ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

The Effect of Crossword and Word Search Puzzles on Nursing Students' Parenteral Medication Administration Knowledge: A Randomized Controlled Study

Çapraz ve Kelime Arama Bulmacalarının Hemşirelik Öğrencilerinin Parenteral İlaç Uygulama Bilgisi Üzerine Etkisi: Randomize Kontrollü Bir Çalışma

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ABSTRACT Objective: This study aimed to evaluate the effect of crossword and word search puzzles on the knowledge of first-year nursing students regarding parenteral medication administration. **Material and Methods:** It was a pretest-posttest parallel-group, randomized controlled study. Conducted from April to June 2023, this study involved 164 nursing students enrolled in the fundamentals of nursing course. Based on baseline measurements, the students were stratified block-randomized into intervention and control groups. The intervention group received theoretical and practical training, followed by engaging with crossword and word search puzzles designed to reinforce their learning. In contrast, the control group continued with the standard curriculum consisting only of theoretical lectures and laboratory practice without puzzle-based activities. **Results:** There was a statistically significant difference between the intervention and control groups' in-group pre-test and post-test scores (p<0.05). However, there was a difference between the normalized change scores between groups (p<0.05), and the effect size was determined as d=1.66. Over half of the students reported that puzzles improved their understanding of concept relationships (56.1%), topics (54.9%), key information (53.7%), and self-evaluation (51.2%).**Conclusion:** The findings of this study suggest that integrating puzzles into nursing education can significantly enhance learning outcomes. Crossword and word search puzzles were shown to promote a deeper understanding and better retention of concepts related to parenteral medication administration. This research suggests including innovative and interactive teaching tools in nursing curricula.

Keywords: Nursing students; medication therapy management; knowledge; randomized controlled trial

ÖZET Amaç: Bu çalışma, çapraz ve kelime arama bulmacalarının hemşirelik birinci sınıf öğrencilerinin parenteral ilaç uygulamasına ilişkin bilgilerine etkisini değerlendirmek amacıyla yapılmıştır. **Gereç ve Yöntemler:** Ön test-son test paralel gruplu, randomize kontrollü bir çalışmadır. Nisan-Haziran 2023 tarihleri arasında yürütülen bu çalışmaya, hemşirelik esasları dersine kayıtlı 164 hemşirelik öğrencisi katılmıştır. Öğrenciler, başlangıç ölçümlerine göre tabakalı blok-randomizasyon ile müdahale ve kontrol gruplarına atanmıştır. Müdahale grubu teorik ve pratik eğitim almış, ardından öğrendiklerini pekiştirmek için tasarlanmış çapraz ve kelime arama bulmacalarını çözmüştür. Buna karşılık kontrol grubu, bulmaca temelli aktiviteler olmaksızın sadece teorik dersler ve laboratuvar uygulamalarından oluşan standart müfredata devam etmiştir. **Bulgular:** Müdahale ve kontrol gruplarının grup içi ön test ve son test puanları arasında istatistiksel olarak anlamlı bir fark bulunmuştur (p<0,05). Bununla birlikte, gruplar arasında normalleştirilmiş değişim puanları arasında istatistiksel olarak anlamlı bir fark bulunmuş (p<0,05) ve etki büyüklüğü d=1,66 olarak belirlenmiştir. Öğrencilerin yarısından fazlası bulmacaların kavram ilişkileri (%56,1), konular (%54,9), anahtar bilgiler (%53,7) ve öz-değerlendirme (%51,2) konusundaki anlayışlarını geliştirdiğini bildirmiştir. **Sonuç:** Bu çalışmanın sonucu, bulmacaların hemşirelik eğitimine entegre edilmesinin öğrenme çıktılarını önemli ölçüde artırabileceğini göstermektedir. Çapraz ve kelime arama bulmacalarının parenteral ilaç uygulamasıyla ilgili kavramların daha iyi anlaşılmasını ve daha iyi akılda tutulmasını sağladığı saptanmıştır. Bu araştırma, yenilikçi ve interaktif öğretim araçlarının hemşirelik müfredatına dâhil edilmesini önermektedir.

Anahtar Kelimeler: Hemşirelik öğrencileri; ilaç tedavisi yönetimi; bilgi; randomize kontrollü çalışma

Medication administration is a fundamental subject in the fundamentals of nursing curriculum. Comprehensive instruction is crucial for patient safety and reducing medication errors.[1,2] A key objective in nursing education is to develop students' proficiency in theoretical understanding and practical execution of drug administration.[3]

Longitudinal studies indicate a need to assess graduates' readiness for theoretical understanding and safe medication administration. Sulosaari et al. observed that none of the 666 nursing students achieved a perfect score on knowledge tests during the 2nd and 7th semesters, with an average correctness rate of 72%.[4] Schneidereith's study with 78 students showed none initially validated all five correct principles in medication administration, but by graduation, 80% demonstrated proficiency.[5] Jarvill found that only one-third of senior nursing students (n=68) were proficient in medication administration, highlighting the need for effective teaching methods to enhance patient safety and care quality.[6]

Research suggests using diverse teaching methods like demonstration, simulation and integrating technological tools and online learning modules in nursing education to improve students' proficiency in safe medication administration.[7-9] Lee and Quinn stressed the importance of designing classroom-based educational interventions for nursing programs with limited facilities to enhance students' competencies in medication administration safety.[9]

Since the 20th century, nursing education has seen significant changes. The rise of educational technology emphasizes student-centred, interactive teaching methods.[10] Educators are urged to use creative activities to enhance student engagement and autonomy.[11] Puzzles are effective in teaching complex concepts.[12] Shawahna and Jaber found crossword puzzles improved epilepsy pharmacology understanding in 224 nursing students.[13] Tosunöz and Doğan showed puzzles helped students learn pain management.[12] Kalkan et al. noted nursing students enjoyed puzzles and learned better.[14] Alcindor highlighted puzzles' collaborative benefits for student understanding and teamwork.[11]

Limited studies in nursing education have explored puzzles' effectiveness in problem-solving, clinical decision-making skills, neurological emergencies, and pain management.[11,12,15] Previous research used scales, reflective evaluations, or focus group discussions to assess puzzle impact.[11,14,15] In contrast, our study uniquely focuses on puzzles for parenteral medication administration (PMA)-which is critical in nursing education and patient safety. Using pre-tests and post-tests, we objectively evaluated puzzles' impact on cognitive development. This research contributes innovatively to nursing education, enhancing PMA knowledge.

While studies show puzzles enhance learning in nursing and health disciplines, few trials examine their impact on student knowledge.[12-19] This study aimed to determine the effect of using crossword and word puzzles on nursing students' knowledge levels about PMA.

Research Questions

1. Do crossword and word search puzzles have a statistically significant effect on nursing students' knowledge of PMA?

2. Do crossword and word search puzzles positively influence nursing students' individual opinions about PMA?

Thus, the following hypothesis was tested:

Hypothesis 1: Crossword and word search puzzles are effective in increasing nursing students' knowledge of PMA.

MATERIAL AND METHODS

STUDY DESIGN AND SETTING

This parallel-group randomized controlled study was conducted at a university's Faculty of Nursing. The study adheres to CONSORT 2010 checklist criteria for reporting randomized trials and is registered at https://register.clinicaltrials.gov (ID: NCT06105216).

PARTICIPANTS AND RANDOMIZATION

This study took place from April to June 2023 and included 220 students enrolled in the Fundamentals of Nursing course. The entire student population meeting

the inclusion criteria was included in the study sample without using a specific sampling method.

Inclusion criteria: (1) First-time registration in the course. Exclusion criteria: (1) Non-native speakers of the country's native language. (2) Previous graduation from any health-related university. Dismissal criteria: (1) Incomplete questionnaire responses. (2) Voluntary withdrawal from the study.

Of the 220 assessed students, 56 were excluded and did not meet the inclusion criteria. After baseline measurements, the remaining 164 students were assigned to the intervention groups (IG) and control groups (CG) using stratified block randomization according to their parenteral medication administration knowledge test (PMAKT) scores. The study had a participation rate of 74.54%, with no data or sample loss (Figure 1).
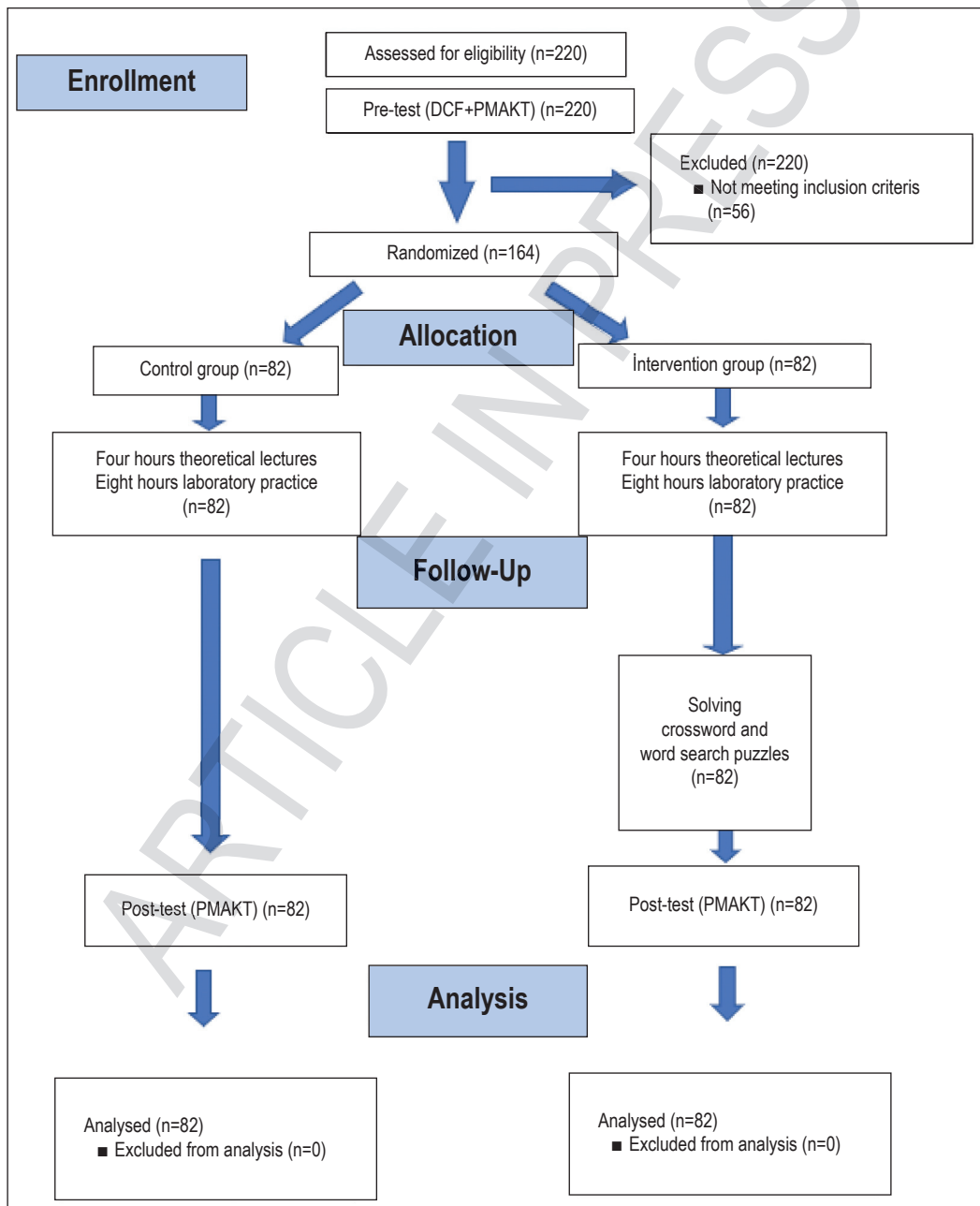

FIGURE 1: Consort flow diagram.
DCF: Demographic characteristics form; PMAKT: Parenteral medication administration knowledge test

Students were assigned to IG and CG using school registration numbers by a non-researcher. Data entered by a third party were analyzed using SPSS by a blinded statistician. Researchers and students were not blinded due to shared laboratory settings, while the statistician remained blinded during the analysis.

THE QUESTIONNAIRES

Data were collected using a "Demographic characteristics form (DCF)", "PMAKT", and "Students' views form (SVF)". The DCF, designed by researchers, included gender and age questions. The researchers developed PMAKT by utilizing the
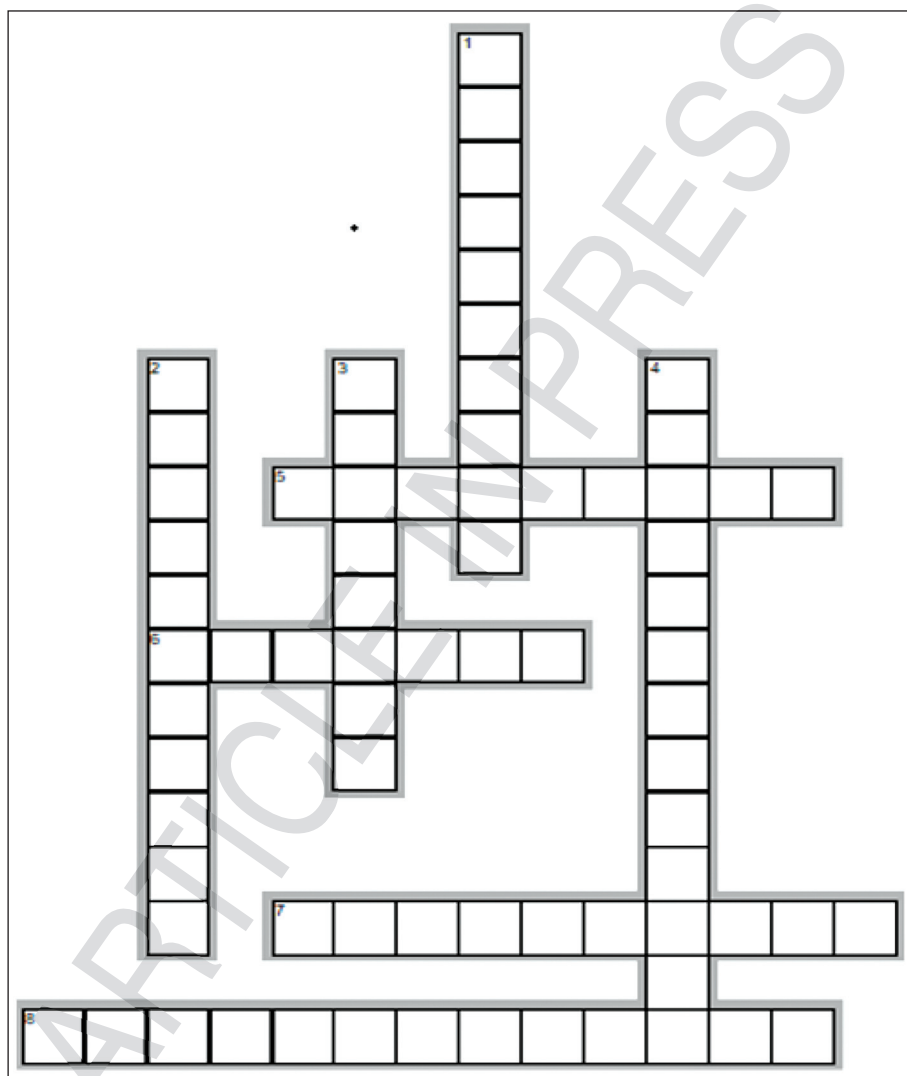

FIGURE 2: A crossword puzzle example.

Down

1. The process of withdrawing the plunger to make sure that the needle does not puncture a vein or artery before administering a drug by intramuscular injection.

2. The name of an injection procedure is one in which the medicine is given under the epidermis and into the dermis.

3. Insulin and low molecular weight heparin are often administered by this injection.

4. It is the name of the first choice site for intramuscular injection in an adult patient because the muscle is deep and away from large blood vessels and nerves.

Across

5. This site should be preferred for subcutaneous injection, as absorption is the fastest.

6. The maximum amount of drug that can be given during intramuscular injection into this muscle should be 1 ml.

7. It is the parenteral route of drug administration with the fastest absorption rate.

8. The injector's entry angle into the tissue should be 90 degrees in these injection applications.

literature. Expert opinions were obtained from five nursing academicians, and corrections were made to the suggestions.[21,22] Then, it was piloted with 61 nursing students from another university to improve item difficulty and discrimination indices.

The final test comprised 25 multiple-choice questions covering general information (5), angle of entry (3), maximum dosage (4), application areas (6), special techniques (4), and complications (3), and scored four points for correct answers and zero for incorrect, with a maximum score of 100. The SVF, a 5-point Likert scale consisting of 14 statements prepared by the researchers, measured students' opinions about the puzzles related to PMA.

APPLICATION OF THE STUDY

Preparation of Puzzles

Researchers used online tools (https://www.eclipse-crossword.com and https://thewordsearch.com) to create crossword and word search puzzles aligned with course content. Crossword puzzles focused on six principles of medication administration, administration areas, and general medication information, with answers oriented vertically and horizontally (Figure 2).

Intervention

Before randomization, all students (n=220) enrolled in the fundamentals of nursing course completed the pre-test (DCF+PMAKT). Then, all 164 randomized students participated in the PMA component, involving four hours of lecture and eight hours of laboratory practice. Expert faculty conducted theoretical and practical sessions in the fundamentals of nursing. During labs, students practiced PMA on simulator mannequins or dressed models using empty syringes. Instructors provided guidance, reinforced correct techniques, and addressed errors.

After laboratory practice, the IG received printed puzzles to solve individually. Researchers supervised students without time constraints and observed them. IG completed puzzles in about 15 minutes. Both groups then took the PMAKT as the post-test. Additionally, the IG completed the SVF.

ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Tokat Gaziosmanpaşa University Social and Human Sci-ences Research Ethics Committee (date: April 25, 2023; no: E-33490967-044-288957), and university permission (date: April 27, 2023; no: E-87008936-199-643654) was secured before the study. Using a single-blind design, students were informed about the research purpose without revealing their group assignment. Following the Declaration of Helsinki, written informed consent explained the study's objectives, voluntary participation, and the right to withdraw. Participants' confidentiality was assured for research purposes. After data collection, Puzzles were provided to the CG.

DATA ANALYSIS

Statistical analyses were performed using IBM SPSS Statistics-22, with a significance level of $p<0.050$. Descriptive statistics included mean and standard deviation for numerical variables and frequency and percentage for categorical variables. The normality of pre-test and post-test knowledge scores was assessed using the Shapiro-Wilk test, indicating normal distribution only for pre-test scores ($p>0.05$). Group comparisons for knowledge scores used independent samples t-tests, Mann-Whitney U tests, and Wilcoxon tests. Chi-square analysis evaluated differences in categorical variables. The normalized change was calculated following the equations outlined by Marx and Cummings[20]:

When the post-test scores>pre-test scores:

$$Normalized\ change = \frac{Posttest\ Score - Pretest\ Score}{100 - Pretest\ Score}$$

When the posttest scores=pretest scores=100 or 0

$$Normalized\ change = 0$$

When posttest scores<pretest scores:

$$Normalized\ change = \frac{Posttest\ Score - Pretest\ Score}{100 - Pretest\ Score}$$

RESULTS

DEMOGRAPHIC INFORMATION

Table 1 summarises the demographic characteristics of the students (n=164). Age and gender distributions were similar between the groups. There were no significant differences between the groups ($p>0.05$).

TABLE 1: Age and gender distribution of the groups.					
		IG (n=82)	CG (n=82)		
Variables		n (%)	n (%)	χ^2/t	p value
Gender	Female	71 (86.59)	67 (81.71)	0.731	0.392
	Male	11 (13.41)	15 (18.29)		
Age (years)	≤20	75 (91.46)	71 (86.59)	0.998	0.318
	>20	7 (8.54)	11 (13.41)		
Mean age ($\overline{X}$±SD) (minimum-maximum)		19.49±1.05 (18-23)	19.48±1.18 (18-24)	0.070	0.944

IG: Intervention groups; CG: Control groups; χ^2: Pearson Chi-square test; t: The independent samples t-test; SD: Standard deviation.

PMAKT SCORES

No statistically significant difference was found between the pre-test scores of the groups (p>0.05) (Table 2).

There was a statistically significant difference between the IG and CG in-group pre-test and post-test scores (p<0.05). The effect size between the pre-test and post-test scores in the IG was determined as dz=2.11 (r=0.553) (Table 2).

There was a difference between the normalized change scores of the groups (p<0.05). The effect size between the normalized change scores of the IG and the CG was determined as d=1.66. It indicates that the difference between the groups is very large (Table 3).

STUDENTS' VIEWS ON PUZZLE-SOLVING

More than half of the students reported that puzzles aided in understanding relationships between concepts (56.1%) and the topic (54.9%), helped them grasp necessary information (53.7%), and facilitated self-evaluation (51.2%).

DISCUSSION

This study was conducted as a randomized controlled trial with 164 first-year nursing students to investigate the effect of crossword and word search puzzles on students' knowledge level about PMA.

No statistically significant difference existed between the groups regarding sociodemographic characteristics and baseline PMAKT mean scores, confirming homogeneous distribution (Table 1, Table 2). Both groups significantly increased their second PMAKT mean scores compared to the baseline (p<0.05). This indicates that solely theoretical lectures and laboratory studies elevated students' knowledge levels in PMA. Furthermore, the effect size

TABLE 2: Comparison of the pre-test and post-test mean scores of the groups.						
	IG (n=82)		CG (n=82)			
Variables	$\overline{X}$±SD	Median (Q1-Q3)	$\overline{X}$±SD	Median (Q1-Q3)	t	p value
Pre-test	53.27±15.79	54 (40-64)	53.22±16.34	52 (44-64)	0.019	0.985
Post-test	82.05±14.88	84 (76-92)	63.41±15.42	64 (52-76)		
z	-7.788	-6.278				
p value	0.001*	0.001*				

*p<0.05; IG: Intervention groups; CG: Control groups; t: The paired samples t-test; z: Wilcoxon test; SD: Standard deviation.

TABLE 3: Comparison of normalized change scores of the groups.						
	IG (n=82)		CG (n=82)			
Variables	$\overline{X}$±SD	Median (Q1-Q3)	$\overline{X}$±SD	Median (Q1-Q3)	U	p value
Normalized change	0.62±0.26	0.67 (0.5-0.8)	0.22±0.22	0.22 (0.08-0.36)	837.5	0.001*

*p<0.05; IG: Intervention groups; CG: Control groups; U: Mann-Whitney U test; SD: Standard deviation.

value between the baseline and second PMAKT mean scores of the IG (dz=2.11, r=0.553) underscores the significant impact of puzzles on enhancing students' knowledge levels. Consistent with our findings, research indicates the effectiveness of puzzles as post-theoretical lesson tools for learning. Marcondes et al. demonstrated the complementarity of puzzles in enhancing the understanding of cardiac cycle physiology following theoretical lectures.[23] Similarly, Khorammakan et al. reported significant improvements in cognitive performance among surgical technology students in comprehending the stages of coronary artery bypass graft surgery, the associated tools, equipment, and sequential preparation through puzzle-based learning.[17]

Normalized change and effect size were also calculated to assess differences from the CG. The advantage of this method is that it considers students who scored 0% or 100% in both the pre-test and post-test.[20] A statistically significant difference in normalized change scores between the groups was observed (p<0.05), with an effect size value (d=1.66) indicating a substantial and noteworthy distinction between the groups (Table 4). This critical finding underscores the significant impact of puzzles on enhancing students' knowledge about PMA. Our results align with other randomized controlled studies, supporting the positive effect of puzzles on cognitive learning.

Shawahna and Jaber observed the effectiveness of puzzles in nursing students' understanding of epilepsy pharmacology.[13] Tosunöz and Doğan demonstrated their efficacy in teaching concepts related to pain management courses.[12]

In our study, 86.6% (n=71) of the IG noted that puzzles enhanced their comprehension, 80.4% (n=66) reported increased motivation, and 78% (n=64) found them helpful for understanding without memorization (Table 4). Puzzles, recognized as a teaching tool, foster active participation and enhance learning skills.[15] They also contribute to improving vocabulary recall skills.[12] Supporting our findings, Kalkan et al. reported increased motivation and improved learning retention among students (n=96) who used puzzles in the Teaching in Nursing course.[14] Qutieshat et al. found that dental students enhanced their understanding of restorative dentistry concepts using crossword puzzles.[19] Similarly, Bawazeer et al. demonstrated improved learning of cardiovascular drug pharmacology among pharmacy students (n=267) using crossword puzzles.[16] Malini et al. highlighted the utility of puzzles in aiding medical students' comprehension of concepts and new vocabulary in endocrine physiology. Additionally, Tosunöz and Doğan reported students' effective exploration of unfamiliar words through puzzle-based activities.[12,24]

TABLE 4: Students' views on puzzle-solving (n=82).					
Items	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
1. The puzzles contained information I needed to learn	1 (1.2)	2 (2.4)	6 (7.3)	40 (48.8)	33 (40.2)
2. After solving the puzzles, I realized what information I needed.	1 (1.2)	5 (6.1)	6 (7.3)	44 (53.7)	26 (31.7)
3. Solving puzzles helped me evaluate myself	1 (1.2)	3 (3.7)	5 (6.1)	42 (51.2)	31 (37.8)
4. The puzzles helped me prepare for my exams.	2 (2.4)	3 (3.7)	6 (7.3)	40 (48.8)	31 (37.8)
5. The puzzles helped me learn the relationships between concepts.	1 (1.2)	2 (2.4)	5 (6.1)	46 (56.1)	28 (34.1)
6. The content of the puzzles was enough for me.	1 (1.2)	6 (7.3)	8 (9.8)	45 (54.9)	22 (26.8)
7. The number of puzzles was sufficient.	1 (1.2)	6 (7.3)	8 (9.8)	43 (52.4)	24 (29.3)
8. Puzzles made it easier for me to learn this topic.	2 (2.4)	4 (4.9)	5 (6.1)	45 (54.9)	26 (31.7)
9. Solving puzzles increased my motivation for the subject.	2 (2.4)	2 (2.4)	12 (14.6)	38 (46.3)	28 (34.1)
10. Puzzles helped me understand the subject without memorizing it.	0 (0)	6 (7.3)	12 (14.6)	37 (45.1)	27 (32.9)
11. I would like to see activities with puzzles in all lessons.	0 (0)	9 (11.0)	20 (24.4)	28 (34.1)	25 (30.5)
12. It took me a lot of time to solve the puzzles.	9 (11.0)	38 (46.3)	21 (25.6)	8 (9.8)	6 (7.3)
13. I found it very difficult to complete the puzzles.	16 (19.5)	37 (45.1)	16 (19.5)	5 (6.1)	8 (9.8)
14. I found solving puzzles fun.	2 (2.4)	5 (6.1)	11 (13.4)	35 (42.7)	29 (35.4)

In our study, 78.1% (n=64) of the IG reported finding puzzle-solving enjoyable (Table 4). Puzzles, recognized as learning tools, not only facilitate learning and increase motivation but also contribute to the enjoyment of lessons.[24] Similarly, Nazeer et al. observed that Faculty of Medicine students (n=150) found solving puzzles to teach basic anatomy concepts a fun and enjoyable learning experience.[18] In the study by Gilani et al., students noted that crossword puzzles enhanced learning by adding an element of enjoyment.[25]

Puzzles are active learning tools that provide learning and comprehensibility of complex concepts and terms and increase memory ability by activating the mind.[19,25] This study showed that crossword and word search puzzles are effective tools to improve nursing students' knowledge about PMA.

LIMITATIONS OF THE STUDY

One limitation of this study is its exclusive focus on nursing undergraduate students at one university. Due to the specificity of this participant pool, findings and conclusions may not be generalized to broader populations or diverse academic settings.

CONCLUSION

Therefore, integrating puzzles significantly enhanced students' PMA knowledge scores. The improvement was statistically significant with a large effect size. This study underscores puzzles as effective tools in nursing education, complementing traditional teaching methods, particularly for complex PMA concepts and terms. Puzzles were found to increase interest, motivation, concept retention, and enjoyment in learning. Future research should explore puzzles' impact across different nursing courses and subjects, focusing on short-term and long-term learning outcomes.

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