Original Article

Effect of using crosswords on operating room students' learning in a Haematology course: A quasi-experimental Study

Mohsen Masoumian Hosseini[1], Fateme Ruhabadi[2], Azam Gazerani[3], Akram Gazerani[4*], Mona Larki[5]

[1]Department of E-learning in Medical Sciences, SMART University of Medical Sciences, Tehran, Iran
[2]MSc, Department of Nursing Sabzevar Faculty of Medical Sciences. Khorasan Razavi. Iran
[3]MSc, Department of Nursing, Neyshabur University of Medical Sciences, Neyshabur, Iran
[4]MSc, Department of Operating Room, Neyshabur University of Medical Sciences, Neyshabur, Iran
[5]School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran

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***Corresponding author:**
Akram Gazerani, MSc, Department of operating room, Neyshabur University of Medical Sciences, Neyshabur, Iran
Email: akramgazrany@gmail.com

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Abstract

Background & Objective: Learning can be promoted through learning games since they are fun and amusing with a competitive nature that creates a stimulating atmosphere in the classroom. The educational system puts an emphasis on student ownership and creative thinking as critical factors in learning. The present study aimed to investigate the effects of crossword puzzles on the learning of operating room students in a hematology course.

Materials & Methods: The study was conducted based on a quasi-experimental pretest and post-test design with an intervention group (designing crossword puzzles) and a control group (solving crossword puzzles) at North Khorasan University of Medical Sciences in 2018. The participants were selected via the census sampling method. A total of 56 students were randomly assigned to control and intervention groups. They were divided into seven groups of four. The intervention was administered during the first 15-20 min of the seven sessions. The data collection instrument consisted of a questionnaire divided into two sections: assessing satisfaction and determining procedural knowledge. PRISM Statistics (version 7) was used for statistical analysis. A p-value of less than 0.05 was considered statistically significant.

Results: The result of the independent t-test demonstrated that the crossword puzzle design group, compared to solving crossword puzzles, significantly improved the knowledge of hematology (P=0.0047). Paired t-tests illustrated that both groups had significant learning gains in the topics covered in the sessions (P<0.0001).

Conclusion: The crossword puzzle design in this study proved to be an effective method to engage students, resulting in higher participation. In this study, crossword puzzles proved to be an effective teaching tool for learning hematology concepts.

Keywords: Creativity, Education, Learning, Problem-Based Learning, Teaching

Introduction

Didactic lectures were common in traditional education; nonetheless, there was a lack of learner engagement, as evidenced by an increase in lecture absenteeism, students' underestimation of lectures, and a corresponding drop in performance, especially in therapeutic courses (1, 2). On average, the first 10 minutes of a lecture are the time when students' attention is greatest, and they retain the most information (3, 4). In general, students are unfocused during about 75% of lectures. This is not surprising since millennials have grown up with technological advances and various means of communication and entertainment (5).

There is evidence of the positive impact of using innovative teaching tools on teaching and learning in health professions, and hematology education is no exception (6). Gleason et al. have categorized active learning methods in the classroom into five types: Cooperative learning, problem-based learning, team-

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based learning, case-based learning, as well as skills-based teaching and assessment for learning (7). In a survey of 202 participants, they reported the use of various active learning strategies, including class discussions (87%), small group discussions (56.9%), learning by teaching (49.5%), as well as case studies and problem-based learning (41.1%) (8). Several other studies have also described the incorporation of active learning techniques in the nursing curriculum (9-11).

Gamification or serious games have recently gained great popularity (12). In their overview of the use of games in the classroom, Biehle and Jeffres identified four essential foundations for the development and use of games (13). These fundamentals are: Firstly, external motivation should be triggered to motivate students internally to master the material. Secondly, whether they win or lose, students should benefit from the subject matter. Thirdly, all students should be equally involved in participation, and finally, the goal of the game should be clearly explained to the students. Several systematic reviews concluded that gamification could improve learning outcomes in health professions education, including hematology (14, 15). The use of crossword puzzles has occasionally been used in the literature in studies in various medical fields (16, 17).

Gaikwad et al. pointed to a significant positive difference between pretest and post-test crossword results when it was used in a pharmacology course on antihypertensive and antiepileptic drugs for second-year Bachelor of Medicine and Bachelor of Surgery (MBBS) medical students (18). Medical students in their fifth year of MBBS showed satisfaction with a crossword puzzle on hormonal contraceptives. The students also had a positive perception of the activity. Shah et al. developed a crossword puzzle as part of the pharmacology and medicinal chemistry module on remedies for gastric ulcers. Over a two-year period, post-activity surveys revealed that most students enjoyed the crosswords and felt that they learned better (19).

As discussed in previous sections, crossword puzzles can be used effectively in the classroom. Nevertheless, none of the studies cited above were related to the design and creation of crossword puzzles by students. There is a tendency for the puzzles to be designed by the teacher or selected from a source outside the classroom. Designing a crossword puzzle can be challenging since students must be able to combine the selected words with other words and abbreviations and acquire knowledge of related vocabulary. Concepts are more predictably and effectively mastered when students manually design a puzzle. The study by Carlos Mario Zapata Jaramillo proposes an alternative approach to the use of crossword puzzles as a learning strategy that combines designing and solving puzzles as instructional activities. The referred case study demonstrated that this strategy is very useful as a non-traditional approach in undergraduate programs to develop skills related to concept formation (20). Nonetheless, the effectiveness of this study was not examined in terms of knowledge acquisition.

Studies evaluating crossword puzzles in hematology are still scarce. Moreover, none of the published work has addressed the impact of crossword puzzle design and students' perception of these educational games. In light of the aforementioned issues, the present study aimed to assess the effect of using crosswords on operating room students' learning in the hematology course in order to (1) assess operating room students' knowledge of hematology terms by using crosswords as a learning aid to enhance learning and (2) assess operating room students' perception of this learning aid.

Materials & Methods

Design and setting(s)

The study was conducted based on a quasi-experimental pretest and post-test design with an intervention group (designing crossword puzzles) and a control group (solving crossword puzzles) at North Khorasan University of Medical Sciences in 2019. In previous semesters, crossword puzzles created by the teacher were used as teaching aids for hematology classes. In this study, the intervention group designed the crossword puzzle, while the control group solved the puzzle as usual.

Participants and sampling

Both groups received a pretest and a post-test to determine baseline and end-line conditions. In this study, the subjects were selected by the census method. The inclusion criteria entailed being enrolled in an anaesthesiology course in 2018 and having a hematology course in the second semester. Candidates were excluded if they had experience designing crossword puzzles and if they had previously participated in a hematology course. As well, students who did not participate in the classroom or did not design or solve puzzles were excluded from the study, and their results were not included in the evaluation. Accordingly, 60 students were selected to participate in the study, four of whom were excluded since they were absent from two classroom sessions. A total of 56

students participated in the study, of whom 40 (71.4%) cases were female, and the mean age of the students was 20.73±0.7975 years. Students were randomly assigned to two groups using block randomization software (Figure 1). The block size of each group was 4 (Table 1).

Figure 1. Quasi-experimental design and random allocation of participants

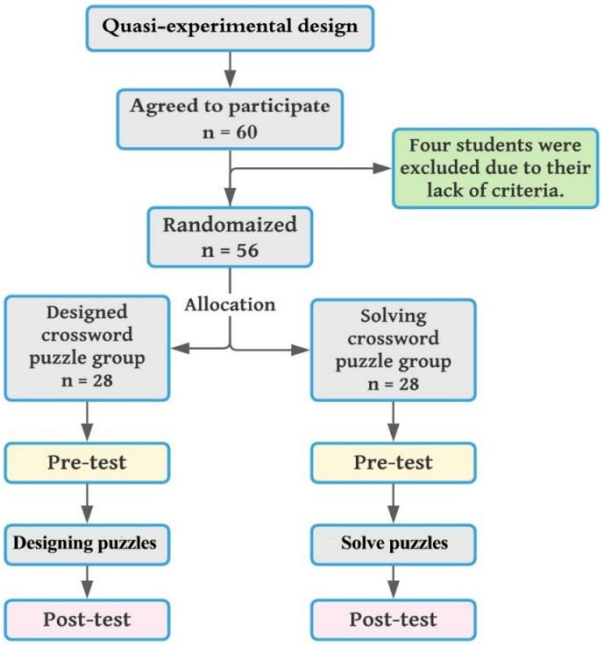

Table 1. Block randomization to randomize students into intervention group (n = 28) and control group (n = 28)

0001: Control	**0002: Intervention**	**0003: Intervention**	**0004: Control**
0005: Control	0006: Control	0007: Intervention	0008: Intervention
0009: Intervention	0010: Control	0011: Control	0012: Intervention
0013: Control	0014: Intervention	0015: Intervention	0016: Control
0017: Control	0018: Intervention	0019: Intervention	0020: Control
0021: Control	0022: Control	0023: Intervention	0024: Intervention
0025: Intervention	0026: Control	0027: Control	0028: Intervention
0029: Control	0030: Intervention	0031: Intervention	0032: Control
0033: Control	0034: Intervention	0035: Intervention	0036: Control
0037: Control	0038: Control	0039: Intervention	0040: Intervention
0041: Intervention	0042: Control	0043: Control	0044: Intervention
0045: Control	0046: Intervention	0047: Intervention	0048: Control
0049: Control	0050: Intervention	0051: Intervention	0052: Control
0053: Control	0054: Control	0055: Intervention	0056: Intervention

Tools/Instruments

The data collection instrument consisted of a questionnaire divided into two sections: assessing satisfaction/stress/anxiety (appendix 1) and determining procedural knowledge. The post-test assessed students' procedural knowledge and problem-solving skills. The test was developed based on a literature review and studies. It consisted of six crossword puzzles, each designed in a multiple-choice format: The questions were selected based on the content of the lesson. Each question had a point value. Five academic staff members of the Hematology Department examined the validity and reliability of the pretest and post-test questions.

Validity and Reliability

To evaluate the validity of the test, five academic staff members in the field of hematology were asked to answer the questions correctly. To evaluate the reliability, Cronbach's alpha was calculated to be 0.84 using SPSS software. Statistical power analysis (SPSS) considers reliability acceptable when the coefficient of reliability (alpha) is ≥0.70.

Content validity

Panel members were invited to rate each question based on its substantive relevance. The first step was to rate the equivalence of each question using a four-point scale, with 1 being the least equivalent and 4 being the

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most equivalent. We reviewed and revised all questions that were rated 1 or 2 by more than 20% (n=1) of panel members. In a second step, expert panel members rated the content relevance of each question to the hematology concept using a 4-point scale (1=not relevant, 2=somewhat relevant, 3=relevant, and 4=extremely relevant). Content validity is usually assessed using the content validity index (CVI). For each question in the test, an item-level CVI (I-CVI) was calculated by dividing the number of panel members who scored 4 (highly relevant) by the total number of panel members (n=5). Next, the S-CVI was calculated based on the mean I-CVI, which was obtained by dividing the sum of all I-CVIs by the number of items (n=60). An S-CVI value of 0.80 (80%) or higher indicates that the content has a high level of validity. The total score of 10 questions was less than 0.80, which is an unacceptable CVI level. After deleting the question from both tests (n=10), the S-CVI was 0.95.

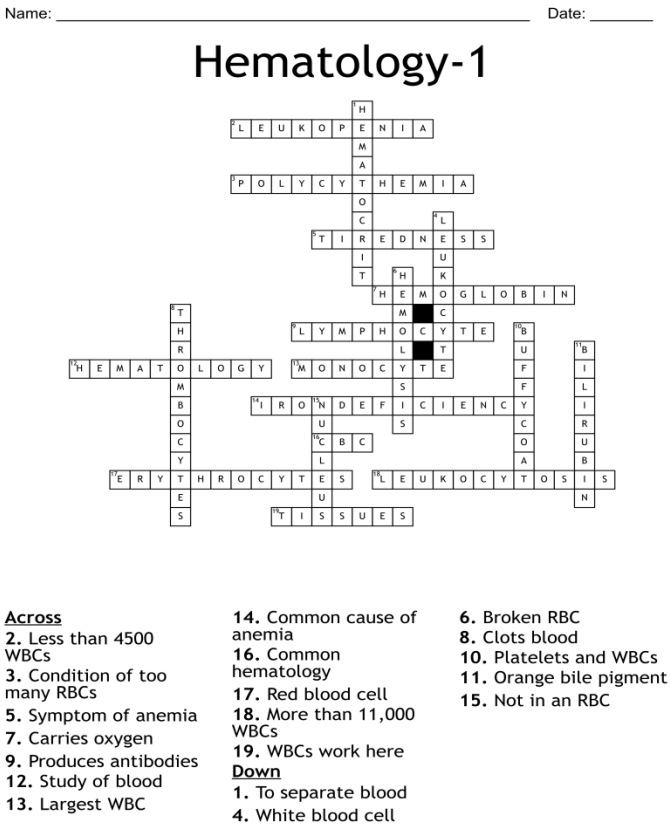
A researcher-designed questionnaire with a four-point Likert Scale was used to assess satisfaction (Appendices). This questionnaire contained 10 questions on three factors related to anaesthesia students' attitudes toward their learning with crossword puzzles. In this questionnaire, students compared designing and solving a crossword puzzle with satisfaction and improvement of learning (four items) and reduction of stress (three items) and anxiety (three items) during the exam. Response options ranged from "neutral" to "very effective." The items were each weighted from 1-4, so the possible range of scores was from 10 to 40, with higher scores indicating more positive attitudes toward teaching hematology through crossword puzzles. Subsequently, the validity of the questionnaire was confirmed by 10 university faculty experts, and its reliability was 0.93 according to Cronbach's alpha.

Data collection methods

Created crossword puzzle

As part of the assignment, students were asked to design a crossword puzzle based on the key definitions in Hoffbrand's Essential Haematology reference. To design the crosswords, the website https://wordmint.com/ was consulted (Figure 2). To ensure that the puzzles were designed correctly, the teacher checked them before starting the lesson and gave them to the students in the control group.

Figure 2. The pattern of the crossword puzzle designed by the intervention group



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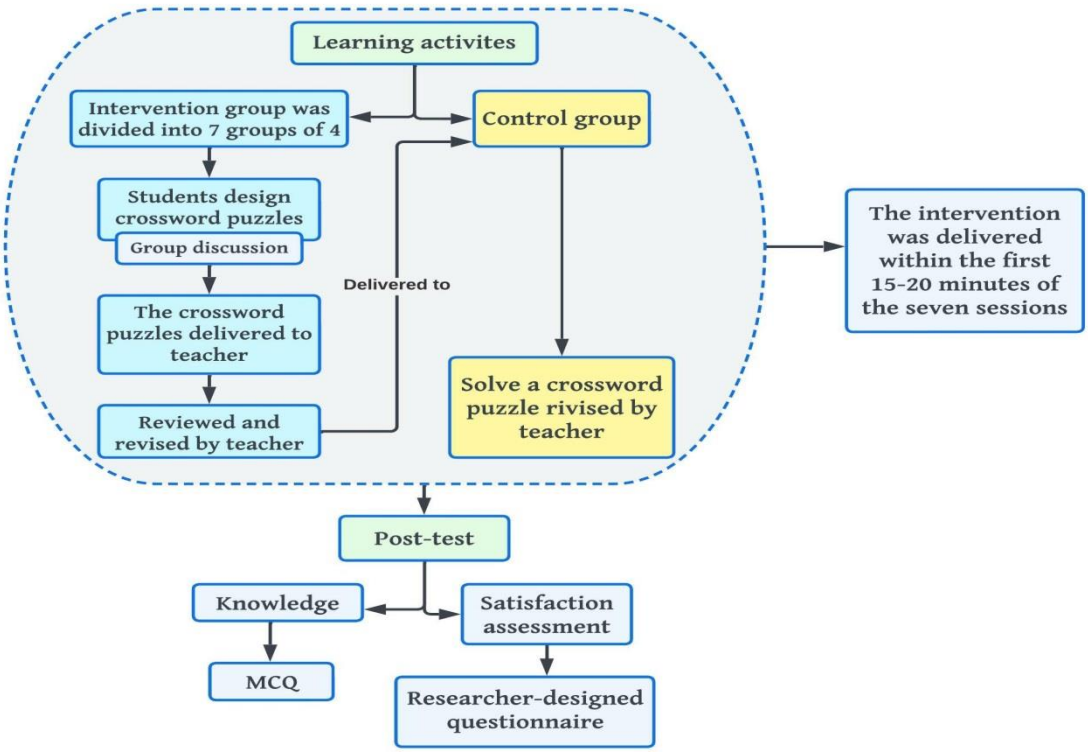
Intervention

The intervention was delivered within the first 15-20 min of the seven sessions. The purpose of the study was explained to the students, and the teacher divided the lesson topics into sessions based on the teaching and assessment methods. In the first session, the intervention group was divided into seven groups of four, and the topic of each group was determined so that a crossword puzzle could be designed. After each instructional session, the groups designed the main content in the form of horizontal word tables. After carefully reviewing the questions and answers and maintaining confidentiality from other students, they submitted the puzzle the day before the class session. A scientific review of the crossword puzzle was conducted by the teacher before it was given to the control group to answer according to their group membership. From the first session on, students were given a crossword puzzle designed by the teacher at the beginning of each session to solve the table.

Each student was responsible for solving the puzzle alone rather than working as a team. In total, 49 crossword puzzles were designed by the teams in the intervention group. The crossword puzzles of the intervention group contained similar terms in many cases. To avoid this, the teacher reviewed the puzzles and removed similar terms, and then gave the control group a crossword puzzle in each session. The knowledge test was administered at the end of seven teaching sessions. The validity and reliability of the test were analyzed as described in the data collection instruments; in addition, the test was similar to the pretest in terms of learning content and difficulty. Figure 3 illustrates the steps of the training process.

Figure 3. Learning activities in the intervention group (designing crossword puzzles) and in the control group (solving crossword puzzles)



Data analysis

PRISM Statistics (version 7) was used for the statistical analysis. Descriptive statistics were used to describe the samples, and the Shapiro-Wilk test was utilized to determine the normality distributions. To examine the effect of designing and solving crossword puzzles in the intervention group compared to the control group, an independent t-test was used to determine the mean (± SD) of students' knowledge before and after the intervention. Paired t-tests were used to compare within groups. Significance levels of $P < 0.05$ were considered acceptable.

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Results

This study first examined the effect of designing or solving crossword puzzles on learning ability by pretesting control and intervention groups. In normality tests (Shapiro-Wilk, histogram, Q-Q plot, etc.), the data for this study had a normal distribution, and parametric tests were applied. Table 2 displays the results of these normality tests. The chi-square test demonstrated gender homogeneity in the intervention and control groups (0.4465, 27). The mean age scores of participants in the intervention and control groups were 20.68±0.82 and 20.79±0.78, respectively, illustrating an insignificant difference (P > 0.998). The results of the independent t-test for the pretest data showed that the two groups were homogeneous. Nevertheless, there was a significant difference between the two groups in terms of the results after six hours of instruction (P=0.0047). Compared to solving crossword puzzles, designing crossword puzzles significantly improved participants' hematology knowledge (P=0.0047). The paired t-test demonstrated a statistically significant difference in the intervention and control groups (P<0.0001 and P0.0001, respectively). Therefore, both groups had significant learning gains in the topics covered in the sessions compared to before the intervention (Table 3).

Table 2. Normality tests of pretest and posttest data of intervention and control groups

Anderson-Darling test	**pretest intervention group**	**pretest control group**	**posttest intervention group**	**posttest control group**
A2*	0.5517	0.5801	0.3950	0.4066
P value	0.1411	0.1187	0.3496	0.3276
Passed normality test (alpha=0.05)?	Yes	Yes	Yes	Yes
P value summary	ns	ns	ns	ns
D'Agostino & Pearson test	**pretest intervention group**	**pretest control group**	**posttest intervention group**	**posttest control group**
K2	2.190	4.176	3.971	1.082
P value	0.3346	0.1240	0.1373	0.5823
Passed normality test (alpha=0.05)?	Yes	Yes	Yes	Yes
P value summary	ns	ns	ns	ns
Shapiro-Wilk test	**pretest intervention group**	**pretest control group**	**posttest intervention group**	**posttest control group**
W	0.9428	0.9336	0.9544	0.9656
P value	0.1305	0.0762	0.2547	0.4692
Passed normality test (alpha=0.05)?	Yes	Yes	Yes	Yes
P value summary	ns	ns	ns	ns
Kolmogorov-Smirnov test	**pretest intervention group**	**pretest control group**	**posttest intervention group**	**posttest control group**
KS distance	0.1338	0.1373	0.1066	0.1499
P value	>0.1000	>0.1000	>0.1000	>0.1000
Passed normality test (alpha=0.05)	Yes	Yes	Yes	Yes
P value summary	ns	ns	ns	ns

Table 3. Mean ± SD of haematology course scores in intervention and control groups during pretest and posttest

Groups	**Pretest**	**Posttest**
Intervention group (designed crossword puzzles)	6.464 ± 1.732	22.04 ± 3.844
Control group (solving crossword puzzles)	6.036 ± 2.151	19.32 ± 2.994
P value	0.4152	0.0047 ***

All 56 questionnaires were completed by the students(100% of the questions were answered). With this scale, the questionnaire tries to measure respondents' attitudes toward the intervention by adding the points given by the students for the proposed items (suggestions). The results of the study regarding the opinion of the students in the group that used the crossword puzzle design group showed that most of them (92.5%) were very satisfied with the presentation of this method and considered its use a means of motivating and promoting learning very effective. In addition, 71.4% of the students indicated that they would use this method in other courses, and it was less stressful than the table-solving method. This assessment method significantly reduced test anxiety, as indicated by 75% of students (Table 4). Students' opinions on education through crossword puzzles denoted that 46.4% of them considered the method satisfactory, motivating, and conducive to learning. Moreover, 50% of students deemed the method moderately effective in

the reduction of stress, while 35.7% of cases considered it ineffective in the mitigation of test anxiety (Table 5).

Table 4. Students' opinion of the crossword puzzle design in the evaluation

Satisfaction factors	Very effective	Moderately effective	Slightly effective	Neutral
Satisfaction and promotion of learning	92.5 %	7.5 %	0	0
Reducing stress	71.4 %	17.8 %	10.7 %	0
Reduce anxiety	75 %	25 %	0	0

Table 5. Students' opinion of the crossword puzzle solving in the evaluation

Satisfaction factors	Very effective	Moderately effective	Slightly effective	Neutral
Satisfaction and promotion of learning	%46.4	%17.85	%35.7	0
Reducing stress	%25	%25	%50	0
Reduce anxiety	%3.57	%28.5	%32.1	%35.7

Discussion

In this study, crossword puzzles provided opportunities for students to develop critical thinking, collaboration, healthy competition, and memory skills. In a competitive environment, solving crossword puzzles is a good complement to active learning. The use of crossword puzzles as an instructional tool in the present study also helped teach important concepts. This study utilized crossword puzzles to teach the concepts of hematology to students. Learning facts requires repetition and practice in the mind, and by designing a crossword puzzle, the intervention group was able to learn more than the control group. According to the results, the mean score of students in the group that designed the crossword puzzle was higher than that of students who solved the puzzle.

In the study by Ghada Bawazeer et al., crossword puzzles were used to train anticoagulation. According to the stated study, crossword puzzles could be an innovative, creative, and simple tool to improve memory, retention, and engagement in students with all learning styles in the classroom (21). The study by Elisa R. Torres et al. shows that crossword puzzles reinforce the importance of assessing knowledge retention, taking into account the institution, course, semester, and students' perceptions (22). Another study on 425 MBBS (Bachelor of Medicine and Bachelor of Surgery) students suggested that crossword puzzles contributed to their knowledge of medicines, facilitated active learning, and helped them memorize the subject matter (23).

The researchers also pointed out that the use of crossword puzzles as a fun and participatory teaching tool in combination with lectures could improve the quality of speech therapy (24). Crossword puzzles have been shown to improve dental students' ability to review and reinforce concepts and terminology. In addition, crossword puzzles are useful and enjoyable, improving students' comprehension, retention of knowledge, and engagement with the subject matter (25). A randomized controlled trial by Ramzi Shawahna on Palestinian nursing students found that crossword puzzles effectively improved student nurses' learning about the pharmacology of epilepsy and the correct spelling of AEDs.

Educators should therefore consider the use of crossword puzzles as an active learning tool to improve students' knowledge in courses (26). The crossword puzzle has also been mentioned in other studies as a game that enhances students' performance in terms of creativity and accuracy (27). It was also stated that games could contribute to self-learning and improve performance in mental activities (11). Therefore, the crossword puzzle can be considered a suitable gamification tool in this context. Although the results of the above studies are consistent with the present research, the studies were conducted in different courses, and in this study, students designed the crossword puzzle instead of solving it themselves.

The results of a study by Carlos Mario Zapata Jaramillo et al. entitled "Designing and solving crossword puzzles: examining efficacy in a classroom exercise" are consistent with these findings. The results of this case study conducted by the University of Nevada denoted that this method, as a non-traditional technique, is very suitable for undergraduate courses to develop conceptualization skills that can be applied to selected areas of knowledge (20). The current study pointed out that students in the crossword puzzle design group had less stress and rated this method effective in the

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reduction of test anxiety. The results of this study are in accordance with those of Mirzaei et al., who investigated formative assessment of reducing student exam night (28).

Therefore, creating and solving a crossword puzzle, which is one way to assess a learner's development, may help reduce anxiety on exam night. Nonetheless, this study has demonstrated that the design of a crossword puzzle has a significant impact on its solution. These results were in line with the final test and student self-reports. This study was unique in that students designed these puzzles themselves and this makes them more interesting to learners. In addition, students are more likely to develop creativity through the use of crossword puzzles in the classroom since the design of a crossword puzzle is closely related to student creativity (29). According to a study in 2011, mental games, such as crossword puzzles, can improve cognitive load (27). Nevertheless, very few studies have examined the relationship between cognitive load and crossword puzzles, which may pave the way for further research in this area.

Limitation

Since the literature search did not find any article that examined the effect of crossword puzzles designed by students, and this was the first study in this area, the results of this research could not be compared with other studies. That is to say that the results of this study cannot be generalized to other studies since there is no basis for comparison. However, the results of this study can serve as a starting point for future research and can be used as a basis for further studies in this area. Furthermore, the researchers explained to the students how to design crossword puzzles since the students had no prior knowledge of how to design crossword puzzles.

Conclusion

As evidenced by the results of this study, crossword puzzles could be used as a means to enhance student learning and allow students to discover knowledge for themselves. This method provides students with a golden opportunity to use their cognitive skills and effectively promotes problem-solving skills. Conversely, students who only solved the crossword puzzle seemed less able to do so. This method also helps to improve problem-solving skills, promote small group discussions, enhance knowledge acquisition, and improve procedural skills through new innovative methods.

Ethical considerations

The Ethics Committee of North Khorasan University of Medical Sciences approved this project (ethics code: IR.NKUMS. REC.REC.1399.037). All subjects were adequately informed about the aims and methodology of the study before their participation. Written informed consent was obtained from participants. They were assured that their data would be kept confidential and that only general information and statistics would be released.

Conflict of interests

The authors declare that they have no conflicts of interest

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Author contributions

A.K. and M.M.H. designed and supervised the procedure. A.Z. and F.R performed the study intervention and collected data. The data were analyzed by M.M.H, who participated in planning the study and revising the manuscript. The manuscript was read and approved by all authors.

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Availability of data and materials

Upon a reasonable request, the corresponding author can provide the data set that was analyzed during this study.

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Appendix 1. The satisfaction, stress, and anxiety questionnaire

Questions	1	2	3	4	Explanations if necessary
Satisfaction and promotion of learning					
Did you have enough time to design or answer the crossword puzzle?					
Did the activities during the course help you learn the concepts of haematology?					
Would you want to use this teaching method again for your next courses?					
Did the feedback from the course instructor help to clear up any ambiguities in your learning?					
Was this intervention able to help answer the final questions of the course?					
Did this intervention meet your pedagogical expectations?					
Was the lecturer's attitude appropriate when teaching the material?					
Was the time during the course used optimally?					
Was the sequence of the beginning and end of the course appropriate?					
Was subject knowledge enhanced by the materials presented?					
Did the feedback from the course instructor help to clear up any ambiguities in your learning?					
Was this intervention able to help answer the final questions of the course?					
Did this intervention meet your pedagogical expectations?					
Reducing stress					
Are you a stressed person?					
Has your stress decreased in relation to the questions the lecturer has asked in this course?					
Did your stress decrease at the end of the course compared to the beginning?					
Were you stressed when designing or solving crossword puzzles?					
When answering the test questions, did you feel that you would not pass the test or that you would get a low score?					
Did you feel you could not answer the questions during the test?					
Reduce anxiety					
Has this teaching method reduced your fears of the haematology course?					
Did this measure reduce your anxiety about answering the questions?					
Did you think of things during the exam that had nothing to do with this lesson?					
Did you sometimes have palpitations and heart palpitations during the exam?					
When you take the exam, you are so nervous that you forget the things you really know					
If possible, you would instead write an essay or do a practical paper to pass the course than take the exam.					
Because you were distracted during the exam, you did not pay enough attention to the questions					
1: Very; 2: moderate; 3: slightly; 4: Neutral					

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