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Effectiveness of Crossword Puzzles in Dental Education: A Scoping Review

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Abstract

Background and Aim: Several studies have investigated the application of crossword puzzles in educational sectors. However, little research has particularly addressed their application and effectiveness in dentistry. Therefore, this scoping review aimed to map the current evidence regarding the inclusion of crossword puzzles in dental educational programs and their influence on the educational outcomes of dental students.

Materials and Methods: We electronically searched the PubMed, Scopus, Embase, and Google Scholar databases and hand-searched pertinent article references to solicit appropriate studies. A narrative synthesis was performed since the studies were heterogeneous in the result parameters.

Results: Crossword puzzles provide students with an enjoyable and engaging learning experience, improve cognitive skills like comprehension and problem-solving, and promote active learning. They have received substantial backing from dental students for inclusion in the dental curricula.

Conclusion: Incorporation of crossword puzzles and other gamified approaches could be a promising option to enhance dental education practices.

Keywords: Education, Dental; Gamification; Problem-Based Learning

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Introduction

Dental education plays a pivotal role in equipping future dental practitioners to deliver top-notch oral healthcare. Many novel terminologies and concepts have been added to the dental curricula in the past few years [1]. In dental colleges, didactic lectures are the most common style of imparting knowledge, which is passive, involves little student participation, and becomes boring after a few minutes [2,3]. This makes it difficult for students to recall, retain, and recite significant concepts. In light of technological breakthroughs and the constantly shifting backdrop of dental practice, educators constantly look for novel approaches to improve their teaching methods and knowledge retention among dental students [4]. One such educational strategy that has grabbed the spotlight as a novel and active teaching aid in dental education is the crossword puzzles.

Crossword puzzles, commonly found in modern magazines and newspapers, are a typical kind of word-based jigsaw which rely on problem-solving abilities and critical thinking to complete the empty spaces in a grid [5]. Their ability to actively engage pupils, promote cognitive processing, and boost memory recall, has led to their widespread use in a variety of educational contexts in recent years [2]. Crossword puzzles adhere to the tenets of active learning, a pedagogical approach that places an emphasis on student engagement and participation in the process of learning. As compared to passive learning methods, active learning has been demonstrated to improve knowledge retention, understanding, and problem-solving skills [6].

Several research projects have investigated the application of crossword puzzles in a variety of educational sectors, including psychology, sociology, pharmacology [5], nursing [7], forensic science [8], and medical training [9]. However, very little research has particularly addressed their application and effectiveness in the field of dentistry [9,10]. Therefore, this scoping review aims to map the evidence that is currently available regarding the inclusion of crossword puzzles in dental educational programmers and their influence on the educational outcomes of dental students, including their capacity to retain and utilize dental concepts in clinical contexts. By critically analyzing the existing studies, we intend to give evidence-based recommendations for dental educators, policymakers, and curriculum developers striving to improve the effectiveness of dental education and the learning process for future dental healthcare providers.

Materials and Methods

Registration and protocol:

We planned and carried out this scoping review in compliance with the Preferred Reporting Items for Scoping Review standards [11]. The protocol was registered with Open Science Framework. The registration link is as follows:
https://doi.org/10.17605/OSF.IO/9VYQZ.

Focused question:

What is the application of crossword puzzles in dental educational programs and their influence on the educational outcomes of dental students?

Eligibility criteria, search strategy and study identification:

We considered every type of original articles, including peer-reviewed publications, preprints, and grey literatures such as cross-sectional studies, randomized controlled trials, and pretest-posttest design with no linguistic constraints. Our investigation lasted from database inception until June 30, 2024. The retrieved publications did not include abstracts, editorials, narrative reviews, opinions, position statements, systematic reviews, or meta-analyses.

The following steps were implemented to identify relevant studies. First, we created an implicit Boolean query string that consisted of the population group (dental students), intervention (crossword puzzle), comparator (traditional teaching style), and desired outcomes (enhancing information retention). However, due to lack of studies on the area of interest, we conducted a broad search including only population and intervention to ensure that potential articles are not missed. The complete search string can be accessed in the Supplementary File S1. Next, we utilized this string to search the PubMed, Scopus, Embase, and Google Scholar databases. In addition, we hand-searched pertinent article references to solicit additional appropriate studies that were not found by the search. Titles and abstracts found during the search were screened using the Rayyan web program by two authors (ST and AM) independently. The full texts of potentially relevant papers were reviewed further based on

the criteria. In this method, relevant studies were selected. Disagreements between the reviewers were resolved by consensus building and discussion by subject experts of the study team (VM and SA).

Data extraction:

We extracted the sample size, author(s), country, study design, main findings, and conclusion from the studies that met our inclusion criteria and entered them into a Microsoft Excel sheet. We also took the estimates of knowledge improvement from the studies that met our inclusion criteria. If any of the aforementioned details were omitted from the study, we communicated with the authors. Data extraction was carried out and independently verified by two authors, with disagreements being settled by discussion and consultation with a third researcher. An interrater reliability of 0.89 was achieved on both the stages of screening and data extraction.

Data analysis:

Since the studies were heterogenous in the result parameters, a narrative synthesis of the data was performed.

Results

Search results:

Our exhaustive search yielded 2,095 citations, 28 of which were duplicates. During the title and abstract screening, 2,059 of the 2067 entries were rejected. The remaining eight articles were sought for retrieval for full text screening; three of these publications were excluded as they did not match our inclusion criteria (S1 File). Finally, five papers were chosen for this review (Figure 1).

Characteristics of included studies:

This scoping review included five original articles published between 2015 and 2023, with a total study population of 434 dental students. Table 1 presents an overview of the studies. Four of the five studies [2,4,9,12] were conducted in India, while the fifth one was conducted in Oman [1]. Although all were experimental in nature, two studies [2,9] employed a randomized parallel-group interventional design, while one had a pretest-posttest design [1], and two had a cross-sectional design [4,12]. Two studies employed the random sampling approach [2,9]; whereas, two used the convenience sampling method [1,12]. The sampling strategy employed in one study was not specified [4]. Three studies enrolled final-year dental students as participants [1,2,9], one study used 2nd year Bachelor of Dental Science students [4], and one study included dental students and interns [12]. Three studies used a Likert-scale questionnaire as their data collection tool [1,4,9], while one used a pre-validated closed-ended questionnaire [2]. Only one study collected data using an open-ended questionnaire [12]. Three of the five studies developed a crossword puzzle utilizing free web resources and had it pre-validated by two departmental subject matter experts [4,9,12]. Two studies did not mention anything about validating the puzzle [1,2] . In three studies, the students were either given the topic through a didactic manner first, or a topic that had already been covered in class was chosen, after which a crossword puzzle was given to each student to do within a specific period of time [2,4,9]. On the other hand, two studies [1,12] reported giving a familiar topic to students sometime before conducting the crossword puzzle game.

Duration and mode of conducting the crossword puzzle:

All studies reported conducting the crossword puzzle activity in groups, with puzzle-solving times ranging from 20 minutes [2,4,9,12] to 9 hours [1]. Four of the five studies conducted the puzzle game face-to-face with students in the classroom [2,4,9,12]; however, Qutieshat et al. [1] built a web-based program for the interactive puzzle and, after completing the puzzle, communicated the questionnaire's objective and completion date to students via email.

Table 1. Characteristics of included studies

Sl. No.	Author/ year	Title of the study	Country	Study method	Population	Sample size	Sampling method	Data collection tool	Duration	Analysis method	Key Findings	Conclusion/Recommendation
1	Saran and Kumar 2015 [4]	Use of crossword puzzle as a teaching aid to facilitate active learning in dental materials.	India	Cross sectional	Second year Dental students.	70	Not mentioned	Likert scale questionnaire	20 minutes	Percentages	Incorporation of crossword puzzles in dental materials curriculum was strongly favored by 80% of students.	Use of crossword puzzle as a teaching tool in dental materials can relieve the tedium of lecture and traditional teaching methods, thereby providing a more relaxed and friendly classroom atmosphere. This will facilitate active learning and make the learning experience of students more productive.
2	Sharma et al, 2019 [12]	Teaching innovation in the dental curriculum: student feedback and future aspects	India	Cross sectional	Dental students and interns	187	Convenience sampling	Open -ended questions	40 minutes	Descriptive statistics were applied to calculate means; Chi-square test	85.5% preferred these games over lectures. 98.9% preferred such games to be played in the future	The preference of students for such innovative techniques necessitates their frequent use while teaching subjects in dentistry. Such innovations could also be included in the curriculum to give the students a breather from their regular lectures and promote learning in a fun and innovative manner.
3	Nirmal et al, 2020 [2]	Use of Puzzles as an Effective Teaching–Learning Method for Dental Undergraduates	India	Randomized parallel group interventional study	Final year Bachelor of Dental Science student	60 (divided into two group)	Random Sampling	Multiple-choice questionnaires	30 minutes	Mann–Whitney nonparametric test	Interventional group students performed well with the P value being significant in three sessions when compared to the control group students.	Puzzles can be used as an active teaching learning tool supplementing traditional teaching for dental undergraduates.
4	Qutieshat et al, 2022 [1]	Interactive Crossword Puzzles as an Adjunct Tool in Teaching Undergraduate Dental Students.	Oman	Pre-post interventional study	Final year dental students	67	Convenience sampling	Likert-scale questionnaire	9 hours	Descriptive statistics	Students found the crossword puzzles engaging, meaningful, and successful. Written comments revealed students' enthusiasm for and a desire to be exposed to more of these exercises.	Further work would be required to confirm the generalizability and applicability of the findings of this study to other dental schools.
5	Gilani et al, 2023 [9]	Crossword Puzzle: An Effective Self-learning Modality for Dental Undergraduates	India	Randomized controlled, parallel group interventional study with open label.	Final year Bachelor of Dental Science students	50	Systematic random sampling	A 5-point Likert scale	45 minutes	Completion index, student's unpaired t test, learning effective index, intervention effectiveness, qualitative analysis of open-ended answers	The score of the experimental group increased from 25% to 50.55%. Group B also showed improvement in test scores from 32.51% to 49.70%. Also, 90% of students strongly agreed that crossword puzzle improved learning through recreation and that it is an effective self-learning method; whereas 70% of students strongly agreed on incorporating crossword puzzle in dental curriculum.	To make undergraduate teaching more interesting and interactive and to promote active learning, future involvement of complex crossword puzzle solving can be useful.

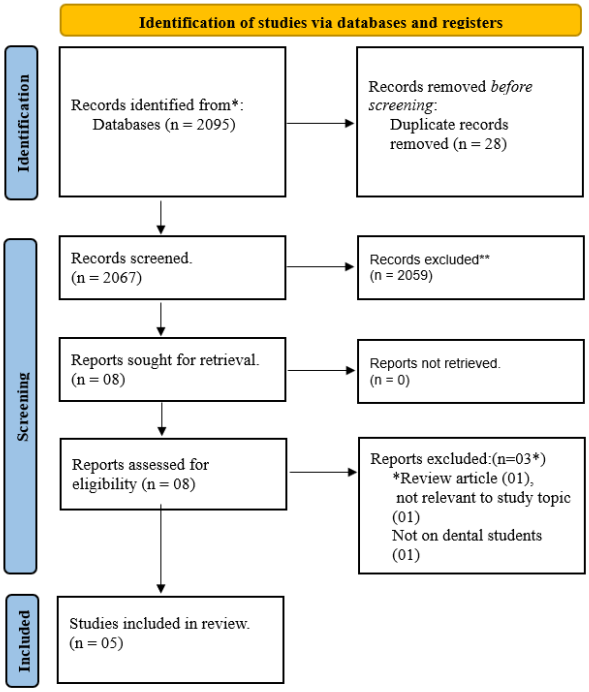

Figure 1. PRISMA flow diagram Assessment

Crossword puzzle as a fun experience:

Students reported crossword puzzle activity as an enjoyable experience in two studies [1,4]. According to Saran and Kumar [4], 93% of students stated that doing crossword puzzles was enjoyable and that they appreciated learning through recreation. Similarly, in the study by Qutieshat et al., [1] several students showed an initial lack of interest in learning games. However, after participating in the crossword puzzle exercise, their perspective shifted. They thought crossword puzzles as a novel way to study tough subjects because they did not feel like a demanding assignment or an anxiety-inducing exam. Instead, they created an exciting challenge that allowed students to interact with the subject without even realizing it. Another important component of the crossword puzzle was its capacity to alleviate the tension involved with learning hard concepts. The activity established a nonformal environment for learning in which students were encouraged to read ahead of time in order to spot answers to the puzzle's hints. As a result, students acquired an extensive knowledge of a wide range of issues easily [1]. Overall, the crossword puzzle was a strong tool for inspiring students to learn, enabling them to take pleasure in the learning process and more efficiently retain complex concepts.

Improvement in cognitive skills:

The results of all studies showed that crossword puzzles are an effective teaching tool that improves understanding, problem-solving skills, and active learning, which eventually results in better academic achievement and knowledge retention [1,2,4,9,12].

Improved understanding of the topic:

Two studies reported the advantages of crossword puzzles in improved understanding and academic achievement [4,9]. According to Saran and Kumar, [4], 82% of students felt very strongly that the crossword activity greatly helped their grasp of the subject. Similarly, 69% of students strongly agreed that the crossword puzzles significantly boosted their knowledge of the subjects covered [9].

Improved problem-solving ability:

The crossword puzzle activity was also reported as effective in terms of boosting problem-solving ability. According to Saran and Kumar [4], 54% of students thought the task was challenging and beneficial for boosting problem-solving abilities. Similarly, Gilani et al. [9] found that roughly 52% of students thought crossword puzzles were brainteasers and helped them improve their problem-solving skills.

Promote active learning and improve *knowledge retention:*

Additionally, it was observed that the crossword exercise encouraged students to engage in active learning. According to Saran and Kumar [4], 64% of students felt that the crossword puzzles helped them remember the

key terms linked to the topics, and 70% of students strongly agreed that they facilitated active learning. According to Qutieshat et al., [1] students recognized crossword puzzles as an effective instrument for long-term retention and reinforcement of important ideas and terminologies, which resulted in higher scores, boosted self-esteem, and improved their performance over time. Similarly, Gilani et al. [9] discovered that the crossword puzzle intervention significantly increased learning gains after comparing pretest and posttest results for the intervention and control groups. The results for the intervention group improved from 25% to 50.55%, and the comparator also showed growth, from 32.51% to 49.70%. Nirmal et al, [2] also found that students who participated in the crossword activity while attending lectures outperformed the control group, confirming the activity's beneficial effects on academic performance.

Student's perception about the inclusion of crossword puzzles in dental curriculum:

Students enthusiastically supported the addition of crossword puzzles to the dental materials curriculum as an adjunctive teaching method to promote active learning. According to Saran and Kumar [4], 80% of students preferred using crossword puzzles as part of their dental education. According to Gilani et al, [9] 70% of students strongly agreed that crossword puzzles should be included in the dental curriculum. Similarly, Sharma et al. [12] reported that 98.9% of students stated a desire for continuation of similar games in the future. Additionally, 85.5% thought these interactive learning exercises were superior to conventional lectures. It was thought to be beneficial that the game might be used in other courses, particularly when dealing with harder subjects. Students recognized the potential advantages of playing crossword puzzles and other games to aid in their understanding of unfamiliar and difficult terms and concepts [1].

Discussion

In the modern world, game-based learning is quickly gaining popularity and acceptability in courses of higher education as well as research [13]. The majority of the included studies in our review were conducted in dental institutions in India and employed a face-to-face approach for carrying out crossword puzzle-based learning. The results brought to light several benefits of employing crossword puzzles as a teaching aid in dental education. According to the findings, crossword puzzles provide students with an enjoyable and engaging learning experience, improve cognitive skills like comprehension and problem-solving, and promote active learning and have received substantial backing from dental students for inclusion in the dental curriculum. There were no negative remarks about employing crossword puzzles in the studies. However, our study found a minimal number of papers with control groups, limiting suggestions for evidence-based teaching practice. In all investigations, no specific theory of learning was offered.

One of the key themes that came across the studies was that it was reported as a fun learning experience by dental students. Similar feedback has been reported in gamification studies conducted among other health professions [8,13,14]. Games are an effective teaching tool because they reinforce knowledge, fill in the gaps between what has been learned through didactic approach, engage students, challenge them to learn difficult material, and encourage them to take more ownership of their learning. However, this calls for a well-designed, clearly structured game with a framework that guarantees successful outcomes for both students and teachers [13]. Prior research on gamification in education claims that

incorporating games into the teaching and learning process may increase motivation and involvement of students through enjoyment and competitiveness elements [15,16]. Since serious games have the capacity to inspire students in a collaborative setting, they ought to be used in healthcare education.

Furthermore, it has been demonstrated that crossword puzzles help dental students improve their cognitive abilities. These results are consistent with the cognitive advantages of puzzle-solving activities, where students must use critical thinking and logical reasoning to find solutions. These findings echoed with previous findings [17-20]. For instance, the effects of simulation games on the nurse practitioner curriculum were extensively investigated by Warren et al., [21] who found that these games had a considerable positive impact on learner satisfaction, information acquisition, attitudes, abilities, and learning outcomes, particularly critical thinking. The study showed that adding simulation games to the curriculum significantly increased the students' knowledge and confidence. In a similar vein, a review [22] demonstrated that simulations and games effectively promoted cognitive learning outcomes by allowing students to apply ideas, learn facts, understand material, and take part in action-oriented learning. Crossword puzzles offer a collaborative learning tool which can be solved both individually and in groups. Students apply critical thinking as they analyze the clues and methodically reduce the pool of potential solutions while solving a crossword puzzle [23]. Thus, crossword puzzles, according to their proponents, encourage constructive skepticism towards unsubstantiated information and unverified notions and act as an avenue for the improvement of problem-solving abilities, critical thinking, decision-making, and deductive reasoning [24]. The need for further development of such kinds of games and understanding of their value above traditional lectures highlight how crucial it is to include interactive and interesting teaching strategies in dental education. The dental students' positive response to the addition of crossword puzzles demonstrates their acceptance and excitement for cutting-edge teaching strategies, which improves the learning process as a whole.

The small number of included articles and diverse study designs made it difficult to make clear comparisons. Most experiments took place in face-to-face classrooms, and future studies should explore how technology-driven crossword puzzles could improve accessibility and participation. Lack of quality appraisal in the studies also raises questions about the applicability and reliability of conclusions. Student satisfaction data used to assess recall and retention may not provide a comprehensive measure of learning improvement. The resources required for crossword puzzles were rarely disclosed, making it difficult to compare their effectiveness. Future research should document the skills and knowledge of the crossword puzzle creator, peer review, and analyze the cost-effectiveness of various pedagogical approaches. Future studies should also perform higher-level evaluation of knowledge retention over time, and assess the influence of this information on patient outcomes using prospective research methodology or controlled trials [16,21,25].

Conclusion

The existing evidence suggests that crossword puzzles can be a useful and enjoyable teaching-learning tool in the dental profession. The puzzles have the ability to promote understanding, problem-solving skills, and active learning, resulting in greater academic success and knowledge retention among dental

students. Thus, incorporation of crossword puzzles and other gamified approaches could be a promising option to enhance dental education practices. However, there is a lack of standardized studies on this topic.

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Conflict of interests

None

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