangvaltaite-Mouhat, 2020; Pisal et al., 2022; Tuil et al., 2023). Only one study (12.5%) assessed the overall usability of the game, which was reported to be high (Hannig et al., 2013). Table 2 summarizes the evidence on the effectiveness of GBL in dental education.

| Sr no | Authors | Objective outcome (Assessment) | Subjective outcome (Perception) | Conclusion |
|---|---|---|---|---|
| 1 | Akaltan, KF et al | The BLS post-test results (10.89 ± 1.08) were significantly higher compared to pre-test results (9.43 ± 1.45) in the SG group (p = 0.00) | Participants reported that SG will improve their learning (4.53 ± 0.66), and exam performance (4.51 ± 0.81) and make learning entertaining (4.62 ± 0.57) and simple (4.60 ± 0.58) | Serious gaming in the management of medical emergencies for dentists also contributes to traditional lecture-style teaching and is a preferred |

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|---|---|---|---|---|
| | | | | learning method for undergraduate dental students. |
| 2 | Mahrous, A et al | 60% of participants in the AiDental group achieved a grade of A or B compared to only 31% of participants in the conventional group (statistically significant) | Participants had a generally positive perception of the ease of use and the ability of software to improve decision-making and critical thinking relative to RPD design choices | The use of AiDental's automated feedback and gamification techniques in RPD education had a positive effect on student grades and it was well-liked by students |
| 3 | Tawepong et al | Significant increase in the knowledge assessment scores after game completion in both collaboration (40.3% to 68.15%) ($p<0.001$) and competition groups (46.85% to 56.85%) ($p = 0.003$) | Participants rated the game positively, in which the scores tended to be higher in the collaboration group (Collaboration: 4.32/5; Competition 3.74/5) | This game appeared to be effective for learning orofacial space infections, and the learning environment within the collaborative group was found to be more supportive in terms of knowledge improvement and satisfaction. |
| 4 | Pisal et al | Mean post-test knowledge of experimental group students (7.4 ±2.6) was significantly higher than mean post-test knowledge of control group students (5.1 ± 2.3)($p=0.002$) | Mean satisfaction of 2nd year students (4.3) was significantly higher than mean satisfaction of 3rd year students (3.9) ($p=0.009$) | Academic performance scores were improved and the findings of the study were quite positive |
| 5 | Tuil et al | Scores significantly increased between Test 1 and Test 2 for students within the “test” group (+11.1 ± 24.9%, $p = 0.04$), while they did not change within the “control” group ($p = 0.21$). | 71% participants rated the SGs as satisfactory and 91% of them judged the consistency of SGs content with lectures to be satisfactory. | Game-based learning showed a positive impact on the learning outcomes of third-year students. |
| 6 | Borit et al | Not assessed | The GBL augmented FC session was statistically significantly more enjoyable than the conventional FC sessions 1 and 2 | Game-based learning augmented FC proved to enhance students’ experience, resulting in increased enjoyment compared to the conventional FC setup. |
| 7 | Felszeghy et al | Significantly higher percentages of correct test scores were obtained when students completed the tests in either the beginning of the histology teaching sessions in team mode (G2 69%) vs. individual player mode (G1 58%; $p<0.05$) or at the end as a team (G4: 87%) vs. individual player mode (G3 82%; $p<0.05$). | 63% of students felt that interactive gamification helped increase their knowledge of basic histology. 85% of the survey participants reported that they gained a better understanding of histology content. | Use of gamification in the teaching of histology can provide a foundation for designing a gamification-integrated curriculum across healthcare disciplines |
| 8 | Andreas Hannig et al | The mean values of knowledge gain for the test group were higher in test group than in the control group | High overall usability of Skills-O-Mat (5.33 points on average on a 1-6 scale) was reported | The game was rated a valuable instrument for teaching and developing practical skills. |

Table 2. Evidence on the effectiveness of GBL in dental education

### 3.4 Pedagogical description of games

The games’ pedagogical description was not always clearly stated by any of the authors of the included studies. However, when they discussed the goals of the game, the motivation of the students, and the state of medical education, they disclosed their pedagogical preferences. Assessment of the game type revealed that five games (62.5%) were game-based simulations (Akaltan et al., 2023; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023), two were games (25%) (Arayapisit et al., 2023; Felszeghy et al., 2019), and one was a gamified app (12.5%) (Borit & Stangvaltaite-Mouhat, 2020). It was also revealed that 62.5% of the games were web-based (Borit & Stangvaltaite-Mouhat, 2020; Felszeghy et al., 2019; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023), and 37.5% of the games were computer-based (Akaltan et al., 2023; Arayapisit et al., 2023; Hannig et al., 2013). Regarding the creators’ choice of the

game genre, five games (Akaltan et al., 2023; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023) were based on training simulation (62.5%), two games (Borit & Stangvaltaite-Mouhat, 2020; Felszeghy et al., 2019) were quiz-based (25%), and only one game (Arayapisit et al., 2023) was adventure-based (12.5%).

On assessing the games' pedagogical role, 75% of the games were complementary to the teaching-learning activities (Borit & Stangvaltaite-Mouhat, 2020; Felszeghy et al., 2019; Hannig et al., 2013; Mahrous et al., 2023; Pisal et al., 2022; Tuil et al., 2023), while 25% of the games were independent (Akaltan et al., 2023; Arayapisit et al., 2023). It was found that 37.5% of the games belonged to a constructivist field (Akaltan et al., 2023; Hannig et al., 2013; Tuil et al., 2023), 37.5% belonged to a cognitivist field (Arayapisit et al., 2023; Felszeghy et al., 2019; Mahrous et al., 2023), while in 25% of the games, the pedagogical strategy data was insufficient (Borit & Stangvaltaite-Mouhat, 2020; Pisal et al., 2022). In 75% of the studies, the game designs were coherent with the pedagogical strategy (Akaltan et al., 2023; Arayapisit et al., 2023; Felszeghy et al., 2019; Hannig et al., 2013; Mahrous et al., 2023; Tuil et al., 2023). Table 3 exhibits the pedagogical description of the games. Due to the considerable heterogeneity of the studies and differences in evaluation methodologies, a meta-analysis could not be performed in any domain.

| Sr no | Authors | Game Name | Game type | Platform | Game genre | Games' pedagogical role | Pedagogical strategy | Game and pedagogy coherence |
|---|---|---|---|---|---|---|---|---|
| 1 | Akaltan, KF et al | Serious game learning | Game based simulation | Computer based | Training simulation | Independent | Constructivism | Coherent |
| 2 | Mahrous, A et al | AiDental software group | Game based simulation | Web based | Training simulation | Complementary | Cognitivism | Coherent |
| 3 | Tawepong et al | Trace the Spread | Game | Computer based | Adventure | Independent | Cognitivism | Coherent |
| 4 | Pisal et al | TAO GBL software | Game based simulation | Web based | Training simulation | Complementary | Insufficient pedagogical description | Insufficient game description |
| 5 | Tuil et al | Playdent project | Game based simulation | Web based | Training simulation | Complementary | Constructivism | Coherent |
| 6 | Borit et al | GoDental | Gamified app | Web based | Quiz | Complementary | Insufficient pedagogical description | Insufficient game description |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | Felszeghy et al | Kahoot | Game | Web based | Quiz | Complementary | Cognitivism | Coherent |
| 8 | Andreas Hannig et al | Skills-O-Mat | Game based simulation | Computer based | Training simulation | Complementary | Constructivism | Coherent |

Table 3. Pedagogical description of games

### 3.5 Risk of bias and quality Assessment

The methodological quality assessment of the included studies by MERSQI showed that the quality of the included articles was adequate, with the scores ranging from 9 to 15.5 (Table 4).

| Author, year | Study design | Sampling | Type of data | Validity of instrument | Data analysis | Outcome | Total score |
|---|---|---|---|---|---|---|---|
| Akaltan et al, 2023 | 3 | 2 | 3 | 1 | 3 | 1.5 | 13.5 |
| Mahrous et al, 2023 | 3 | 2 | 3 | 3 | 3 | 1.5 | 15.5 |
| Tawepong et al, 2023 | 3 | 2 | 3 | 3 | 3 | 1.5 | 15.5 |
| Pisal et al, 2022 | 3 | 2 | 3 | 1 | 3 | 1.5 | 13.5 |
| Tuil et al, 2022 | 3 | 2 | 3 | 3 | 3 | 1.5 | 15.5 |
| Borit et al, 2020 | 2 | 2 | 1 | 1 | 2 | 1 | 9 |
| Felszeghy et al, 2019 | 2 | 2 | 3 | 3 | 3 | 1.5 | 14.5 |
| Andreas Hannig et al, 2013 | 3 | 2 | 3 | 1 | 3 | 1.5 | 13.5 |

Table 4. Appraisal of methodological quality of included articles using the Medical Education Research Study Quality Instrument

## 4 DISCUSSION

Conventional learning employs simple delivery of knowledge in the form of textbooks, didactic lectures, and tutorials. However, GBL enables students to actively interact with the learning process (Byusa et al., 2022). A well-made game empowers the students to become problem-solvers by motivating and interesting them at the same time (Jääskä & Aaltonen, 2022). In a meeting on emerging technologies hosted by the Association for Dental Education in Europe in 2017, it was predicted that GBL would have a profound impact on dental teaching over the next ten years (Dragan et al., 2020). However, six years later, the debate still remains about whether GBL is a better learning aid than traditional learning in dental education. Hence, the aim of the present systematic review was to explore the effectiveness of GBL compared to conventional learning in dental education and to draw a conclusion regarding its effectiveness

Simulation-based GBL immerses students in realistic virtual worlds that simulate real-world circumstances, allowing them to practice decision-making and problem-solving in a safe, risk-free environment (Chernikova et al., 2020). This sort of GBL is commonly used in medicine, allowing trainees to practice virtual procedures. It also employs simulations to imitate workplace scenarios, allowing students to build practical skills in controlled environments (Chernikova et al., 2020).

Quiz-based GBL aims to reinforce knowledge through interactive questions and challenges (Xu et al., 2023). It is a useful tool for revisiting key topics and boosting retention that is frequently used in classrooms and for standardized test preparation (Xu et al., 2023). Quiz-based activities are competitive and typically use score systems to motivate students. Popular examples include platforms such as Kahoot! and Quizizz, where students take real-time quizzes and compete against one another to study information in a fun, engaging fashion (Xu et al., 2023).

Role-playing GBL allows students to perform certain roles within a controlled narrative or historical context (Xu et al., 2023). This sort of GBL enables students to consider multiple perspectives and make judgments depending on their assigned roles (Xu et al., 2023). These games put students in several other peoples' shoes, requiring them to discuss, negotiate, and understand events from the characters' perspectives, so encouraging critical thinking and empathy (Xu et al., 2023).

Finally, puzzle-based GBL focuses on problem solving and logical reasoning (Xu et al., 2023). This sort of GBL promotes cognitive flexibility and pattern recognition by offering increasingly difficult puzzles (Xu et al., 2023). Puzzle-based GBL requires learners to think creatively and strategically in order to tackle complicated challenges (Xu et al., 2023). Depending on the learner's needs and educational goals, each of these GBL types provides distinct benefits, assisting in the development of specific skills ranging from cognitive reasoning and problem-solving to empathy and strategic thinking.

Our systematic review contributes meaningfully to the broader literature by reaffirming the effectiveness of game-based learning (GBL) in increasing knowledge retention among students. This is consistent with findings from other fields, where GBL is recognized for its ability to engage learners through motivation, rewards, and competition. (Martín-Hernández et al., 2021). This increased motivation leads to a more positive student experience and engagement. Additionally, GBL promotes student autonomy and competence via the self-determination theory by making students feel in total control of their actions, and competent to accomplish tasks (Farrell, 2014). Lastly, game elements like timed questions and leader board competitions help activate student action and encourage students to function under pressure (Sailer et al., 2017).

Our review highlighted that the majority of the studies (62.5%) used game-based simulation as their preferred game type. Another key finding of our review was that the majority of the games were based on training simulation (62.5%). During simulation-based training, the player hones valuable skills such as interpersonal communication, teamwork, leadership, decision-making, task prioritization, and stress management (Al-Elq, 2010). Simulations allow students to see the results of their choices in real-time, and take responsibility for decision-making through problem-solving competencies, resulting in a more active, transforming, and experiential reception of knowledge (Lateef, 2010). The majority of the researchers preferred web-based games (62.5%). This could be due to the fact that the twenty-first century students are more familiar with using technological tools than physical or board games (Nkadimeng & Ankiewicz, 2022).

In terms of their pedagogical role, the majority of the games (75%) were complementary to the teaching-learning activities. GBL is not intended to replace any of the effective pedagogy methods. Rather, it can be a valuable addition to the teaching toolbox that educators can leverage to engage modern dental students (Mormer, 2018). Our review also pointed out that 75% of the games were classified as constructivist or cognitivist, with the majority of game designs being aligned with the pedagogical strategy. This was understandable given that the dental students preferred quizzes and simulations and emphasized memory and skill development through repetition. This also suggests that dental students concentrate on these two domains and do not seek more complicated games (Al-Saud, 2023).

## 5 LIMITATIONS

Despite stringent inclusion and exclusion criteria, this systematic review has a few potential limitations. Firstly, the number of included studies is too small to draw conclusive evidence regarding the effectiveness of GBL in dental education. Secondly, only short-term learning outcomes have been assessed. Thirdly, a quantitative assessment of the studies was not possible due to the heterogeneity of the data. Fourthly, slow and advanced learners were not assessed independently. The learning outcomes should be aligned with the students' competencies. Finally, all studies were single institute studies. One major concern with single-institution studies is that they are underpowered and are prone to type II error.

## 6 FUTURE DIRECTIONS

In the future, the long-term effects of GBL need to be appraised. Clinical procedures and psychomotor skills cannot be completely replicated in a virtual environment, hence physical games need to be formulated and their effectiveness needs to be assessed. Slow and advanced learners need to be assessed independently to check the effectiveness of GBL among these sub-groups. Multicentric- inter-institutional studies should be encouraged with a larger and wider sample size. Finally, games need to be formulated or modified to assess all three domains simultaneously.

## 7 CONCLUSION

Based on our systematic review, we conclude that GBL contributes to traditional learning, and can be used as an adjunct tool to traditional classroom learning to improve knowledge attainment of dental graduate and postgraduate students. Integration of GBL into dental education improves student satisfaction and enjoyability, and can provide additional scaffolding for student learning. Further studies should explore whether the use of GBL has the potential to improve clinical performance and soft skills.

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## TOTES FEINES I RES DE JOC FAN DE JACK UN NEN AVORRIT: UNA REVISIÓ SISTEMÀTICA SOBRE L'EFICÀCIA DE L'APRENENTATGE BASAT EN JOCS A L'EDUCACIÓ DENTAL

L'aprenentatge basat en jocs (GBL) és una eina d'aprenentatge eficaç perquè els estudiants universitaris de medicina i odontologia millorin els coneixements i les habilitats, així com per aconseguir el compromís i la motivació dels estudiants. Els jocs educatius poden crear un entorn d'aprenentatge social constructivista, on els alumnes poden construir el coneixement a través d'interaccions amb els companys i els instructors. Aquest concepte és prometedor perquè els alumnes autodirigeixin el seu aprenentatge. No obstant això, encara no hi ha proves clares que donen suport a la seva eficàcia respecte als enfocaments tradicionals en termes de millora de la competència. Aquesta revisió sistemàtica va tenir com a objectiu avaluar i comparar tota la literatura disponible sobre l'efecte de l'aprenentatge basat en jocs a l'educació dental. Es van fer cerques a les bases de dades PubMed, Scopus, Cochrane, Science Direct, Lilac i Web of Science utilitzant termes MeSH predeterminats i criteris d'elegibilitat. La cerca va llançar un total de vuit articles. Els estudis van incloure aplicacions com Kahoot, GoDental, DentalByte, Skills-o-mat i Playdent per a GBL i van comparar la seva eficàcia amb els mètodes convencionals. Es va descobrir que la satisfacció, la motivació i l'interès general dels estudiants eren més grans en els mètodes GBL en comparació dels mètodes convencionals d'aprenentatge. GBL sembla una eina eficaç per a l'adquisició de coneixements entre els estudiants d'odontologia. Tanmateix, cal fer més investigacions per comparar l'eficàcia del GBL amb altres mètodes d'aprenentatge. Els jocs més nous també es poden personalitzar per a objectius específics d'aprenentatge.

PARAULES CLAU: educació dental; aprenentatge basat en jocs; ensenyament

## TODO TRABAJO Y NADA DE JUEGO HACEN DE JACK UN NIÑO ABURRIDO: UNA REVISIÓN SISTEMÁTICA SOBRE LA EFICACIA DEL APRENDIZAJE BASADO EN JUEGOS EN LA EDUCACIÓN DENTAL

El aprendizaje basado en juegos (GBL) es una herramienta de aprendizaje eficaz para que los estudiantes universitarios de medicina y odontología mejoren sus conocimientos y habilidades, así como para lograr el compromiso y la motivación de los estudiantes. Los juegos educativos pueden crear un entorno de aprendizaje social constructivista, donde los alumnos pueden construir su conocimiento a través de interacciones con sus compañeros e instructores. Este concepto es prometedor para que los alumnos autodirijan su aprendizaje. Sin embargo, todavía no hay pruebas claras que respalden su eficacia con respecto a los enfoques tradicionales en términos de mejora de la competencia. La presente revisión sistemática tuvo como objetivo evaluar y comparar toda la literatura disponible sobre el efecto del aprendizaje basado en juegos en la educación dental. Se realizaron búsquedas en las bases de datos PubMed, Scopus, Cochrane, Science Direct, Lilac y Web of Science utilizando términos MeSH predeterminados y criterios de elegibilidad. La búsqueda arrojó un total de ocho artículos. Los estudios incluyeron aplicaciones como Kahoot, GoDental, DentalByte, Skills-o-mat y Playdent para GBL y compararon su eficacia con los métodos convencionales. Se descubrió que la satisfacción, la motivación y el interés general de los estudiantes eran mayores en los métodos GBL en comparación con los métodos convencionales de aprendizaje. GBL parece ser una herramienta eficaz para la adquisición de conocimientos entre los estudiantes de odontología. Sin embargo, se deben realizar más investigaciones para comparar la eficacia del GBL con otros métodos de aprendizaje. Los juegos más nuevos también se pueden personalizar para objetivos de aprendizaje específicos.

PALABRAS CLAVE: Educación dental; aprendizaje basado en juegos; enseñanza