

# The Comparison of Three Teaching Methods on the Knowledge and Satisfaction of Nursing Students in the Emergency Medical Procedures Class: A Non-Randomised Controlled Study

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DOI: <https://www.doi.org/10.64332/ujbb.3.1.1>

Manuscript received: February 26, 2026.  
Accepted for publication: April 19, 2026.

## Abstract

**Background:** Nursing education in Croatia is primarily based on traditional frontal teaching methods. There is limited evidence comparing collaborative learning and ICT-based gamification with traditional methods regarding knowledge acquisition and student satisfaction.

**Aim:** This study compared the effects of three teaching methods - gamification with ICT, collaborative learning, and frontal teaching - on the knowledge and satisfaction of nursing high school students during an emergency medical procedures course.

**Methods:** This was a non-randomised quasi-experimental study with parallel pretest-posttest groups including 65 fourth-grade nursing high school students in Zagreb, Croatia. Three classes were assigned to gamification with ICT (n=24), collaborative learning (n=18), or frontal teaching (n=23). All groups received eight hours of instruction over two months. Outcomes were measured using a standardised knowledge exam and a satisfaction questionnaire.

**Results:** A total of 54 participants completed the questionnaire. Baseline knowledge did not significantly differ between the groups. Following the interventions, the gamification and ICT group achieved significantly higher total knowledge scores compared to both the frontal teaching group (p=0.021) and the collaborative learning group (p=0.040). Significant differences were also observed across all specific cognitive domains, including factual knowledge, understanding, and application/analysis. Regarding student satisfaction, the collaborative learning group reported significantly lower perceived teacher support compared to the other two groups.

**Conclusion:** Gamification with ICT was associated with higher post-intervention knowledge scores than frontal teaching and collaborative learning, while overall student satisfaction did not differ significantly. These findings suggest that gamification with ICT may be a promising approach for improving short-term knowledge acquisition in nursing education.

**Keywords:** nursing; frontal teaching; collaborative learning; gamification; information and communication technologies

## Introduction

Innovative approaches and modalities for educating students in health professions education are constantly being evaluated to improve teaching and learning, with the ultimate goal to improve patient care and outcomes (1).

Traditional frontal teaching implies that the teachers address all the students in the class. The advantage of such teaching is its efficiency; a high number of students can be addressed, a teacher has an overview of the class and insight into student activities. The disadvantage of frontal teaching is the neglect of individual characteristics. It is anticipated that all students will start and finish the planned tasks at the same time, which is not advantageous for students who fall behind or those who are solving tasks faster than others (2). It has been described that many students describe traditional schooling as ineffective and boring, hampering student engagement and motivation (3). Gamification and collaborative learning are more recent methods used to enhance formal education.

The use of educational games as a learning method is considered promising due to the games' abilities to teach and the fact that they reinforce not only knowledge but also important skills such as problem-solving, collaboration, and communication. Games are motivating and engaging, with the possibility of winning serving as a reward. However, creating a full-blown, elaborate instructional game is difficult, time-consuming, and costly. Thus, the "gamification" approach uses game thinking and game design elements in education to foster students' engagement and motivation (4).

Collaborative learning is a method where learners at various performance levels work together in small groups toward a common goal. In such an approach, the learners are responsible for the learning of their peers and also for their own learning. Thus, the success of one learner helps other students to be successful (5). It is based on the idea that students will find it easier to discover, understand, and adopt complex concepts if they discuss, argue with them, and come to

common conclusions. Research supports this theory because those who learn in this way learn faster and easier, and knowledge is often longer retained (5).

In Croatia, frontal teaching is still the dominant mode of teaching, where, contrary to the modern educational paradigms, a teacher is still at the centre of the educational process. In 2015, the Ministry of Education and Health of the Republic of Croatia started a project titled "e-Schools: a comprehensive informatisation of school operation processes and teaching processes aimed at the creation of digitally mature schools for the 21st century". Within this project, digital technologies and modern tools were introduced into schools, together with additional information and communication technologies (ICT) for teachers (6). However, it is still unclear whether the new teaching methods are better in terms of knowledge gained and student satisfaction, compared with the traditional frontal teaching.

This study aimed to compare the effects of three teaching methods - gamification with ICT, collaborative learning, and frontal teaching - on the knowledge and satisfaction of nursing high school students during an emergency medical procedures course.

## Methods

### *Study design*

This was a non-randomised controlled quasi-experimental study with parallel groups (pretest-posttest design).

### *Ethics*

The Council of the Department of Nursing at the Catholic University of Croatia approved the study protocol on November 20, 2019. Subsequently, the school board of the Medical School Vrapce, Croatia, which is also in charge of overseeing ethics issues in the institution, approved the study protocol on December 20, 2019. The students provided their written consent to participate in the study via e-mail.

### *Time and place of the study*

The study was conducted in the Medical School Vrapce, Croatia, during two months in the second part of the academic year 2019/2020. In the last lesson in the first part of the academic year 2019/2020, students were informed about this study and invited to participate.

### *Participants*

Nursing students in the 4th grade of the nursing medical school Vrapce, aged 18 or 19 years, participated in the study. All students were invited to participate in the study. There were three groups of students, attending classes 4a, 4b and 4c. We excluded all other classes in the school where the study took place, because the researcher conducting the study (MM) teaches emergency medical procedures only to the 4th-grade students.

### *General baseline knowledge testing*

At the beginning of the school year, the students were initially tested for the most relevant learning outcomes from subjects taught during the 3rd year of their studies. Knowledge from the following topics was tested: Anatomy and Physiology, Basic Nursing Care, General Principles of Health and Care, Nursing Care for Healthy Children and Adolescents. This knowledge is considered to be the basic prior knowledge that is supposed to be retained from lower study years to higher study years, and upgraded in higher study years. This knowledge test was conducted in the school independently of this study. We analysed the results of this knowledge to see whether there were any baseline differences in the knowledge of the most relevant learning outcomes among the three groups of students.

### *Domain-specific baseline knowledge testing*

The baseline written knowledge test on Emergency Medical Procedures was conducted on November 21, 2019, independent of the study. The exam content included teaching topics: the historical overview of emergency medical care, ABCDE examination (standardised procedure of physical examination of the patient: A-maintenance of

airway patency, B-assessment of respiration, C-assessment of circulation, D-rapid neurological examination, E-detection of the patient and examination from head to toe), state of consciousness, airway obstruction by a foreign body, and maintenance of airway patency. The maximum number of points was 25. We analysed the results of this test to verify whether there were any baseline differences between the groups in the knowledge of emergency medicine.

### *Interventions*

The three teaching methods were applied during the second educational period of the academic year 2019/2020 for two months. During those two months, each class underwent 8 hours of emergency medicine instruction. The teaching topics covered were: bleeding, shock, and chest injuries. Supplementary file 1 lists the teaching units covered during the study and the learning outcomes of each teaching unit.

The students belonged to the same type of studies (nursing), they had the same literature, and the same teacher held classes. However, each class received different teaching methods about emergency medical procedures.

The first experimental group was taught using gamification and ICT, and the second experimental group was taught using collaborative learning. The control group received frontal teaching.

### *Knowledge assessment and student satisfaction with teaching*

Immediately after completing the application of the tested teaching methods (two months from the beginning of teaching within the study), a standard knowledge test and a survey on satisfaction with teaching were conducted among students on March 5, 2020, to determine whether there is a difference in knowledge acquisition and satisfaction among the students.

The written knowledge test contained 15 questions, and the maximum number of points was 31.5. The knowledge test included three parts, assessing different

cognitive aspects of knowledge. The first part assessed knowledge of the facts; it contained 3 questions, with a maximum of 7 points (22% of the total points). The second part assessed understanding; it had 10 questions and a maximum of 16 points (51% of the total points). The third part assessed the application of knowledge, analysis and synthesis; it had 2 questions and a maximum of 8.5 points (27% of the total points).

The knowledge test was conducted at the same time for all students in three different classrooms. The students had 45 minutes for the exam.

We used a questionnaire that was used in the study of Jagic and Jurcic (7). Their questionnaire was adapted from two questionnaires by Oswald et al. from 1989. (8) and Jurić in 1989 (9) for studying the multidimensionality of the classroom-teaching climate. The questionnaire was used to survey student satisfaction with teaching. The questionnaire was delivered in the Croatian language. The instrument contained 68 items and assessed four factors: fear of failure (9 items), teacher support (15 items), class cohesion (18 items), and satisfaction with teaching (20 items) (7). Each item is scored with a Likert scale ranging from 1 to 5, where 1 indicates "completely disagree" and 5 indicates "completely agree".

The translation of the questionnaire into English is available in Supplementary file 2. Additionally, students received socio-demographic questions, including sex, size of the place of residence, mothers' and fathers' education, and mothers' and fathers' employment status.

### *Data analysis*

Data were analysed using descriptive and inferential statistics. Categorical variables were presented as frequencies and percentages, while continuous variables were described using means and standard deviations ( $M \pm SD$ ). Normality of distributions was assessed using the Shapiro-Wilk test separately for each factor and teaching group.

For the student satisfaction questionnaire, items 27, 28, 30, 39, 40, 41, 46, 47, 48, 63, 64

and 65 were reverse-scored in accordance with the original instrument so that higher scores consistently reflected more positive perceptions. After reverse scoring, composite factor scores were calculated for each participant by averaging item responses within each factor: fear of failure (9 items), teacher support (15 items), class cohesion (18 items), and satisfaction with teaching (20 items).

Internal consistency of each factor was evaluated using Cronbach's alpha. Group differences in factor scores were analysed at the factor level. For factors with approximately normal distributions and homogeneous variances, one-way analysis of variance (ANOVA) was used. When the assumption of homogeneity of variance was violated, Welch's ANOVA was applied. For factors with non-normally distributed data, the Kruskal-Wallis test was used.

Normality of factor score distributions was examined separately for each teaching group. A deviation from normal distribution was observed only for the fear of failure factor in the collaborative learning group; therefore, non-parametric testing was applied for this factor. Distributions of the remaining three factors did not significantly deviate from normality and were analysed using parametric methods.

Post-hoc comparisons were conducted when overall group differences were statistically significant. Tukey's honestly significant difference (HSD) test was used following standard ANOVA; Games-Howell tests were used following Welch's ANOVA.

Baseline and post-intervention knowledge test scores were analysed using parametric methods, as distributions did not significantly deviate from normality. Group comparisons were performed using one-way ANOVA. Post hoc comparisons were performed using Tukey's test.

All statistical tests were two-tailed, and statistical significance was set at  $p < 0.05$ . Microsoft Excel (Microsoft Inc., Redmond, WA, USA) and IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA) were used for data analyses.

## Results

### Participants

The study was conducted on a sample of 65 fourth-grade nursing students. The majority of participants were women, and most lived in a city with more than 200,000 inhabitants. Most students' mothers had completed four-year secondary education and were employed, while most fathers had completed secondary education and were also employed (Table 1).

**Table 1.** *Participants' demographic characteristics*

Variable	N
<b>Sex</b>	
Man	15
Woman	39
<b>Size of the city/village of residence</b>	
Under 2,000 inhabitants	3
2,001 to 5,000 inhabitants	5
5,001 to 10,000 inhabitants	7
10,001 to 200,000 inhabitants	14
More than 200,000 inhabitants	24
<b>Mother's education</b>	
Unknown	1
Higher education	10
Polytechnic	1
Four-year high school	36
Three-year high school	4
Primary school	2
<b>Mother's employment</b>	
Employed	39
Unemployed	12
Student	2
Retired	1
Deceased	0
<b>Father's education</b>	
Unknown	3
Higher education	3
Polytechnic	3
Four-year high school	24
Three-year high school	19
Primary school	2
<b>Father's employment</b>	
Employed	46
Unemployed	1
Student	0
Retired	5
Deceased	1

\* The number of responses varies due to missing data.

There were 23 students in the control group receiving frontal teaching, 24 students in the group receiving gamification with ICT, and 18 students in the group receiving collaborative learning. Two months after completion of the intervention, the post-intervention knowledge test was completed by 58 students, as seven students were absent on the testing day. Of those, four students subsequently left due to illness, resulting in 54 completed questionnaires for the analysis of student satisfaction.

### General baseline knowledge test results

The baseline knowledge test assessing the most relevant learning outcomes from the lower study year, which was conducted at the beginning of the school year independently of the study, was completed by 64 students. The maximum possible score was 48. Data were normally distributed in all three groups. There were no significant differences in baseline knowledge between the control group receiving frontal teaching ( $18 \pm 8.1$ ;  $N=22$ ), the intervention group receiving gamification and ICT ( $20 \pm 8.2$ ;  $N=24$ ), and the intervention group receiving collaborative learning ( $19 \pm 7.6$ ;  $N=18$ ) ( $p=0.7852$ ).

### Baseline knowledge about emergency medicine

A total of 64 students completed the baseline domain-specific knowledge test on emergency medical procedures. The maximum possible score was 25. Data were normally distributed in all three groups, and baseline knowledge did not differ significantly among the groups ( $p=0.898$ ). Baseline test results are presented in Table 2.

### Knowledge about emergency medicine after the interventions

Following the intervention, significant differences were observed among the three groups in total post-intervention knowledge scores on emergency medical procedures ( $p=0.011$ ), as well as across all assessed cognitive domains: knowledge of facts ( $p=0.017$ ), understanding ( $p=0.024$ ), and application of knowledge, analysis, and synthesis ( $p=0.015$ ).

Post-hoc analyses showed that students in the gamification and ICT group achieved significantly higher total knowledge scores compared with students in the frontal teaching group ( $p=0.021$ ). No significant difference in total knowledge scores was observed between the collaborative learning group and the frontal teaching group ( $p=0.999$ ). Total knowledge scores were also significantly higher in the gamification and ICT group compared with the collaborative learning group ( $p=0.040$ ) (Table 3).

For the domain knowledge of facts, students in the gamification and ICT group scored significantly higher than those in the frontal teaching group ( $p=0.012$ ). No significant differences were observed between the collaborative learning and

frontal teaching groups ( $p=0.343$ ), nor between the gamification and ICT and collaborative learning groups ( $p=0.412$ ) (Table 3). For the domain understanding, there were no significant differences in the gamification and ICT group compared with the frontal teaching group ( $p=0.089$ ). Also, no significant difference was found between the collaborative learning and frontal teaching groups ( $p=0.827$ ). Statistical significance was found in the difference between gamification and the collaborative learning group ( $p=0.033$ ).

For the domain application of knowledge, analysis, and synthesis, students in the gamification and ICT group achieved significantly higher scores than those in the frontal teaching group ( $p=0.025$ ). No

**Table 2.** Results of the domain-specific baseline knowledge test about emergency medicine procedures before and after the intervention

Testing time	Baseline						After the intervention					
	Gamification and ICT		Frontal teaching		Collaborative learning		Gamification and ICT		Frontal teaching		Collaborative learning	
Values	N	M (SD)	N	M (SD)	N	M (SD)	N	M (SD)	N	M (SD)	N	M (SD)
Total score	24	17 (4.5)	22	17 (4.2)	18	17 (4.1)	23	23 (5.3)	20	17 (7.7)	15	17 (5.9)
Knowledge of the facts							23	5.3 (1.3)	20	3.9 (1.8)	15	4.6 (1.8)
Understanding							23	10.9 (3.1)	20	8.6 (4.4)	15	7.9 (2.5)
Application of knowledge, analysis and synthesis							23	6.4 (1.6)	20	4.8 (2.1)	15	4.9 (2.3)

**Table 3.** Results of the post-hoc test for knowledge about emergency medicine after the interventions

Knowledge domain	Comparison	MD	95% CI	P*
Total post-intervention knowledge	A-B	5,367	[0,677; 10,058]	0,021
	B-C	-0,833	[-5,324; 5,157]	0,999
	A-C	5,284	[0,192; 10,376]	0,040
Knowledge of facts	A-B	1,466	[0,273; 2,659]	0,012
	B-C	-0,708	[-2,041; 0,625]	0,412
	A-C	0,758	[-0,537; 2,053]	0,343
Understanding	A-B	2,266	[-0,270; 4,803]	0,089
	B-C	0,692	[-2,142; 3,525]	0,827
	A-C	2,958	[0,205; 5,711]	0,033
Knowledge, analysis, and synthesis	A-B	1,635	[0,175; 3,095]	0,025
	B-C	-0,067	[-1,698; 1,564]	0,995
	A-C	1,568	[-0,164; 3,153]	0,053

Acronyms: A: gamification ICT; B: frontal teaching; C: collaborative learning; I: confidence interval; MD: mean difference; \*Tukey Post Hoc test

significant difference was observed between the gamification and ICT group and the collaborative learning group ( $p=0.053$ ), nor between the collaborative learning and frontal teaching groups ( $p=0.995$ ).

### Reliability and distribution of satisfaction factors

Internal consistency of the satisfaction questionnaire factors was assessed prior to group comparisons. The reliability of the fear of failure scale (9 items) was good (Cronbach's  $\alpha=0.887$ ), as was the reliability of the teacher support scale (15 items;  $\alpha=0.895$ ). The class cohesion scale (18 items) and the satisfaction

with teaching scale (7 items) demonstrated acceptable internal consistency ( $\alpha=0.767$  and  $\alpha=0.722$ , respectively) (Table 4).

### Differences between teaching groups after the intervention

Differences between teaching groups after the intervention were analysed at the factor level for four dimensions of student satisfaction – fear of failure, teacher support, class cohesion, and satisfaction with teaching (Table 5).

For fear of failure, no statistically significant differences were observed between the three teaching groups in perceived fear of failure

**Table 4.** Reliability and normality of student satisfaction factors

Factor	Class	Cronbach $\alpha$	P*
Fear of failure	Gamification and ICT	0.887	0.950
	Frontal teaching		0.010
	Collaborative learning		0.467
Teacher support	Gamification and ICT	0.895	0.085
	Frontal teaching		0.211
	Collaborative learning		0.982
Class cohesion	Gamification and ICT	0.767	0.263
	Frontal teaching		0.253
	Collaborative learning		0.060
Satisfaction with teaching	Gamification and ICT	0.722	0.351
	Frontal teaching		0.269
	Collaborative learning		0.760

\* Shapiro Wilk

Acronym: ICT = information and communication technologies

**Table 5.** Comparison across teaching groups after the intervention

Factor	Gamification and ICT; M $\pm$ SD	Frontal teaching; M $\pm$ SD	Collaborative learning; M $\pm$ SD	F/H	df	P
Fear of failure	2.68 $\pm$ 0.91	2.52 $\pm$ 1.37	2.56 $\pm$ 0.69	1.206	2	0.547*
Teacher support	4.04 $\pm$ 0.52	4.24 $\pm$ 0.5	3.34 $\pm$ 0.89	8.705	2	0.001** Post-hoc: C < A, C < B
Class cohesion	3.28 $\pm$ 0.44	3.24 $\pm$ 0.44	2.7 $\pm$ 0.71	3.850	2/28.442	0.033*** Post-hoc: A > C
Satisfaction with teaching	3.04 $\pm$ 0.74	2.63 $\pm$ 0.84	3.28 $\pm$ 0.81	2.811	2	0.069**

\*Kruskal-Wallis, \*\* ANOVA, \*\*\* Welch ANOVA

(Kruskal–Wallis test,  $p=0.547$ ). For teacher support, a statistically significant difference between groups was found for perceived teacher support (one-way ANOVA,  $p=0.001$ ). Post-hoc analyses showed that students in the collaborative learning group reported significantly lower perceived teacher support compared with both the gamification and ICT group and the frontal teaching group, while no significant difference was observed between the latter two groups.

For class cohesion, group differences were also observed (Welch ANOVA,  $p=0.033$ ). Post-hoc comparisons indicated significantly higher perceived class cohesion in the frontal teaching group compared with the collaborative learning group, while differences involving the gamification and ICT group did not reach statistical significance. For satisfaction with teaching, differences in overall satisfaction with teaching did not reach statistical significance at the factor level (one-way ANOVA,  $p=0.069$ ).

## Discussion

This study evaluated the impact of different pedagogical approaches on knowledge acquisition and satisfaction among nursing students during emergency medical training. Our findings support the growing body of evidence suggesting that student-centred, active learning environments are more effective for teaching high-stakes clinical content than passive, teacher-centred models.

The success of the gamified approach can be interpreted through Ryan and Deci's Self-Determination Theory (SDT), which posits that motivation is driven by the satisfaction of three basic psychological needs, including autonomy, competence, and relatedness (10). In our study, the gamified elements, likely providing immediate feedback and a sense of progress, addressed these needs more effectively than the frontal method, where students remain passive recipients of information.

Our findings are in line with the systematic review of Andretta et al., published in 2026, which aimed to provide a critical and

updated synthesis of the evidence on the use of gamification in basic nursing education (11). The results of the review indicated that gamification is a promising educational strategy in undergraduate nursing education. Across 48 included studies, gamified approaches were associated with improvements in short-term knowledge and performance, as well as consistently positive effects on motivation, engagement, self-efficacy, and satisfaction. Effects appeared stronger when interventions incorporated immediate feedback and opportunities for repeated practice. However, evidence regarding long-term knowledge retention and practical skill development remains limited, as relatively few studies assessed follow-up outcomes and methodological quality was often constrained by quasi-experimental designs and variable risk of bias. Overall certainty of evidence ranged from low to moderate, highlighting the need for more rigorous trials with standardised outcome measures and longer follow-up periods to clarify the sustained educational impact of gamification (11).

Of note, our results showed that while collaborative learning was effective, gamification provided an additional engagement boost. This mirrors findings in other emergency care contexts, where active performers in simulation-based exercises reported higher satisfaction than those in more traditional observational roles (12).

The contrast in satisfaction scores between the experimental group and the frontal group could be an indicator of a fundamental shift in the pedagogical expectations of contemporary nursing students. This generation, frequently described as "digital natives," has been conditioned by highly interactive, multimedia-driven environments, making traditional, unidirectional lecturing feel increasingly obsolete and disconnected from their cognitive styles. Research indicates that when nursing students are exposed to technology-enhanced, active environments, their perceived value of the educational experience increases, as these methods mirror the fast-paced, information-rich reality of modern clinical practice (13).

Lindsø Andersen et al. published a scoping review in 2022, which showed that Generation Z nursing students, a generation immersed in technology, prefer interactive, tech-driven and visually engaging learning approaches, and that traditional lectures may be misaligned with their learning preferences, whereas modern, interactive strategies can better meet their needs (13).

Beyond satisfaction, this transition toward active involvement addresses the development of essential 21st-century competencies. By shifting the locus of responsibility from the teacher to the learner, a core tenet of the “Learning by Teaching” (LbT) model, educators can foster a higher degree of self-confidence and professional agency. For instance, recent studies utilising LbT in nursing skills education have shown that students who take an active role in explaining or demonstrating procedures to their peers achieve a more robust understanding of complex clinical protocols than those who remain passive observers (14).

This empowerment is particularly vital in the chaotic and unpredictable environment of emergency medicine. In such settings, nurses must act with autonomy and critical thinking, traits that are stifled by the standardised frontal model but nurtured by gamified and collaborative simulations that demand real-time decision-making. Furthermore, international research suggests that spike engagement caused by competitive or interactive elements helps bridge the boredom gap often reported in traditional nursing curricula, thereby reducing academic burnout and improving long-term professional identification (15). By integrating these dynamic elements, educators are not just making classes fun, but are systematically building the cognitive resilience required for high-stakes healthcare environments.

The notably lower satisfaction with the frontal method (the current standard in many Croatian schools) suggests a pedagogical mismatch. When students perceive teaching as boring or unmotivating, their cognitive investment drops. Our findings on satisfaction are consistent with research on

“Flipped Learning,” which found that active methodologies facilitate a better approach to the object of learning, allowing students to discover knowledge rather than just memorise it (16).

However, it is important to note that collaborative learning, despite being effective, can sometimes lead to “socio-cognitive conflict” or unequal participation if not structured correctly. Unequal participation is a known challenge in collaborative learning, and it can negatively affect student satisfaction and learning outcomes unless educators support the group process (17).

In our study, the structured nature of the gamified quizzes may have provided a more consistent framework for all students to participate equally compared to the open-ended nature of collaborative group work.

### **Implications for nursing curricula and future research**

Our findings suggest that Croatian nursing curricula should integrate structured gamified and technology-enhanced active learning strategies, particularly in clinically demanding subjects such as emergency medicine. Rather than fully abandoning frontal teaching, a blended approach that combines concise theoretical instruction with interactive, scenario-based reinforcement may be most effective. Implementation should be accompanied by targeted teacher training in digital pedagogy and structured facilitation of collaborative learning to ensure equitable participation and pedagogical quality.

Future research should prioritise randomised and multicentre studies to strengthen causal inference and generalisability. Longitudinal designs are needed to assess long-term knowledge retention, transfer to clinical performance, and effects on professional identity and burnout. Additionally, studies should examine which specific elements of gamification (e.g., feedback, competition, repetition) drive effectiveness and whether hybrid models combining gamification and structured collaboration yield optimal educational outcomes.

## Strengths and limitations

A strength of this study is its comparative framework, which allowed for a direct evaluation of three fundamentally different teaching strategies – frontal, collaborative, and gamified – all implemented within the same educational environment and subject matter. This consistency across groups helped isolate the impact of the teaching methodology itself. Additionally, focusing on emergency medical procedures provides a practical lens through which to measure both technical knowledge acquisition and the subjective satisfaction of students preparing for stressful clinical roles.

The study had several potential limitations. Primarily, the non-randomised approach to group assignment may have allowed for inherent selection bias, as existing class structures were utilised. While the baseline knowledge levels (pre-test scores) were comparable across all groups, unmeasured variables such as individual student motivation or previous experience with digital tools could have influenced the outcomes. Furthermore, the assessment of knowledge gain was limited to short-term results immediately following the intervention. Since emergency medical skills require high levels of long-term retention to be effective in real-world practice, the durability of these learning gains over time remains unknown.

Another limitation is that a single teacher was responsible for implementing multiple instructional methods. While this may have reduced variability related to teaching style, it also raises the possibility that differences in the teacher's motivation or expectations toward particular instructional approaches may have influenced how the methods were delivered, which could have affected the study outcomes.

While gamification is highly effective at sparking immediate engagement and short-term motivation, excessive stimulation through competitive elements can sometimes overshadow deep cognitive processing. Without a long-term follow-up spanning a full academic year, it is difficult to determine whether the high satisfaction and

knowledge scores observed would translate into sustained clinical competence or if the novelty of the gamified elements would eventually diminish.

## Conclusion

In this study, gamification with ICT was associated with higher post-intervention knowledge scores than frontal teaching and collaborative learning, while student satisfaction did not differ significantly at the overall factor level. These findings suggest that gamification with ICT may be a promising teaching approach in nursing education, particularly for improving short-term knowledge acquisition in emergency medical procedures.

## Declarations

**Acknowledgments:** We are grateful to the students who took part in the study.

### Authors' contributions:

Study design: MM, LP;

Data collection: MM

Data analysis: MM, DČ, LP

Writing of the manuscript: MM, DČ, LP

Revising the manuscript: MM, DČ, LP

Final approval of the manuscript: MM, DČ, LP

**Ethics considerations:** The Council of the Department of Nursing at the Catholic University of Croatia approved the study protocol on November 20, 2019. Subsequently, the school board of the Medical School Vrapce, Croatia, which is also in charge of overseeing ethics issues in the institution, approved the study protocol on December 20, 2019. The students provided their written consent to participate in the study via e-mail.

**Funding:** None

**Competing interests:** None

**Data sharing statement:** Raw data collected within the study are available from the corresponding author on request. They are not publicly available because we did not ask participants to consent to public data sharing.

**AI disclosure:** During the preparation of this work, the authors used the Grammarly tool for language editing. The authors reviewed and

edited the content and take full responsibility for its accuracy and integrity.

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**Supplementary file 1.****Overview of teaching units and learning outcomes**

Hour	Teaching unit	Learning outcomes
1	Bleeding and methods of stopping bleeding, internal bleeding	<ul style="list-style-type: none"> <li>- Distinguish different types of external bleeding</li> <li>- Describe methods of stopping bleeding</li> <li>- Compare individual methods of stopping bleeding</li> <li>- Recognise the symptoms of internal bleeding</li> <li>- Clarify procedures for internal bleeding</li> <li>- Clarify procedures for some specific bleeding</li> </ul>
2	Shock (definition, shock pathophysiology)	<ul style="list-style-type: none"> <li>- Define shock</li> <li>- List the four components of the vascular system necessary for normal tissue perfusion</li> <li>- Describe the symptoms and signs of shock in the order in which they develop</li> <li>- Clarify methods to prevent shock</li> </ul>
3	Hypovolemic shock	<ul style="list-style-type: none"> <li>- Explain the mechanism of shock due to hypovolemia</li> <li>- Recognise hypovolemic shock in casualties</li> <li>- List prehospital interventions due to hypovolemia</li> <li>- Analyse the symptoms and signs that occur due to the development of shock</li> </ul>
4	Mechanical shock	<ul style="list-style-type: none"> <li>- Explain the mechanism of shock due to tension pneumothorax</li> <li>- Describe the symptoms and signs of shock due to tension pneumothorax</li> <li>- List prehospital interventions due to shock caused by tension pneumothorax</li> <li>- Explain the mechanism of shock due to cardiac tamponade</li> <li>- Describe the symptoms and signs of shock due to cardiac tamponade</li> <li>- List prehospital interventions due to shock caused by cardiac tamponade</li> </ul>
5	Vasodilatory shock	<ul style="list-style-type: none"> <li>- Explain the mechanism of vasodilatory shock</li> <li>- Describe the symptoms and signs of vasodilatory shock</li> <li>- Clarify emergency medical interventions due to vasodilatory shock</li> <li>- Describe the mechanism of occurrence, symptoms and signs and management of neurogenic shock</li> </ul>
6	Chest injuries (tension pneumothorax, open pneumothorax)	<ul style="list-style-type: none"> <li>- Explain the reasons for the occurrence of open pneumothorax</li> <li>- Describe the symptoms and signs of open pneumothorax</li> <li>- Specify procedures for the management of open pneumothorax</li> <li>- Define tension pneumothorax</li> <li>- Describe the symptoms and signs of tension pneumothorax</li> <li>- Specify procedures for the management of tension pneumothorax</li> <li>- Associate symptoms and signs with a specific care procedure</li> </ul>
7	Chest injuries (hemothorax, unstable chest, cardiac tamponade)	<ul style="list-style-type: none"> <li>- Define hemothorax</li> <li>- Explain the pathophysiology of hemothorax</li> <li>- Distinguish tension pneumothorax and hemothorax</li> <li>- List interventions for the care of patients with hemothorax</li> <li>- Explain the pathophysiology of cardiac tamponade</li> <li>- Create procedures for the care of individual chest injuries</li> </ul>
8	Chest injuries (hemothorax, unstable chest, cardiac tamponade)	

## Supplementary file 2.

### Questionnaire used in the study

Dear students,

This survey is part of a study titled “The comparison of three teaching methods on the knowledge and satisfaction of nursing students in the emergency medical procedures class”.

The research is conducted by Mate Maretić under the mentorship of Prof. Livia Puljak, for the purpose of writing a diploma thesis in the field of university nursing studies at the Catholic University of Croatia.

There are no correct or incorrect answers in the survey; we are interested in your personal opinion. Please choose the answers that best reflect your opinions and feelings, and answer all the questions in the survey. The survey refers exclusively to your views on the teaching of emergency medical procedures in the school year 2019/2020.

Completing the survey takes between 15 and 20 minutes and is completely anonymous. So we will not record who you are, and your answers will not be able to be related to a specific person. Please answer all the questions honestly and, if you wish, at any time you can opt out of further completion of the survey.

Thanks again for your valuable contribution to this research.

**1. Sex:**

- a) Man
- b) Woman

**2. Size of the city/village of residence:**

- a) Under 2,000 inhabitants
- b) 2,001 to 5,000 inhabitants
- c) 5,001 to 10,000 inhabitants
- d) 10,001 to 200,000 inhabitants
- e) More than 200,000 inhabitants

**3. Mother’s education:**

- a) Unknown
- b) Higher education
- c) Polytechnic
- d) Four-year high school
- e) Three-year high school
- f) Primary school

**4. Mother’s employment:**

- a) Employed
- b) Unemployed
- c) Student
- d) Retired
- e) Deceased

**5. Father’s education:**

- a) Unknown
- b) Higher education
- c) Polytechnic
- d) Four-year high school
- e) Three-year high school
- f) Primary school

**6. Father’s employment:**

- a) Employed
- b) Unemployed
- c) Student
- d) Retired
- e) Deceased

**Please express your attitudes on the following statements. You are expressing your attitude by circling ONLY ONE of the offered answers.**

- 1 - I do not agree at all
- 2 - I mostly disagree
- 3 - I neither agree nor disagree
- 4 - I mostly agree
- 5 - I completely agree

Fear of failure						
7.	I often make mistakes when solving tests because I am too disconcerted	1	2	3	4	5
8.	I often feel sick before an examination or test	1	2	3	4	5
9.	When I participate in work, I speak or answer questions, if the teacher evaluates me, I speak with a lot of fear	1	2	3	4	5
10.	The night before the test, in most cases, I can’t sleep well and can’t think of anything other than the test	1	2	3	4	5
11.	When I hear my name (during class), I am immediately overwhelmed by an anxious feeling	1	2	3	4	5
12.	When I see that there is little time left during the test, I easily lose my temper	1	2	3	4	5
13.	Sometimes during class, I don’t dare say anything	1	2	3	4	5
14.	When I notice that other students are already done with the test, I prefer to give up immediately or hand in the paper	1	2	3	4	5
15.	It is often difficult for me to finish all my homework on time	1	2	3	4	5

<b>Teacher's support</b>						
16.	The teacher encourages me and prods me in my work	1	2	3	4	5
17.	The teacher seems close and inclined to help and encourage me	1	2	3	4	5
18.	When I don't understand something, the teacher tries to explain it to us one more time	1	2	3	4	5
19.	When a student has a personal problem, the teacher will stand up for the student	1	2	3	4	5
20.	The teacher accepts our opinions even if they differ from his/hers	1	2	3	4	5
21.	If most students in the class disagree with something, the teacher is willing to talk about it	1	2	3	4	5
22.	When a student does something wrong, the teacher first tries to talk to the student instead of punishing the student immediately	1	2	3	4	5
23.	The teacher often asks us for our opinion when something important needs to be decided	1	2	3	4	5
24.	The teacher encourages us to speak and talk freely	1	2	3	4	5
25.	The teacher is always in a good mood during the class	1	2	3	4	5
26.	If we have good suggestions, we can influence the teaching and decide together about the teaching form	1	2	3	4	5
27.	The teacher cares about the success of only a small number of students	1	2	3	4	5
28.	In our school, everyone has to "break through" on their own; one cannot count much on the support of teachers	1	2	3	4	5
29.	The teacher shows an understanding that in the last school hours, we can no longer focus completely on work	1	2	3	4	5
30.	The teacher appreciates only advanced students	1	2	3	4	5

<b>Satisfaction with teaching</b>						
49.	If I could change something about the way teaching is conducted, then I would make big changes	1	2	3	4	5
50.	I would easily accept the permanent suspension of classes	1	2	3	4	5
51.	There are days when I would rather not go to school	1	2	3	4	5
52.	I find the teaching boring and not interesting	1	2	3	4	5
53.	The teacher thinks that his/her subject is the most important	1	2	3	4	5
54.	If I could have an opportunity to study elsewhere (e.g., at home), and just have my knowledge assessed at school, I would immediately choose that	1	2	3	4	5
55.	When it comes to testing, the teacher does not pay attention to whether we have another test that day	1	2	3	4	5
56.	I am satisfied with the teaching	1	2	3	4	5
57.	The content of the subject is interesting to me	1	2	3	4	5
58.	I learn a lot of useful things in class	1	2	3	4	5
59.	Homework is useful	1	2	3	4	5

60.	The school material needs to be explained to me by someone other than the teacher so that I can understand it	1	2	3	4	5
61.	Teacher lectures and work instructions are clear	1	2	3	4	5
62.	The way of interpreting the material is interesting and motivating	1	2	3	4	5
63.	I have too many classes	1	2	3	4	5
64.	In class, we learn things we will never need	1	2	3	4	5
65.	I am bored with the way the teacher teaches	1	2	3	4	5
66.	Classes are mostly dynamic and well-used	1	2	3	4	5
67.	If you are attentive during the class, it is not necessary to study too much at home	1	2	3	4	5
68.	Methods, examples, and tasks facilitate the achievement of learning outcomes	1	2	3	4	5

69.	What do you like about the work of a teacher?
70.	What could a teacher do to make teaching better?
71.	What didn't you like about the teacher's work on this subject?

Thank you for your time