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5cardsgame, innovative comprehensive integrative puzzle to enhance clinical reasoning in surgical technologist students: a pre-experimental study

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Abstract

Background Clinical reasoning is essential for healthcare professionals to ensure patient safety. Various teaching and assessment methods, such as comprehensive integrative puzzles (CIP), have been developed to enhance clinical reasoning in medical education. This study implemented a modified CIP titled 5CardsGame to enhance and assess clinical reasoning in surgical technologist students.

Method This pre-experimental study employed an interrupted time-series design. Thirty-six students were recruited using convenience sampling. The intervention, based on gamification principles and script theory, involved playing with color-coded cards related to five surgical procedures over six weeks, with three series of tests conducted biweekly. The mean correct card selection for each scenario and the time taken to complete them in the first test served as baseline criteria. Scores and times recorded in the subsequent two tests were used to compare learning progress and clinical reasoning skill improvement.

Results The mean score increased from 1.17 in the first test to 2.39 and 3.83 in the second and third tests, respectively. The mean completion time decreased from 14.67 min to 9.19 and 6.42 min. Paired comparisons revealed that the mean time reduction was significant across all three comparisons. Statistical analysis showed strong effect sizes for both score improvements and time reductions.

Conclusion The 5CardsGame significantly improved students' learning and clinical reasoning skills in surgical technology education. The game's ability to enhance both accuracy and speed of decision-making suggests its effectiveness in developing crucial competencies. Integration of this method into educational programs for surgical technologist students could potentially enhance their preparedness for professional practice.

Keywords Gamification, Comprehensive integrative puzzle, Clinical reasoning, Surgical technologist, Education

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Introduction

Surgical education continues to grapple with the challenge of effectively bridging the gap between theoretical knowledge and practical skills [1]. A significant disconnect persists between the concepts taught in classroom settings and the realities encountered in clinical environments, leaving students struggling to align theory with practice [2]. This misalignment often hinders the development of clinical reasoning, a critical competency in healthcare education that ensures patient safety and improves clinical decision-making [3–5]. Clinical reasoning encompasses the cognitive processes through which healthcare professionals gather, interpret, and evaluate patient data, enabling them to make informed decisions and choose appropriate interventions [6]. To address this issue, various teaching and assessment methods have been proposed in medical education, including Case-Based Discussion (CBD), Script Concordance Test (SCT), Key Feature (KF), Task-Based Learning (TBL), Concept Mapping, Problem-Based Learning (PBL), Clinical Reasoning Problem (CRP), and Comprehensive Integrative Puzzle (CIP) [7–13]. Among these, the Comprehensive Integrative Puzzle (CIP), introduced by Ber in 1997, stands out as a structured tool that promotes the integration of knowledge and the consolidation of "illness scripts"—mental frameworks that help learners organize and retrieve diagnostic information [9, 14, 15]. Illness script theory, which underpins CIP, explains how medical knowledge is structured, stored, and applied in clinical contexts, enabling learners to recognize patterns, interpret symptoms, and predict disease progression [11, 16–18].

Cognitive load theory further informs this approach by emphasizing the importance of optimizing how information is presented to enhance learning efficiency. By reducing cognitive overload through strategies such as gamification, educators can improve knowledge retention and engagement [19]. Gamification elements, such as points and badges, have been shown to transform traditional learning into interactive and enjoyable experiences, fostering deeper involvement and better problem-solving skills [20, 21]. Building on these principles, the 5CardsGame integrates CIP with Gamification elements to address the specific educational needs of surgical technologist students. They face various surgical procedures and must learn in a crowded and stressful educational climate in operating theatres [22]. So, this innovative tool aims to help students develop "surgical procedure scripts" by synthesizing preoperative care, anatomy, surgical techniques, intraoperative care, and potential complications into cohesive mental models that can be readily applied in clinical settings.

The present study seeks to address the existing gap in surgical education by implementing and evaluating the 5CardsGame as a modified CIP tool to enhance and assess clinical reasoning among surgical technologist students. By combining the strengths of CIP and gamification, this approach aims to foster the integration of theoretical knowledge with practical skills, ultimately improving clinical reasoning and patient care outcomes.

Methods

Study design

The study employed a pre-experimental design, as no control group was included. Students were recruited using convenience sampling and met the following inclusion criteria: informed consent and completion of courses on principles and techniques of circular and scrub nursing, surgical technology, and operating room tools and equipment.

Figure 1 provides a schematic overview of the study methodology, illustrating these key components and their interrelationships.

Game development

The "5CardsGame" is a modified Comprehensive Integrative Puzzle (CIP) designed to assess and improve clinical reasoning based on script theory and gamification principle. A panel of clinical instructors and faculty members selected five common surgical procedures (open and laparoscopic cholecystectomy, appendectomy, laparotomy, and inguinal hernia) for inclusion in the game. For each procedure, five sets of color-coded cards were created, representing key aspects:

- Green: Preoperative care.
- Pink: Anatomy and surgical technique.
- White: Intraoperative care and instruments.
- Purple: Postoperative care.
- Yellow: Surgical complications.

Game preparation

Before game starting, participants received a detailed briefing on the game's objectives, rules, and other gamification elements. The colors used for each section were explained. Attending the exam on time, complete all five scenarios and arrange the cards in a logical sequence to solve the problem with considering time management and having a chance to ask just one question to the instructor and receive guidance on the first round of the exam were considered as rules of this game. Also, Points are awarded based on accuracy and speed, with immediate feedback provided after each round as other gamification elements.

Game playing

The 5CardsGame is a gamified task where players are presented with five cards, each representing a component

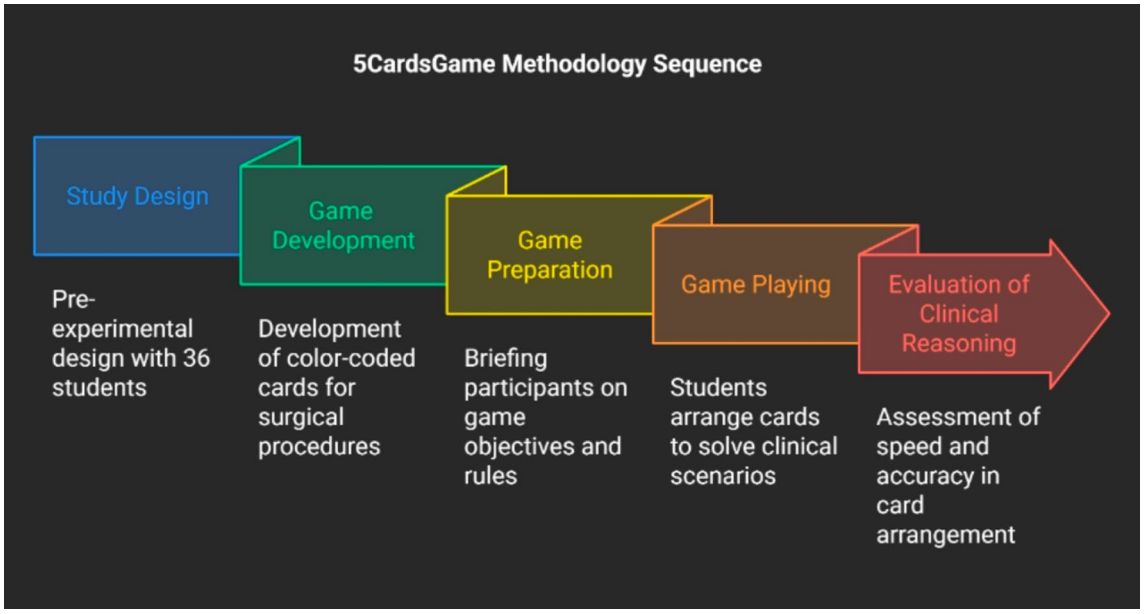

Fig. 1 Schematic overview of the 5CardsGame study methodology

Fig. 2 Selecting correct cards for each scenario

of a surgical procedure. In each round, six students participated simultaneously and they tried to put together like puzzle pieces, 5 cards related to components of each scenario that was stuck on table (Fig. 2).

Evaluation

Clinical reasoning was evaluated using a comprehensive checklist designed to assess both speed and accuracy in card selection and arrangement (supplementary 1). Accuracy was scored from 0 to 5 points for each scenario, with one point awarded for each correctly selected card based on expert-validated answers. Time measurements included total completion time for all five scenarios and individual scenario completion times This evaluation tool was validated by an expert panel and pilot-tested with graduates before study implementation. Assessment was conducted over a 6-week period in three time series. In first time, participants completed a baseline assessment. Students then continued their regular internship activities for three weeks before participating in a second assessment session. A final assessment session occurred following another three-weeks period of regular internship activities.

Data analysis

Baseline data included the mean number of correctly selected cards and completion time for each scenario in the initial assessment. Repeated measures analysis of variance was used to compare differences in mean times and scores across the three assessment sessions. Follow-up comparisons were performed using the Bonferroni test, and trends were analyzed using linear charts. The relationship between background variables and main variables was measured using the Pearson correlation test. Data were analyzed using SPSS version 28 software, with a significance level of $p \leq 0.05$.

Results

Participant characteristics

The study included 36 participants (77.8% female) with a mean age of 21.25 years (± 0.91). The mean score of the surgical technology course was 18.84 (± 1.70), and the GPA system ranged from 0 to 20, with a mean of 17.51 (± 1.22), indicating high academic.

Table 1 Student performance (clinical reasoning skill) and response time across three test sessions

Variable	Mean ± SD	Min	Max	Skewness	Kurtosis
Score	1.17 ± 1.10	0.5	5	1.24	1.31
	2.39 ± 1.56	0.5	5	0.81	-0.04
	3.83 ± 1.04	2	5	0.71	-0.72
Time	14.67 ± 3.60	9	23	0.59	-0.62
	9.19 ± 3.33	4	16	0.44	-0.78
	6.42 ± 2.58	3	14	1.04	1.59

Game performance and clinical reasoning

Students showed progressive improvement across the three test sessions. Mean scores increased from 1.17 (SD = 1.10) in the first test to 2.39 (SD = 1.56) in the second and 3.83 (SD = 1.04) in the third test. Concurrently, mean completion times decreased from 14.67 (SD = 3.60) to 9.19 (SD = 3.33) and 6.42 (SD = 2.58) minutes, respectively (Table 1).

Comparison between sessions revealed significant improvements in both scores and completion times ($p < 0.05$) (Table 2). The mean score increased by 1.22 points from first to second test (d = 0.89), and by 1.44 points from second to third test (d = 1.07). Mean completion time decreased by 5.48 min from first to second test (d = 1.57) and by 2.77 min from second to third test (d = 0.93). All effect sizes were calculated using Cohen's d formula: (M2 - M1)/SD pooled.

Correlation analysis

Pearson correlation analysis (Table 3) revealed significant relationships between scores across all three tests (r ranging from 0.375 to 0.655, $p < 0.05$). A significant negative correlation was found between first test scores and completion times (r = -0.547, $p < 0.01$), indicating that students who scored higher initially completed the tasks more quickly. Completion times in subsequent tests showed moderate positive correlations ($r = 0.218$ to 0.673).

Discussion

This study evaluated the effectiveness of the 5Cards-Game, an innovative comprehensive integrative puzzle, in enhancing clinical reasoning skills among surgical technologist students. The results demonstrated potential improvement in students' clinical reasoning skill over the course of the intervention, by increased accuracy in card selection and decreased response times.

The observed improvement in students' scores in the third test coupled with reduction in response time indicates a substantial enhancement in clinical reasoning skills based on structured color cards that promotes the integration of knowledge and the consolidation of a mental frameworks and help learners organize and retrieve prior information based on script theory. Our findings align with Montrezor's study (2016) and Hu H et al.(2021) that found active learning strategies, including puzzles and games, significantly improved students' medical knowledge retention, clinical reasoning skill and cognitive skills [23, 24]. By reducing cognitive overload through, similar successful applications include [25] "Happy Families" card game, which enhanced learning enjoyment and promoted student cognition in musculoskeletal physiotherapy by engaging learners in analyzing patient examinations. Also, results of this study are consistent with those of Torre et al., who investigated a five-part assessment tool for evaluating clinical reasoning in medical students. Their study found that using a puzzle-like tool played a facilitating role in students' learning [26]. Similarly, Vincent F's introduction of CIP for

Table 2 Comparison of students' learning scores and response time progress across three test sessions

Variable	Reference variable	Comparison variable	Mean difference	F(df)	*p*	Cohen's d
Score	First Score	Second Score	-1.22	F(1,35) = 34.71	< 0.001	0.89
Score	First Score	Third Score	-2.67	F(1,35) = 179.20	< 0.001	1.07
Score	Second Score	Third Score	-1.44	F(1,35) = 53.77	< 0.001	0.93
Time	First Time	Second Time	5.47	F(1,35) = 57.26	< 0.001	1.57
Time	First Time	Third Time	8.25	F(1,35) = 178.39	< 0.001	2.62
Time	Second Time	Third Time	2.78	F(1,35) = 44.96	< 0.001	0.9

Table 3 Correlation analysis of students' learning scores and response time progress across three test sessions

Variables	First Score	Second Score	Third Score	First Time	Second Time	Third Time
First Score	1					
Second Score	0.612***	1				
Third Score	0.375**	0.655***	1			
First Time	−0.547***	−0.022	−0.084	1		
Second Time	0.120	−0.166	−0.085	0.218	1	
Third Time	0.010	−0.236	−0.234	0.317*	0.673***	1

*** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$

second-year medical students found the tool to be reliable in developing students' clinical skills [15].

This study uniquely focuses on surgical technologist students, who often perform nursing duties in perioperative settings, highlighting the importance of clinical reasoning in this specialized field. The findings resonate with recent recommendations by Bae et al. (2023) and Huesmann et al. (2023), who emphasized the need to enhance clinical reasoning skills across various health disciplines, including nursing [27, 28]. Furthermore, the study aligns with Jesmi et al.'s research, which identified CIP as a valuable tool for assessing decision-making abilities and improving clinical reasoning in nursing students during internships. These parallels underscore the broader applicability of puzzle-based learning tools in healthcare education [29].

Practical application

The application of our findings extends beyond surgical technology education. The principles underlying the 5CardsGame could be adapted to various healthcare education contexts. For instance, in nursing education, a similar game could be developed to enhance clinical reasoning in patient assessment and care planning. In medical residency programs, the game could be adapted to focus on differential diagnosis and treatment planning. For continuing education of healthcare professionals, it could be used to reinforce and update knowledge of best practices and new procedures.

The 5CardsGame's format could also be adapted to create digital versions, allowing for remote learning and self-paced practice. The potential for integrating such game-based learning approaches into surgical technology curricula is significant, offering an engaging method for learning while providing a structured approach to developing critical thinking and decision-making skills specific to surgical procedures.

Limitations and future perspectives

While the 5CardsGame demonstrated potential in enhancing surgical skills, the study has several limitations. **Firstly**, the pre-experimental design and the lack of a control group limit our ability to definitively attribute the observed improvements solely to the 5CardGame intervention. Future research could benefit from a randomized controlled trial design to more rigorously assess the game's effectiveness compared to traditional teaching methods. **Secondly**, while we observed improvements in game performance, further research is needed to determine how these improvements translate to actual clinical reasoning skill in the operating room and real context. Long-term follow-up studies could provide valuable insights into the retention and practical application of the clinical reasoning skills developed through this game-based approach.

Thirdly, our study was conducted with a relatively small sample size from a single institution, which may limit the generalizability of our findings. Future studies with larger, more diverse samples across multiple institutions would provide more robust evidence of the game's effectiveness. **Lastly**, while the game was designed to cover a broad range of surgical procedures, it may not encompass all the complexities and variations encountered in real-world surgical settings. Continuous refinement and expansion of the game scenarios and card sets would be necessary to ensure comprehensive coverage of surgical technology education.

Conclusion

The 5CardGame demonstrates significant potential as an innovative tool for enhancing clinical reasoning skills in surgical technologist education. Our study reveals substantial improvements in students' decision-making accuracy and speed, effectively bridging theoretical knowledge and practical application. The game's structure, integrating various aspects of surgical procedures in an engaging format, develops comprehensive understanding of surgical processes and patient care. While acknowledging the study's limitations, these results provide a strong foundation for future research. Further studies, particularly randomized controlled trials, are needed to fully establish this method's long-term efficacy in improving clinical reasoning skill. Future studies should also include follow-up assessments to evaluate the long-term retention of clinical reasoning skills developed through the 5CardGame intervention.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07057-2.

Supplementary Material 1

Supplementary Material 2

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Author contributions

LS has made substantial contributions to the conception and design of the work and substantively revised it and she has approved the submitted version and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.FE has made substantial contributions to the conception and has drafted the work and has approved the submitted version and has agreed both to be personally accountable for the author's own

contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.RA has made substantial contributions to the conception and has drafted the work and has approved the submitted version and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.SK has made substantial contributions to the conception and has drafted the work and has approved the submitted version and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.NH* she is Corresponding authors and has made substantial contributions to the conception and design of the work; and the acquisition, analysis, and interpretation of data; and the creation of new software used in the work and has approved the submitted version and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
Consent to participate in this research was obtained from all participants. Also, this research has been reviewed by the Ethics Committee of Alborz University of Medical Sciences.

Competing interests
The authors declare no competing interests.

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