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Original Article

Evaluating the Impact of QR Code-Based Assessment on Learning Outcomes of Training in Surgical Instruments Including Sutures and Needles

Marzieh Nasiri Sangri[1], **Reza Salehinia**[1*]

[1]Surgical Technology, Tabas Nursing School, Birjand University of Medical Sciences, Birjand, Iran

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***Corresponding author:**
Reza Salehinia,
Email: rezaotg@gmail.com

Abstract

Background: With the advancement of modern technologies, traditional teaching methods have gradually given way to digital and interactive tools. Quick response (QR) code technology, as one such tool, has gained attention in education due to its ease of use and rapid access to information. This study aimed to investigate the impact of using QR code technology in teaching operating room skills on students' learning components.

Methods: This interventional study was conducted in 2023 at Tabas School of Nursing on 42 operating room students. The samples were selected using the census method. During a workshop, concepts related to surgical threads and needles were taught, followed by an online test conducted using QR codes. Data were collected using a learning management system (LMS) satisfaction questionnaire and analyzed using statistical methods such as the independent *t*-test and Pearson correlation coefficient in SPSS. The reliability and validity of the questionnaire were confirmed with Cronbach's alpha values ranging from 0.712 to 0.849.

Results: The results showed that students had a positive attitude toward the ease of use (23.53 ± 1.13), usefulness (35.78 ± 2.51), motivation (19.34 ± 1), and knowledge transfer (17.05 ± 2) through QR codes. Seventh-semester students achieved the highest scores across all domains. Analysis revealed a significant relationship between academic term and perceived ease of use, but gender had no effect on learning domains.

Conclusion: QR code technology effectively improved the learning process by simplifying access to information and enhancing learning motivation. This technology also contributed to reducing resource consumption and increasing teaching efficiency. However, challenges such as the need for familiarity with digital tools and limited access to smart devices should be considered.

Keywords: Learning, Operating room, QR code, Technology

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Introduction

Education is a deliberate and systematic process through which instructors design and implement conditions to facilitate learning and achieve educational objectives. The effectiveness of education largely depends on the teaching methods and techniques employed, as well as on the assessment strategies that measure and enhance learning outcomes (1,2). Traditional teaching methods, such as lecture-based instruction using slides, remain common; however, with rapid technological advancements, there is an increasing need to innovate both teaching and assessment approaches in medical education (3). Among the emerging technologies, quick response (QR) code technology has gained attention for its potential to improve educational processes. QR codes are two-dimensional barcodes capable of storing substantial amounts of information, which can be easily accessed via smartphones and other devices. This technology bridges the physical and digital worlds, enabling quick and convenient access to educational content, multimedia resources, and interactive assessments (6-4). In medical and nursing education, QR codes have been utilized to enhance learning by providing easy access to course materials, instructional videos, quizzes, and real-time feedback, thereby promoting active learning and student engagement (7). Studies have highlighted the advantages of QR code technology in facilitating self-directed learning and improving knowledge retention, while also noting

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challenges such as technological barriers and the need for instructor training (8). Specifically, in the context of operating room education, teaching practical skills and equipment knowledge is critical. The use of QR codes can support students by providing immediate access to detailed information on surgical instruments, sutures, and procedural steps, which may enhance understanding and motivation (9,10). However, research on the application of QR codes specifically to operating room technology students remains limited, indicating a need for further investigation to establish effective teaching models in this specialized field. This study aims to evaluate the impact of QR code technology on the learning outcomes of students in the operating room technology program, focusing on their understanding of suturing materials and techniques. By integrating QR codes into the educational and assessment process, this research seeks to contribute evidence-based insights into innovative teaching methods that can improve educational effectiveness in surgical technology training.

Materials and Methods

This study was quasi-experimental research with a pre-test and post-test design without a control group. The samples were selected using the census method, in which 42 students enrolled in the Operating Room Technology program at the School of Nursing in Tabas participated. The students of the Surgical Technology program studying at the School of Nursing in Tabas who were willing to participate in the study were included in the study. Exclusion criteria included students' unwillingness to attend the training session or complete the questionnaires, absence from the training session, or failure to fully complete the questionnaires within the specified time. The study procedure was as follows. First, a detailed explanation about QR code scanning methods and their applications was provided. Then, in a training session (workshop), the topic of surgical sutures and surgical needles, including their tissue support duration and complete absorption time (which was new to all students), was presented through a lecture. This content included an introduction, body, and conclusion and was delivered using educational aids such as slides, charts, images, and videos. Additionally, physical samples of surgical sutures and needles were provided so that students could observe and examine these tools practically. At the end of the session, five questions were designed, each with a 30-second response time (with the condition that after 30 seconds, the system automatically moved to the next question without the option to return to the previous one). These questions were created using QR code technology linked to the content. Students in the class scanned the designated QR codes using their smartphones and answered the questions. The QR codes played a key role in facilitating quick and easy access to the educational questions. Students who answered correctly received positive scores. Demographic characteristics of the students, including age, gender, and overall Grade Point Average (GPA), were recorded. This information was used in statistical analysis to assess the impact of demographic factors on the study outcomes. Finally, the standard questionnaire for evaluating the impact of learning management system (LMS) on knowledge management (KM) (11) was employed to assess student satisfaction. In this study, the LMS platform was used as a medium for delivering educational content, collecting student responses, and distributing online questionnaires. This system played a crucial role in providing structured information and facilitating the educational process. Students accessed the LMS to review the content taught, answer questions, and access supplementary educational resources. The LMS impact assessment questionnaire was distributed online via the website https://porsline.ir/. It included 31 questions in four sections: "Perceived Ease of Use", "Perceived Usefulness", "Motivation and Intention to Use", and "Knowledge Transfer." This questionnaire was rated on a Likert scale (0 to 4), where a score of zero indicated the lowest and a score of 4 indicated the highest level. Each domain was divided into four ranges based on the maximum possible score. For example, in the "Perceived Ease of Use" section, a maximum score of 36 was divided into the following ranges: a score of 0 to 9 indicated "very weak", 9 to 18 indicated "negative attitude", 18 to 27 indicated a "more positive attitude", and 27 to 36 indicated a "good perception of ease of use"(12). In the "Perceived Usefulness" section, a score of 0 to 11 indicates "very weak", 11 to 22 indicates "negative", 22 to 33 indicates "positive", and 33 to 44 indicates a "good perception". In the "Motivation and Intention to Use" section, a score of 0 to 6 indicates "very weak", 6 to 12 indicates "negative", 12 to 18 indicates "positive", and 18 to 24 indicates a "good perception". In the "Knowledge Transfer" section, a score of 0 to 5 indicates "very weak", 5 to 10 indicates "negative", 10 to 15 indicates "positive", and 15 to 20 indicates a "good perception. "The total score across the four domains is 124, where a score of 0 to 31 indicates a "very weak attitude toward learning", 31 to 62 indicates a "negative attitude toward learning", 62 to 93 indicates a "more positive attitude", and 93 to 124 indicates a "good perception of learning" (13). The validity of this questionnaire was confirmed using the content validity method. The questionnaire was reviewed by several experts in the field of organization and management, and after receiving their feedback and making the necessary revisions, the final questionnaire was approved by Louei (11).

Additionally, the reliability of the questionnaire was evaluated using Cronbach's alpha for five different variables. Cronbach's alpha is a measure used to assess the internal consistency and reliability of measurement tools. Values above 0.7 indicate good reliability. The Cronbach's alpha values for each variable are as follows:

- LMS: A value of 0.805 indicates excellent reliability for this measurement tool, meaning that the LMS

evaluation tool can reliably assess this variable.

- Perceived ease of use: A value of 0.712 indicates acceptable reliability, suggesting that the tool reasonably and reliably measures perceived ease of use for the LMS.
- Perceived usefulness: A value of 0.750 also indicates good reliability, confirming that the tool used to evaluate the perceived usefulness of the digital learning system is sufficiently valid.
- Motivation and intention to use: A value of 0.741 indicates acceptable reliability for measuring motivation and intention to use the system.
- Knowledge transfer: With a value of 0.849, this variable has the highest Cronbach's alpha, indicating the highest level of reliability among the five variables. This score suggests that the measurement tool for evaluating knowledge transfer has a high degree of precision and consistency (14).

Finally, the collected questionnaires were analyzed using SPSS version 27 with various statistical methods. These methods included the independent-samples *t* test and Pearson correlation coefficient. To select these statistical methods, the normality of data distribution was first examined using the Kolmogorov-Smirnov test, which confirmed that the data followed a normal distribution.

Results

In this study, among the 42 students surveyed, 76% (32 participants) were female, and the mean age of the participants was 22.23 ± 2 years. The questionnaire findings indicated that in the domain of Perceived Ease of Use of the QR code method, students scored 23.53 ± 1.13, reflecting a positive attitude toward the ease of use of this method. In the domain of Perceived Usefulness of the QR code method, a score of 35.78 ± 2.51 indicated a very good perception of the usefulness of the method. Similarly, in the domain of Motivation and Intention to Use the QR code method, a score of 19.34 ± 1 revealed that students had high motivation to use this method. In the domain of Knowledge Transfer through the QR code method, a score of 17.05 ± 2 indicated a good perception in this area. Overall, the total score of the questionnaire, with a value of 94.5 ± 2.25, demonstrated that students had a positive overall attitude and perception of learning through this method. When comparing academic semesters, seventh-semester students achieved the highest scores across all learning domains. Analysis of variable correlations showed a significant relationship with the academic semester ($P < 0.05$) in the domain of Perceived Ease of Use, based on the non-parametric Pearson test. However, no significant relationship was observed in the other domains. Additionally, using the independent samples *t* test, it was found that gender had no significant effect on the learning domains in the questionnaire ($P > 0.05$; Table 1).

Discussion

The use of QR code technology as an innovative method for student assessment in the Operating Room program showed positive effects on evaluating students' understanding of concepts, perceived usefulness, and learning motivation in this study. The results indicate the high effectiveness of this technology in facilitating the assessment process and increasing student engagement with educational content, which aligns with similar research emphasizing the importance of interactive technologies in educational evaluation. This study demonstrated that using QR codes facilitated students' access to assessment questions and created a positive user experience. The high average scores reflect the simple and practical design of this method. These findings are consistent with the results of the study by Tovar et al, which highlighted the role of user-friendly interfaces in technology adoption (15). Another notable result of this study was the students' positive attitude towards the usefulness of QR codes. This technology has improved teaching efficiency by simplifying access to information resources. This finding aligns with studies such as the research by Tukhtabayeva et al, which showed that technologies providing fast and accurate information can enhance the learning experience (16). Additionally, the ability to integrate QR codes with multimedia content, such as videos and images, makes it an effective tool for teaching subjects that require practical and hands-on training. This study revealed that students had high motivation to use QR codes in their learning process. This indicates the attractiveness of this technology and its ability to create enthusiasm for learning. Studies like the research conducted by Li et al confirm that interactive technologies can strengthen students' motivation by creating a dynamic and engaging environment (17). A study by Masih evaluated the use of QR codes specifically for registration and teaching evaluation processes and found that this method significantly improved learner

Table 1. Analysis of the Relationship Between Academic Term and Gender Across Different Domains

	1st semester	3rd semester	5th semester	7th semester	Total	*P* value (gender: male/female)	*P* value (academic term)
Perceived ease of use	22.07 ± 1.38	23.55 ± 0.52	23 ± 1	2 ± 25.5	23.53 ± 1.13	Ns	0.05 >
Perceived usefulness	35.30 ± 2.59	35.77 ± 2.63	35.85 ± 2.67	2.23 ± 36.23	35.78 ± 2.51	Ns	0.05 <
Motivation and intention to use	18.92 ± 1.03	19.11 ± 1.05	19.14 ± 1.06	1.07 ± 20.2	19.34 ± 1	Ns	0.05 <
Knowledge transfer	17.15 ± 2.07	16.77 ± 2.10	16.71 ± 2.13	2.23 ± 17.6	17.05 ± 2	Ns	0.05 <

N.S: Not significant.

participation and response rates compared to traditional paper-based systems. This supports our findings by showing that QR code technology not only simplifies the evaluation process but also encourages greater student involvement. In our study, the high student engagement and motivation observed during the assessment phase may be attributed to the same mechanisms identified by Masih, namely the convenience, speed, and digital familiarity provided by QR codes. This reinforces the growing evidence that incorporating QR technology into evaluation phases, rather than just teaching content delivery, offers tangible benefits in terms of both usability and learning outcomes (18).

These findings emphasize the importance of digital tools in attracting students' attention and increasing their engagement with educational content. The high scores of students in the knowledge transfer domain indicated that QR codes helped simplify the understanding of complex concepts. This result is consistent with the study by Krishnamurthy et al, which introduced digital technologies as an effective tool for improving knowledge transfer in medical education (19). This finding suggests that integrating QR codes with collaborative teaching methods can lead to more meaningful and deeper learning. The findings of this study showed that senior students (especially in the seventh semester) performed better in all learning domains. This is likely due to their greater experience in educational environments and familiarity with modern teaching methods. This finding may indicate the importance of educational experience in the acceptance and use of technologies. However, comparing results between students from different semesters should be done with greater caution to avoid potential misinterpretations of data. It should be noted that changes in learning performance may be influenced by various factors, including teaching methods and students' familiarity with technologies, which should be explored in future research. This research highlights the benefits of using QR codes in reducing time and costs. By eliminating the need for paper resources and reducing traditional educational complexities, this technology can improve the efficiency of the educational process. This finding is consistent with the study conducted by Monaem et al, which demonstrated that digital technologies can reduce resource wastage and increase productivity (20). The analysis of the relationship between gender and learning domains showed no significant difference between male and female students. This result is consistent with the study by Salehinia et al, which stated that gender does not have a significant impact on the acceptance of educational technologies (2). This finding emphasizes that for successful technology adoption, factors such as educational experience and familiarity with new technologies may play a more determining role. This study emphasizes the positive impact of QR code technology on students' learning, but there are also some limitations in this research. They include potential limitations in sample size and the influence of environmental variables on study outcomes. Further research is recommended to examine the role of other variables, such as students' digital skills, technological infrastructure in educational institutions, and the impact of technology in both practical and theoretical lessons. Additionally, exploring the integration of QR codes with other emerging technologies such as virtual reality and augmented reality may reveal new dimensions of interactive and practical learning (21). However, there are also some challenges, including the need for students to have sufficient familiarity with digital tools and limited access to smartphones or the internet. These factors indicate that appropriate infrastructure must be provided for the successful implementation of such technologies.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the sample size was limited to 42 students from a single institution, which may affect the generalizability of the findings to other settings or larger populations. Second, the quasi-experimental design without a control group limits the ability to establish causal relationships between the use of QR code technology and learning outcomes. Third, the study focused on a specific educational topic (surgical sutures and needles), which may not represent the effects of this technology in other areas of operating room education. Finally, the reliance on self-reported questionnaires to assess perceptions and motivation may introduce response bias. Future research with larger multi-center samples and randomized controlled designs is recommended to validate and extend these findings.

Conclusion

In conclusion, the use of QR codes in presenting questions through the Porsline platform had a positive impact on students' understanding of concepts, perceived usefulness, and motivation for receiving information about surgical equipment used in the operating room. This technology has improved the learning process by providing a simple and interactive method. However, for optimal utilization, attention to infrastructural challenges and user training is essential. The findings of this study align with previous research and emphasize the necessity of utilizing digital tools in educational processes. To better understand the effectiveness of this method, it is suggested that future studies be conducted with broader empirical evidence and a more detailed examination of the limitations of this technology.

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Authors' Contribution

Conceptualization: Reza Salehinia, Marzieh Nasiri Sangari.
Data curation: Reza Salehinia.
Formal analysis: Reza Salehinia.
Investigation: Reza Salehinia, Marzieh Nasiri Sangari.
Methodology: Reza Salehinia, Marzieh Nasiri Sangari.
Project administration: Reza Salehinia.
Resources: Reza Salehinia, Marzieh Nasiri Sangari.
Supervision: Reza Salehinia.
Validation: Marzieh Nasiri Sangari, Reza Salehinia.
Visualization: Marzieh Nasiri Sangari.
Writing – original draft: Marzieh Nasiri Sangari.
Writing – review & editing: Reza Salehinia, Marzieh Nasiri Sangari.

Competing Interests

The authors declare no conflict of interests.

Consent for Publication

Not Applicable.

Data Availability Statement

The data supporting the findings of this study are available upon reasonable request from the corresponding author. The materials used in the study, including the educational content and assessment tools, can also be provided upon request.

Ethical Approval

All the ethical standards related to the research, including maintaining the confidentiality of the information of the participants, were observed. This study was approved by the Ethics Committee of Birjand University of Medical Sciences (IR.BUMS.REC.1403.296), and the necessary permits were obtained from the competent authorities. There was no bias or interference by the researchers in the research stages. Informed consent to participate was obtained from all participants in this study. This study was conducted in accordance with the principles of the Declaration of Helsinki.

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