Original Article

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Which Active Learning Method is More Effective? A Comparison of Crossword Puzzles and Mind Mapping in Teaching Emergency Trolley Medications to Anesthesia Students

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Abstract

Introduction: Effective education on emergency trolley medications is vital for the patient safety. Traditional methods often fall short of promoting deep and lasting learning. This study compared two active learning strategies, crossword puzzles and mind mapping, for teaching emergency trolley medications to anesthesia students.

Methods: This quasi-experimental study was conducted on 40 undergraduate anesthesia students of Iran University of Medical Sciences (IUMS) and Tehran University of Medical Sciences (TUMS) selected by census sampling. The same instructor delivered both groups personally. Simple individual randomization was used to randomly divide the participants into the mind mapping group (n = 20) and the crossword puzzle group (n = 20), through a coin toss procedure Two training sessions on emergency trolley medication-related concepts were attended by each group. To examine the efficacy of the intervention, we administeredthree tests: a pre-test, a post-test, and an unexpected retention test (after 3 weeks). Independent t-test and repeated measures ANOVA were used to analyze the data. The tests were constructed following the Bloom's taxonomy Table, and the reliability and validity of both tests were validated using standard procedures.

Results: Demographic factors such as age, GPA, and gender did not impact the results significantly either (P0.05). Independent t-test indicated that there was no significant difference in the two groups at pre-test levels (mind mapping: 5.58 ± 0.47; crossword puzzle: 5.60 ± 0.47; P = 0.985). Both of the methods led to a significant improvement in post-test learning metrics compared with pre-test results (map: 12.87 ± 0.53; puzzle: 13.25 ± 0.59; P = 0.641; repeated measures ANOVA: P < 0.001). However, in the retention test, students in the crossword puzzle group outperformed those in the mind map group (9.36 ± 0.66 vs. 6.52 ± 0.65; P = 0.004), indicating better long-term retention.

Conclusion: Although both methods enhanced short-term learning, crossword puzzles were more effective for long-term retention. These findings underscore the need to tailor instructional strategies to achieve desired learning outcomes.

Keywords: Active learning, Retention, Emergency, Teaching

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Introduction

Medical students need to master specialized knowledge about pharmacology because it plays a vital role in their ability to handle emergency situations that include cardiopulmonary resuscitation. The quality of healthcare services and patient safety standards depend on effective clinical education programs that train medical professionals in their respective fields. Therefore, selecting appropriate teaching methods that enhance motivation, cognitive engagement, and active student participation is of paramount importance (1, 2). In recent decades, traditional lecture-based instruction was criticized for its passive nature and inability to meet the evolving educational needs of medical students in the field. In contrast, modern approaches, such as active learning, which emphasize direct learner involvement in the learning process, showed significant improvements in the comprehension, analysis, and long-term retention (3). Among widely used strategies in active learning are educational games, such as crossword puzzles, and visual tools, such as mind maps. Each method, through its unique yet effective approach, facilitates understanding, content organization, and memory enhancement (4, 5).

Crossword puzzles are an engaging and intellectually stimulating learning tool that enhances semantic memory and problem-solving skills, thereby increasing student involvement in the learning process (6). This technique was applied in the teaching of medical sciences, including pharmacology, dentistry, and rehabilitation, and its effectiveness in enhancing learning outcomes, and student satisfaction was confirmed by multiple studies (4, 7, 8). Alternatively, mind mapping as a visualization system that organizes and connects ideas uses both hemispheres of the brain and visual memory to enhance creativity and facilitate retention (9). This approach is effectively used in different fields, including medicine, nursing, anesthesia, and midwifery education to teach complex areas of study (10). Furthermore, studies showed that many students and even clinical staff lack sufficient and accurate knowledge about emergency trolley medications, which can have serious consequences for the performance of resuscitation teams (11). One contributing factor is the inefficient use of traditional teaching methods and the lack of active learning strategies in the instruction of critical subjects, such as emergency medications (1, 11). Because emergency medication use is pressurized, anesthesia students need to access drug information rapidly and also retain it over time. This suggests that crossword puzzles could be rich in strengthening memorization and direct recall accuracy, while mind mapping may improve conceptual organization and visual learning techniques (10, 12). Thus, it is important to compare these two strategies in order to identify which method better accommodates the learning needs of emergency trolley medications.

Methods

Study Design

The educational research study was done at Iran University of Medical Sciences (IUMS) and Tehran University of Medical Sciences (TUMS). The research objective was to evaluate which teaching method, i.e. mind mapping or crossword puzzle solving, better taught undergraduate anesthesia students emergency trolley medications.

Participant Selection and Description

The study population consisted of sixth-semester undergraduate anesthesia students from Iran University of Medical Sciences (IUMS) and Tehran University of Medical Sciences (TUMS). A total of 40 undergraduate anesthesia students were recruited; they participated in the study through census sampling. The sample size was determined using Altman's nomogram based on previous findings (13). The inclusion criteria were participants who voluntarily participated, had not previously attended such workshops, and had not yet passed the "Emergency Care II" course. Students who did not attend instructional sessions or complete the assessments were excluded. In order to reduce bias, we randomly assigned the participants to one of the two instructional conditions using a simple individual randomization procedure through a coin toss.

Sample Size and Power Calculation

The final sample size was determined using a standard formula to compare the means of two independent groups. A confidence level of 95% ($Z_{1-\alpha/2} = 1.96$) and a statistical power of 80% ($Z_{1-\beta} = 0.84$) were used. Based on previous research findings (13), The sample size calculation was performed as follows:

$$n = ((Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma^2) / (\mu_1 - \mu_2)^2$$

$$n = ((1.96 + 0.84)^2 \times 3.88^2) / (15.55 - 13.05)^2 \approx 19$$

Moreover, 19 participants were required per group. Considering the study design and to ensure adequate statistical power, we included a total of 40 students in the final analysis. Written informed consent was obtained from all students before enrollment.

Intervention

Before the educational sessions, a 2-hour orientation was held for each group to introduce the instructional strategies and explain their potential benefits. All educational sessions were conducted by the same instructor, using PowerPoint lectures complemented by active teaching strategies. Each group attended two sessions, during which half of the essential emergency medications, those requiring cardiac monitoring,were covered in each session.

The medications discussed included epinephrine, atropine, adenosine, amiodarone, lidocaine, verapamil, nitroglycerin, dopamine, dobutamine, digoxin, haloperidol, midazolam, magnesium sulfate, labetalol, phenytoin, phenobarbital, sodium bicarbonate, and calcium gluconate.

Group A (IUMS): Instruction was done via mind map–based teaching. After each counseling session, they prepared at least one mind map for teaching the targeted medications either on a paper or with the assistance of XMind software. At the end of each session, students submitted their mind maps and also shared them in a dedicated WhatsApp group for peer discussion (A sample mind map is in Figure 1).

Group B (TUMS): Students used validated crossword puzzles as a supplementary learning method. The puzzles were designed by the instructor using WordMint platform (https://wordmint.com), with clues focusing on drug dosages, indications, contraindications, mechanisms of action, and nursing considerations. Students initially completed the puzzles individually, followed by collaborative review sessions. The completed puzzles were then shared in the WhatsApp group (Figures 2 and 3).

Assessment

A pre-test was administered before the intervention, followed by a post-test immediately afterward and a surprise retention test three weeks later. All three assessments consisted of 20 questions each, including 16 multiple-choice (MCQ) and 4 short-answer items, developed based on Bloom's taxonomy covering levels 1 to 3. The questions focused on emergency trolley medications, including drug dosages, indications, contraindications, mechanisms of action, and monitoring requirements.

The same instrument was used for pre-test and post-test to ensure equivalent levels of difficulty; the retention test included equivalent items within the same content domain to prevent recall bias. Each correct answer received 1 point, yielding a total score range of 0 to 20. Short-answer responses were evaluated using a predefined answer key to ensure consistency, and any ambiguities were resolved by discussion among the raters.

Examples of questions included:

"Which dose of dopamine is used to increase cardiac output (mcg/kg/min)?"

"For which cardiac arrhythmia is lidocaine the most useful treatment ?"

Instrument validity was confirmed by 10 subject-matter experts, resulting in acceptable indices (CVR > 0.8, CVI > 0.9). Reliability was tested in a pilot study of 25 students using intraclass correlation, yielding excellent agreement (ICC = 0.999; 95% CI: 0.998–1.000). The complete set of assessment questions has been provided as a supplementary appendix.

Ethical Consideration

Ethical approval for this study was obtained from the Research Council of School of Allied Medical Sciences at Iran University of Medical Sciences with an ethical approval code of IR.IUMS.REC.1403.780. Data were collected from all students after obtaining written informed consent. Participation was optional, and students were assured that their personal details and records of academic achievement would remain confidential. All the ethical principles established in the Declaration of Helsinki were observed in this study.

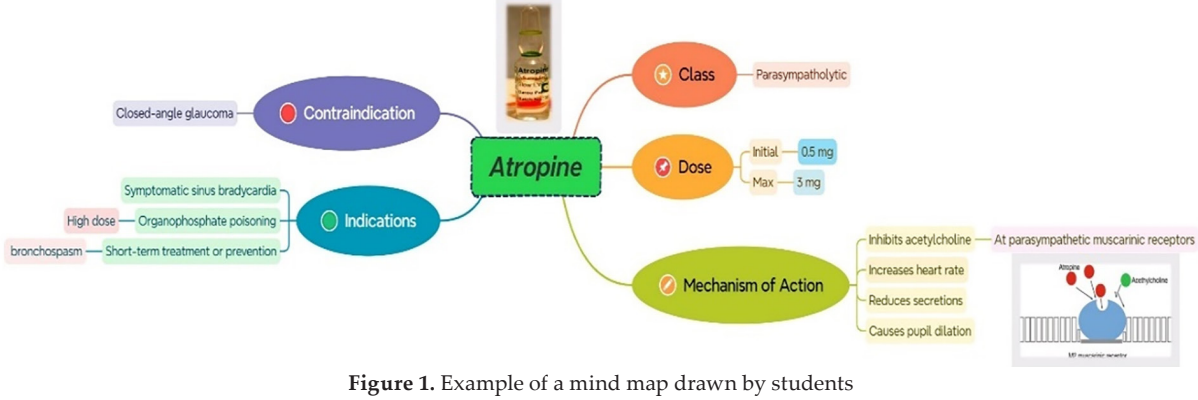
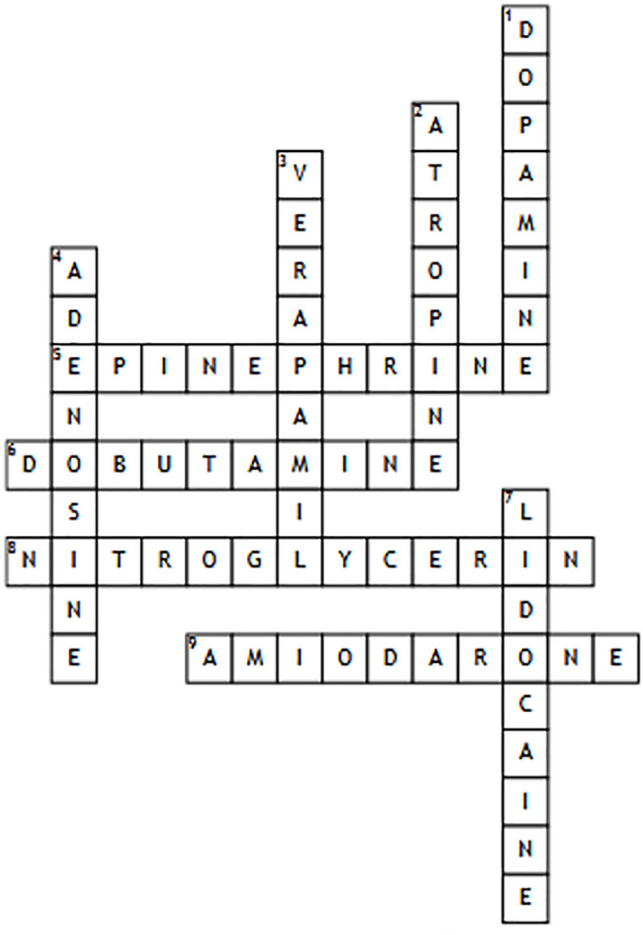


Figure 1. Example of a mind map drawn by students

Name: _____ Date: _____

Session 1



Across

5. A drug to treat severe allergic reactions
6. A drug that enhances the contractile strength of the heart in CHF patients, incompatible with alkaline solutions.
8. Preferred drug for improving symptoms of congestive heart failure and reducing pain in angina pectoris
9. A class III antiarrhythmic drug that affects sodium, potassium, and calcium channels, with a potential for lethal pulmonary toxicity upon injection.

Down

1. Increased urinary output with the use of a low dose of it.
2. The chosen drug for treating farmers poisoned with organophosphate pesticides, with a contraindication in angle-closure glaucoma.
3. This drug is used to treat angina pain and hypertension by blocking calcium channels in the heart and vascular smooth muscles.
4. Requires rapid injection into the central vein for sufficient effectiveness of this drug.
7. Seizures as the first symptom of poisoning with this drug, used in the treatment of ventricular arrhythmias by blocking sodium channels.

Word Bank

Amiodarone	Nitroglycerin	Dobutamine
Dopamine	Epinephrine	Atropine
Verapamil	Adenosine	Lidocaine

Figure 2. Crossword Puzzle Implemented in Session 1

Name: _____ Date: _____

Session 2

Across

2. The drug is positive inotropic and negative chronotropic; it can be life-saving but risky in hypokalemia. Early signs of poisoning are nausea, vomiting, loss of appetite, blurred vision, and halos.

8. The preferred drug for torsades de pointes arrhythmia, seizure prevention or control in preeclampsia and eclampsia, and a sign of its poisoning is hyporeflexia.

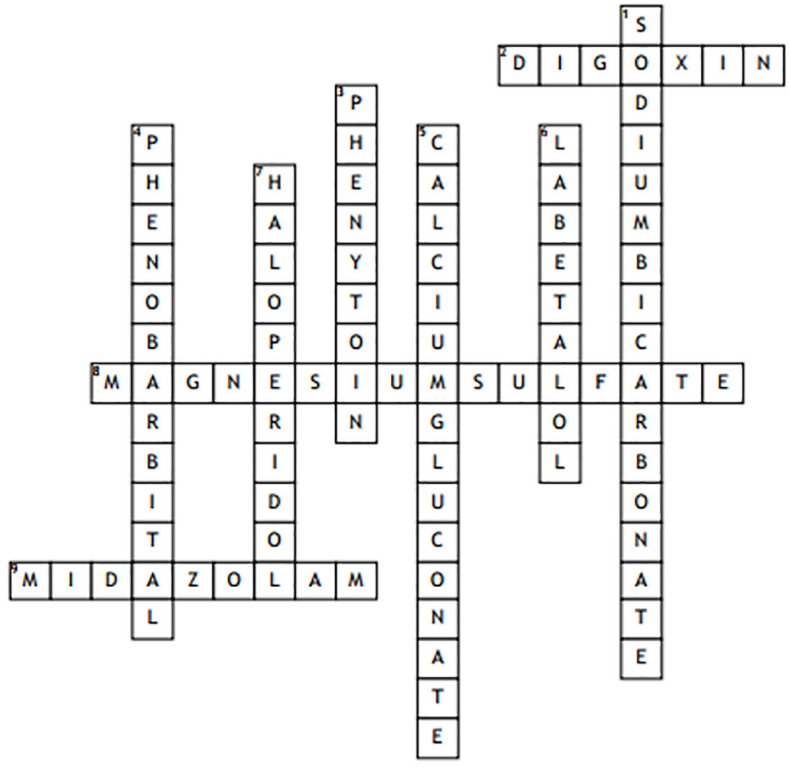
9. A drug that enhances GABA inhibitory effects and is used for sedation in intubated patients on ventilators.

Down

1. Used in treating metabolic acidosis; contraindicated in hypochloremia and hypocalcemia.

3. Used for seizure and epilepsy; important side effects include arrhythmia and hypotension.

4. Rapid injection of this anticonvulsant drug can impair respiration but is effective in treating various types of epilepsy.



5. The preferred drug for hyperkalemia and hypermagnesemia; contraindicated for IM and subcutaneous injection.

6. Use of this drug is prohibited for treating hypertension in patients with asthma.

7. Used in the treatment of acute psychiatric disorders with a risk of neuroleptic malignant syndrome and extrapyramidal side effects.

Figure 3. Crossword Puzzle Implemented in Session 2

Statistical Analysis

Statistical analyses were performed using SPSS (version 27). Demographic data were summarized using descriptive statistics. Comparison of Means Using Independent t-test Independent t-test was utilized to compare the mean scores between the two groups at each stage (Pre-test, Post-test and Retention test). Furthermore, repeated measures ANOVA was applied to detect change over time within groups and also to examine the interaction effect between time and instruction method. Statistical significance was defined as $P < 0.05$. The size of the study was determined a priori using power calculation with previously described effect sizes (Figure 4).

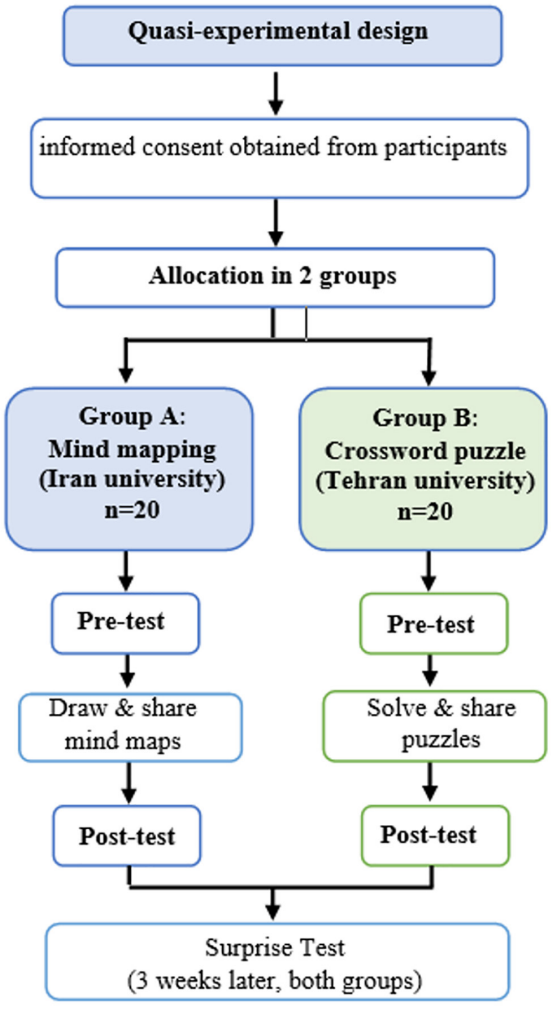


Figure 4. Study design and intervention flow

Results

Demographics

In this study, 40 undergraduate anesthesia students of Iran University of Medical Sciences (IUMS) (Group A) and Tehran University of Medical Sciences (TUMS)(Group B) participated, each group containing 20 students . The gender distribution was similar between the groups (60% female, 40% male). The mean age was 22.5 years in group A and 21.5 years in group B, and there was no significant difference between the two groups in this regard (P = 0.205). Group A had a mean Grade Point Average (GPA) of 16.96, versus Group B which had a mean GPA of 17.15 (P = 0.612). These findings are consistent with both groups being demographically homogeneous, indicating that the differences in education observed within both groups can be attributed to the intervention (Table 1).

Intervention Outcomes

At pre-test (T0), no significant difference in the two groups' mean scores was seen (P = 0.985), signifying similar knowledge levels at baseline. Post-test (T1) showed no significant difference after the intervention (P = 0.641), indicating that both educational strategies were equally effective in a short time. In fact, during the retention test (T2), Group B outperformed Group A (P = 0.004) with significantly greater long-term knowledge retention in the crossword puzzle group (Table 2). Regarding within-group performance, Group A (mind map) showed a significant improvement

Table 1. Baseline demographic characteristics of the students in the two intervention groups

Variables	Groups		p-value
	Group A N=20	Group B N=20	
Age (Years)			
Mean ± SD	22.5 ± 0.738	21.5 ± 0.235	0.205
Gender [n (%)]			
Male	8 (40%)	8 (40%)	1.000
Female	12 (60%)	12 (60%)	-
GPA			
Mean ± SD	16.96 ± 0.279	17.15 ± 0.237	0.612

Table 2. Comparison of Mean Knowledge Scores of Anesthesia Students between and within Educational Intervention Groups across Timepoints

Timepoints		Groups		Test[a], P*
		Group A N=20	Group B N=20	
Students' knowledge	T0	5.58 ± 0.47	5.60 ± 0.47	t=0.019, P=0.985
	T1	12.87 ± 0.53	13.25 ± 0.59	t=0.470, P=0.641
	T2	6.52 ± 0.65	9.36 ± 0.66	t=3.045, P=0.004
Test[b], P**		T1 vs. T0: P<0.001; T2 vs. T0: P=0.516; T2 vs. T1: P<0.001	T1 & T2 vs. T0: P<0.001; T2 vs. T1: P<0.001	

T0: Before education; T1: Immediately after education; T2: Three weeks after the end of education; Test[a]: Independent-samples T test; Test[b]: Repeated measures ANOVA; n: numbers; P*: Between-groups comparison; P**: Within-group comparison

from T0 to T1 ($P < 0.001$; mean difference = -7.288), demonstrating the short-term effectiveness of the intervention. However, the difference between T0 and T2 was not significant ($P = 0.516$; mean difference = -0.937), suggesting a decline in long-term retention. Sag between T1 and T2 was significant (mean difference = 6.350). In Group B (crossword puzzle), there were significantly better results in each time point ($P < 0.001$).The score markedly increased from T0 to T1 (mean difference = -7.650); although the scores declined between T1 and T2 (mean difference = 3.888), the reduction was less than in Group A, suggesting better retention (Table 2).

As shown in Figure 5, both groups started from a similar knowledge baseline at T0. After the intervention, performance improved at T1 in both groups. However, at T2, Group A showed a steeper decline in performance, highlighting the greater long-term effectiveness of the crossword puzzle approach (Group B).

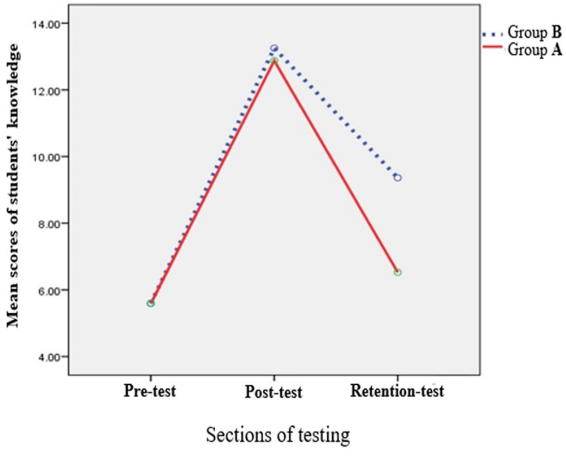


Figure 5. Mean knowledge scores of students at three assessment points (pre-test, post-test, and retention test) in Groups A and B, indicating better long-term retention in Group B due to the crossword puzzle strategy

In addition, the results of the repeated measures ANOVA showed that there was a significant main effect for time on knowledge scores, $F(2, 76) = 161.275$, $P < 0.001$, and $\eta^2 = 0.809$, confirming change in performance over time points. Furthermore, there was also a prominent time × group interaction effect, $F(2, 76) = 6.532$, $P = 0.002$, and $\eta^2 = 0.147$, indicating that the two instructional delivery approaches were differential in terms of changes over time. These results reinforce the significance of implementation strategies in knowledge retention over time.

Discussion

This study was conducted to investigate and compare the effect of crossword puzzles and mind maps on learning as well as the long-term retention of the emergency trolley medications in anesthesia students. Results indicated that both approaches enhanced short-term learning significantly, and that there was no differences in performance at baseline. However, the crossword puzzle method outperformed in long-term retention, with participants exhibiting a smaller drop in scores on the surprise test. These findings are consistent with previous studies reporting the effectiveness of crossword puzzles in improving learning and memory stability (4, 12-17). Prior research indicated crossword puzzles as engaging, memorable, and effective tools for reinforcing content (8, 16, 18). Although most of these studies primarily focused on short-term learning or perception rather than retention, the present results extend the existing evidence by demonstrating clear advantages in long-term recall.

Conversely, although mind mapping enhanced immediate learning, its effect on retention was lower. This is in partial contrast with studies reporting positive effects of mind maps on long-term retention (5, 19, 20). However, other studies support short-term effects without establishing long-term impact (21, 22), which is in the same line with the current findings. Variations are related to a content type, instruction time, or the cognitive requirements for the topic. Overall, the study suggests that crossword puzzles may be more effective for structured, list-based content, such as pharmacology items, whereas mind maps may be better suited for conceptual or analytical domains. These findings underscore the importance of aligning teaching strategies with content characteristics and learner needs. Although both methods were useful, crossword puzzles provided greater educational value in this context.

The current study adds to existing knowledge by simultaneously evaluating learning and retention, using two active strategies, and applying them to clinically relevant content. Emergency trolley medications require rapid recall and long-term retention; therefore, these results have practical implications for medical education, particularly within anesthesia training. Integrating crossword-based learning activities into Iranian medical curricula,especially in pharmacology and emergency care courses, may strengthen retention and support safer clinical practice.

Despite valuable findings, this study had limitations. Participants were drawn from only two institutions, which may affect generalizability. The study duration was short, and only one type of educational content was examined. Besides, learning styles, previous exposure to similar

instructional methods, and student motivation were not assessed, which may have influenced outcomes.

Based on the results of this study, it is recommended that future research should compare the effectiveness of crossword puzzles and mind maps with other active teaching methods, such as game-based learning, storytelling, or collaborative education. Furthermore, conducting studies with larger sample sizes across different disciplines can help improve the generalizability of results. Implementing these methods over an entire academic semester and evaluating their effects at different time intervals would enable a more accurate assessment of their long-term impacts. Furthermore, it is suggested that the influence of these methods on other aspects such as concentration, motivation, interest, and student participation should be explored.

Conclusion

Data analysis revealed that although both groups showed a decrease in scores after three weeks, the decline was significantly smaller in the group who were taught through crossword puzzles. This finding indicates that, compared to mind mapping, crossword puzzles have a greater impact on consolidating information in the long-term memory of anesthesia students.

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Authors' Contributions

M.N: Conceptualization; M.N, J.A: Data curation; J.A: Formal analysis; M.N, P.M: Methodology; Project administration: M.N, P.M, S.S; Writing – original draft: M.N, P.M, S.S; Writing – review & editing: all authors.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

Declaration of AI Use

The authors declare that artificial intelligence tools were used solely to improve the clarity, language quality, and English editing of the manuscript. The scientific content, data analysis, and interpretation of the results were entirely conducted by the authors.

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