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Enhancing spatial intelligence and visual memory: Educational gamification to improve operating room scrub nurses' skills

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ABSTRACT

This article investigates the essential function of spatial intelligence and visual memory in improving the performance of scrub nurses in the operating room (OR). Cognitive abilities are crucial for the swift and precise handling of surgical tools, significantly influencing surgical efficiency and patient safety. Delays in handing over instruments, especially during critical times, can make surgery take longer, cause more problems, and even put the patient's life at risk. The current programs that train nurses mostly focus on technical skills, while cognitive skills such as spatial intelligence and visual memory are often overlooked. One approach could be to incorporate cognitive skill assessments during the hiring or admissions process to identify candidates with strong cognitive abilities, which could lead to improved performance in the operating room.

The article examines scientific data indicating that spatial intelligence and visual memory may be enhanced using modern educational methods, such as Virtual Reality (VR), Augmented Reality (AR), and microlearning. These technologies offer immersive, interactive environments that allow scrub nurses to practice visualizing and recalling surgical instrument arrangements under simulated high-pressure conditions. The research also suggests an interactive teaching game that simulates real-world surgical problems, allowing nurses to develop cognitive abilities including quick instrument recognition and exact tool delivery. By incorporating cognitive training into scrub nurse education, these methods have the potential to increase performance, minimize medical mistakes, and improve overall surgical results. The article highlights the importance of including cognitive skills in training programs, arguing that doing so could considerably contribute to safer and more efficient surgical operations, eventually leading to improved patient outcomes.

1. Introduction

The operating room (OR) is a dynamic, intricate, and very stressful setting that requires surgical team members to coordinate precisely and react quickly.[1,2] Scrub nurses are important members of this team because they are in charge of finding, getting, and quickly delivering surgical tools. This is an important part of keeping the flow of the procedure and making sure the patient's safety.[1,3] In our clinical experience, a lot of the mistakes scrub nurses make while delivering instruments are caused by deficiencies in spatial perception and visual memory rather than a lack of expertise.[3,4]

In instances of severe intraoperative bleeding, a delay in the delivery of a critical controlling instrument, such as a clamp, can exacerbate blood loss and obscure the surgical field, thereby complicating the surgeon's ability to manage the bleeding site effectively.[5] Even minor errors of this nature can extend surgical duration, elevate complications, and pose a risk to the patient's life.[3] These conditions place considerable demands on visual memory and spatial intelligence; deficiencies in these cognitive domains may result in delays during instrument handover and a heightened risk of errors.[4] These examples clearly show that spatial

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intelligence, which is the ability to understand how instruments are arranged in space, and visual memory, which is the ability to quickly remember the shape and position of instruments, are not only cognitive skills but also important clinical skills.[6] These essential cognitive skills now lack a designated role in scrub nurse education and training curricula, which primarily focus on technical competencies. Including cognitive skills in this framework could enhance the overall development of surgical competency in scrub nurses.[4]

2. Theoretical framework and scientific evidence

Visual-spatial intelligence, according to Howard Gardner's theory of multiple intelligences, denotes an individual's capacity to perceive, analyze, and manipulate visual and spatial information. This cognitive skill involves the mental processes of visualizing, creating, and comprehending spatial relationships among objects.[7] Individuals possessing strong visual-spatial intelligence exhibit enhanced capabilities in tasks necessitating mental manipulation of images, spatial reasoning, and the discernment of visual details. This form of intelligence encompasses several essential components: mental manipulation of images, which pertains to the capacity for mentally rotating, flipping, and transforming objects; spatial reasoning, involving the comprehension of spatial relationships and the positioning of objects; visual memory, defined as the ability to quickly recall visual details and patterns; and environmental awareness, which refers to the capability to perceive and orient oneself within one's surroundings. Each component is essential for cognitive and professional tasks requiring high spatial awareness and rapid decision-making under pressure.[8]

Spatial intelligence refers to an individual's capacity to perceive and handle three-dimensional situations and spatial interactions among items. .[9] This ability helps scrub nurses to keep a precise mental map of the operating room's surgical instrument setup, which consists of a large and intricate variety of surgical instruments.[10] Visual memory, or the capacity to swiftly remember and recover visual information such as the shape, size, and position of instruments, helps lessen cognitive load generated by physically looking for equipment.[11] Research in neuroscience demonstrates that particular regions of the brain associated with spatial information processing and visual memory exhibit activation, and the enhancement of these regions can improve corresponding cognitive performance. Additional studies demonstrate that spatial intelligence can be taught.[10,11] Studies have shown that higher levels of spatial intelligence and visual memory correlate with increased speed and accuracy. Nurses possessing these abilities demonstrate superior performance in instrument management and surgeon interactions, enabling them to operate more effectively in high-stress situations.[12]

3. Educational and technological approaches

Teaching cognitive abilities like visual memory and spatial intelligence calls for a method that goes beyond the conventional repetition-based and observation-based learning approaches.[12] In recent years, virtual reality (VR) and augmented reality (AR) technologies have surfaced as pioneering instructional instruments in the domain of surgical care.[13] A recent study by Yi-Hung Lai et al. in teaching hospitals in Taiwan found that virtual reality (VR)-assisted training significantly enhanced operating room nurses' familiarity with surgical equipment and procedures, resulting in a more effective learning experience.[14] Khorammakan et al.'s study in Iran found that using puzzle games in CABG surgery training significantly improved surgical technology students' knowledge and cognitive performance regarding the stages of CABG surgery, their sequence, as well as the tools and equipment used in each stage and the order of their preparation.[15] The findings demonstrate the efficacy of simulation-based technologies in enhancing spatial intelligence and visual memory in high-pressure surgical environments.[16]

In addition, microlearning—brief, focused educational sessions—has been useful in improving cognitive abilities among scrub nurses.[17] Studies indicate that microlearning enables repeated, targeted practice of specific cognitive tasks within short intervals, significantly improving skill retention and performance.[18] Interactive video exercises, ranging from three to five minutes, that simulate surgical instrument arrangement, retrieval positions, and rapid scene-change detection, can be effectively incorporated into microlearning modules and refresher courses.[19]

Visual memory is also systematically improved by include cognitive activities like quick visual-recognition tests and digital spatial puzzle games. These exercises facilitate the rapid identification, location, and delivery of instruments by nurses, thereby decreasing cognitive load and enhancing efficiency in high-stress surgical settings.[15] Ultimately, rapid feedback mechanisms and cognitive checklists may provide organized training frameworks. Real-time feedback allows scrub nurses to swiftly rectify errors and enhance their competencies. Practical evaluations of spatial intelligence and visual memory should be included into recruiting examinations and ongoing training programs, so establishing these cognitive abilities as critical markers of actual performance rather than just theoretical concepts.[4]

4. Proposal of an educational gamification for enhancing cognitive skills in scrub nurses

Educational games serve as an effective instrument in the training of surgical nurses, enhancing cognitive skills including visual memory and spatial visualization. The games simulate real-world conditions and offer an interactive environment, thereby assisting nurses in enhancing their skills in instrument identification and rapid decision-making under stress. Studies indicate that gamification enhances nurses' motivation and engagement, resulting in more effective learning and improved performance in practical settings.[14,15]

To improve cognitive abilities, including visual memory and spatial intelligence, in operating room nurses, we propose the development of an interactive educational game that replicates real-world operating room scenarios. The proposed game utilizes a 3D surgical tray to emulate the operating room setting. This tray holds numerous surgical instruments such as scalpels, forceps, scissors, and other tools that nurses must properly put in defined areas inside the tray. Below the tray, a tool panel enables nurses to pick different instruments for placement in the surgical tray. This is the first game of its sort that the authors created to help operating room nurses improve their cognitive abilities. It focuses on increasing visual memory and spatial intelligence. You may play the game on a variety of platforms, including mobile phones and desktops, thanks to the dynamic software platform it was built on. This design allows nurses to hone their skills anytime and anywhere without requiring actual presence in the operation room. The game has four stages, each increasingly enhancing the cognitive abilities of the nurses.

The main mechanics of the game are as follows:

Drag and Drop: Nurses must use the mouse or touchscreen to pick up tools from the tool panel and put them in the right places on the surgical tray. You can use drag and drop to put each tool in its right place.

Scoring: The nurse gets points every time they put an instrument in the right place. If an instrument is put in the wrong place, the score for that part goes down. This scoring system helps nurses figure out how fast and accurately they are working and get better over time.

Real-Time Feedback: The game gives nurses real-time feedback right after each action. If a tool is put in the right place, a confirmation message appears. If the tool is put in the wrong place, a warning message appears, and the nurse can try again to put the tool in the right place. This instant feedback helps nurses find and fix their mistakes quickly.

Timer: The game has a timer to see how quickly players can make decisions. The timer starts when the game starts, and nurses must try to put the instruments in the right places as quickly as they can. This function makes it easier to make quick decisions when the pressure is on.

Different Difficulty Levels: The game has four levels, and each one

gets harder as you go along:

Level 1: Nurses familiarize themselves with the instruments and match them based on shape and color.

Level 2: Nurses must remember the correct order of instruments based on a reference pattern and place them on the tray.

Level 3: Real surgical scenarios are introduced, and nurses must arrange the instruments from memory based on the type of surgery (such as appendectomy or cesarean).

Level 4: Nurses must distinguish between similar instruments with subtle differences, enhancing their visual differentiation skills (Fig. 1).

Spatial Accuracy: The game includes a spatial accuracy scoring system that evaluates nurses' precision in placing instruments in exact locations. This feature helps nurses improve their accuracy, which is crucial in the real operating room environment.

By simulating real surgical conditions, this game helps nurses practice their skills without the stress of the operating room, boosting their motivation to learn. The flexible training allows nurses to use it at any time and from any location. Instant feedback quickly corrects mistakes. Although the game offers a good simulation of the operating room environment, it cannot fully replicate the challenges of a real operating room, such as massive intraoperative bleeding or situations where multiple surgeons simultaneously request instruments. These scenarios, however, represent the true complexity and stress of the operating room environment. It also focuses primarily on cognitive skills and may not fully train operational skills. Ultimately, this educational game can be an effective tool for enhancing the cognitive skills of surgical nurses, helping them make faster and more accurate decisions in real operating room situations. By providing an engaging and effective learning method, it can help reduce cognitive load, improve accuracy, and enhance efficiency, ultimately leading to improved patient safety and better surgical outcomes.

5. Limitations and future directions

Some of OR educational programs' limitations are because they concentrate more on hands-on practice. Cognitive skills like spatial intelligence and visual memory are very important in OR, yet they are generally ignored. These may be cultivated and enhanced via many activities; the use of gamification serves as an excellent strategy for scrub nurses to get exposure to a broad spectrum of cognitive skills in conjunction with technical competence prior to real-world performance.

Future initiatives should concentrate on using modern technologies like Virtual Reality (VR) and Augmented Reality (AR) to enhance cognitive abilities. These technologies can provide realistic, simulated surgical settings, allowing scrub nurses to train in high-pressure situations. Moreover, techniques such as microlearning and educational games may further facilitate the improvement of spatial intelligence and visual memory via brief, concentrated training sessions.

Ultimately, surgical mistakes may be greatly decreased and patient safety can be enhanced by identifying and addressing the cognitive aspects of scrub nurse training.

In addition, one limitation of the current study is that the proposed educational game was primarily focused on developing visual memory and spatial intelligence under controlled conditions. It did not yet include complex real-world OR scenarios such as massive intraoperative bleeding, septic complications, or situations where multiple surgeons simultaneously request instruments. These scenarios, however, represent the true complexity and stress of the operating room environment. Incorporating such dynamic challenges into future versions of the game would allow scrub nurses to practice not only rapid recognition and delivery of instruments, but also prioritization, multitasking, and decision-making under pressure. Future research and development should therefore aim to integrate these realistic scenarios to enhance the ecological validity and practical value of the training program.

6. Conclusion and clinical implications

Delays in timely tool delivery are a serious difficulty during surgery, especially in critical conditions. The patient may suffer grave repercussions as a result of this delay. In this situation, reducing instrument search time and increasing delivery speed may be achieved by improving scrub nurses' mental visualization of instruments and their arrangement. As a result, surgical procedures go more smoothly, the surgical team has less stress, and patient safety is greatly improved. Because of the special circumstances of the operating room, which need prompt and accurate decision-making under extreme pressure, enhancing cognitive abilities may significantly raise the standard of surgical treatment and patient safety.

Integrating interactive teaching games that mimic actual surgical obstacles and provide nurses experience mentally memorizing and picturing the surgical tray and tool arrangement is a useful strategy for achieving this aim. By simulating high-pressure scenarios, these games may assist nurses in properly and swiftly identifying and delivering tools to the surgeon. By using these techniques, nurses may increase their spatial intelligence and visual memory, which will help them navigate the surgical environment more skillfully. This article emphasizes the importance of incorporating cognitive skill development into scrub nurse education, as this approach not only improves nurse performance

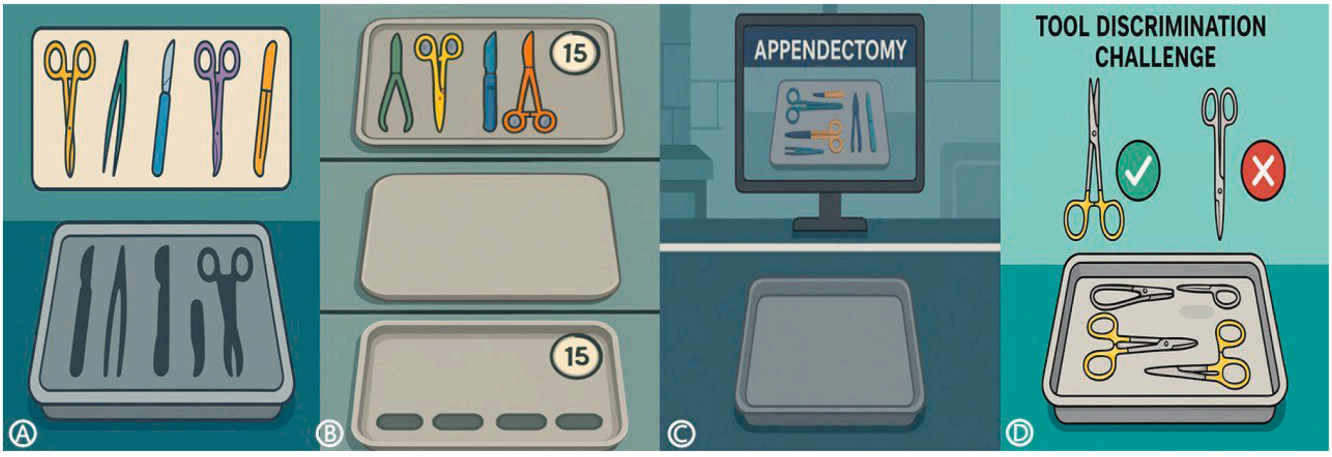

Fig. 1. Four progressive levels of the proposed educational game for surgical nurses: (A) matching instruments by shape and color; (B) recalling and placing instruments according to a reference pattern; (C) arranging instruments from memory based on surgical scenarios; (D) distinguishing between visually similar instruments to enhance fine visual differentiation skills.

but also contributes to safer, more efficient surgeries, leading to better patient outcomes.

Consent for publication

This study does not include any personal data of individuals.

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Zohreh Khoshgoftar: Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Sara Bagheri:** Writing – review & editing, Writing – original draft, Methodology. **Atiyeh Sadat Sajadi:** Writing – review & editing, Writing – original draft, Methodology. **Nasrin Aghazadeh:** Conceptualization, Investigation, Writing – review & editing, Methodology. **Vahid Rahmani:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization.

Declaration of competing interest

The authors assert that they own no identifiable conflicting financial interests or personal affiliations that may have seemingly influenced the work presented in this study.

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