Original Article

Journal of Advances in Medical Education & Professionalism

Developing a Mobile Application-based System for Enhancing Medical Skill Training

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Introduction: In a regional hospital in Southern Taiwan, an average of 25 heart surgeries are performed annually, with surgical education conducted one-on-one. This indicates that opportunities for paramedics to participate in surgical procedures are quite limited. Although 80 paramedics in the hospital can perform surgical procedures, 69 have more than two years of experience, and only 19 are selected by surgeons to perform surgical procedures. Consequently, paramedics without hands-on experience are likely to feel panicked and helpless.

Methods: The present study employed a systematic software development approach to create a mobile application-based medical skill training system. Initially, we conducted a comprehensive needs analysis through in-depth interviews with cardiac surgery nurses and administrators to accurately identify the key training requirements. In the system architecture design phase, we chose Windows Server as the operating system, combined PHP and Apache to handle web service requests, used MariaDB for data storage and management, and applied FastAPI to facilitate data exchange with other services. Client-side development utilized the Flutter framework, ensuring a consistent user experience across iOS and Android platforms.

Results: We also designed complex data structures to accommodate testing and recording needs, including exam data, question types, and option records. For user flow implementation, we developed a complete process including user registration, subject management, test preparation, and evaluation. Finally, we implemented core functionalities such as the login interface, question selection, and test interface to ensure the system's comprehensiveness and practicality. This multi-stage development approach aimed to create an efficient, user-friendly, and adaptive training platform to meet the specific needs of cardiac surgery nursing staff.

Conclusion: The development and implementation of the mobile application-based system for enhancing medical skill training has demonstrated significant potential in addressing the challenges of paramedics in cardiac surgery settings. While the initial results are promising, further long-term studies are needed to assess the impact on actual surgical outcomes and patient care quality.

Keywords: Mobile application; Surgery; Learning; Medical education

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Please cite this paper as:
Weng TS, Chen XR. Developing a Mobile Application-based System for Enhancing Medical Skill Training. J Adv Med Educ Prof. 2025;13(1):25-35. DOI: 10.30476/jamp.2024.103650.2019.

Received: 7 August 2024
Accepted: 9 October 2024

Introduction

In a regional hospital in Southern Taiwan, an average of 25 heart surgeries are performed annually, with surgical education conducted one-on-one. This indicates that opportunities for paramedics to participate in surgical procedures are quite limited. Although 80 paramedics in the hospital can perform surgical procedures, 69 have more than two years of experience, and only 19 are selected by surgeons to perform surgical procedures. Consequently, paramedics without hands-on experience are likely to feel panicked and helpless.

The complexity of heart surgery and the requirements of heart surgery for critical thinking ability and clinical judgment abilities among paramedics present significant challenges to traditional clinical training and teaching.

Due to temporal and spatial limitations, traditional operation room clinical training may not provide sufficient practice opportunities, creating difficulties for paramedics in learning and memorizing all surgical procedures. Additionally, limitations in human resources, along with relevant clinical requirements and constraints, impose challenges on paramedics (1, 2).

Background of Research and Program Examples in Medical Education

In recent years, medical education has witnessed a significant shift towards technology-enhanced learning, with numerous studies and programs paving the way for innovative training approaches.

By utilizing smartphone applications, medical students can engage in self-directed learning, allowing them to take charge of their education and stay updated with advancements in the medical field (3). The findings suggest that mobile applications can serve as effective adjunct tools in medical education, offering low-cost, versatile, and flexible learning options that can be utilized in both online and offline settings (4). Matthew et al. (2022) assessed the effectiveness of a smartphone app, QuizTime, in changing clinician prescribing patterns for intravenous fluids and pain medications. This is significant as it explores a modern approach to medical education that leverages technology to enhance learning and practice (5). Ritesh et al. (2019) confirms that smartphones are widely adopted by residents, healthcare professionals, and teaching staff, enhancing learning and ongoing patient care (6). Edmund et al. (2023) conducted a survey on the use and demand for medical applications, and provided practical advice for those preparing to develop medical applications, particularly in radiology education. Their recommendations include methods for evaluating and refining these applications to achieve optimal effectiveness in use (7).

These diverse studies collectively underscore the growing importance and effectiveness of technology-enhanced learning methods across various domains of medical education.

Research Objectives

Mobile device-based education has shown significant potential in medical training. Smart mobile devices can be integrated into mixed and remote teaching, allowing students to learn autonomously anytime and anywhere. Most medical students find smartphones and mobile applications highly useful in clinical education as they provide easy access to educational resources, improving knowledge and confidence while reducing learning anxiety.

Mobile applications enhance learning engagement, boost motivation for autonomous learning, and help improve critical thinking abilities through innovative approaches designs. However, it's important to consider usability and user feedback in the design of these applications to enhance their effectiveness and user acceptance.

Application-based systems, in the context of this study, refer to software applications designed for mobile devices that provide interactive, accessible, and personalized learning experiences. These systems leverage the ubiquity of smartphones and tablets to deliver educational content and training exercises to users anytime and anywhere.

The aim of this study was to develop an application-based medical skill training system that leverages the convenience of mobile devices and medical resources to assist medics and paramedics in skill practice and training. By creating an innovative and engaging learning platform, this system aims to enhance the knowledge of medical professionals and reduce error rates in the operating room. Through repeated exercises and specialized training accessible anytime and anywhere, the system seeks to improve learning efficiency, comprehension ability, and confidence among paramedics.

The aim of this study was to develop and implement an application-based medical skill training system for paramedicine students. This paper focuses on the design and implementation phases, laying the groundwork for future evaluation of its educational effectiveness.

Innovation of the Current Study

Our study builds upon the foundation

of technology-enhanced medical education by introducing several innovative aspects that address crucial gaps in the field. Unlike previous research which focused primarily on medical students or surgeons, we specifically target cardiac surgery paramedics, employing a mobile-first approach that leverages devices already in daily use, thus ensuring accessibility and frequent engagement.

The system offers comprehensive skill development, incorporating practical skills such as surgical instrument management alongside critical thinking and decision-making in high-pressure scenarios. By utilizing adaptive learning algorithms, the application personalizes the learning experience based on individual performance and learning patterns.

The integration of real-world scenarios from the regional hospital provides contextually relevant training, while collaborative learning features mirror the teamwork essential in operating rooms. The continuous assessment and feedback mechanism of the system allows for immediate error correction and reinforcement of correct practices.

Furthermore, it generates data-driven insights for educators and administrators, enabling curriculum improvements and trend identification. Tailored to the specific practices and needs of a regional hospital in Southern Taiwan, the content addresses unique cultural and systemic factors often overlooked in generic training programs.

Despite its specific design, the architecture of the system allows for scalability and adaptability to various healthcare settings and specialties, potentially broadening its impact on medical education. This comprehensive approach not only fills a critical gap in current medical education practices but also sets a new standard for technology-enhanced learning in specialized healthcare fields.

Mobile device-based education

Smart mobile devices can be integrated into mixed and remote teaching, enabling students to learn anytime and anywhere according to their learning styles and progress in a personalized and autonomous manner (8).

Most medical students find smartphones and mobile applications highly useful in clinical education, as they allow for easy and quick access to educational resources, improving their knowledge and confidence and reducing their learning anxiety (9). Educators should recommend appropriate educational applications to students and provide the necessary technical support and Wi-Fi access to ensure the effective use of mobile technology in learning (10). While education-oriented mobile applications enhance learning engagement, they also boost students' motivation for autonomous learning, making the process more interesting and efficient.

Additionally, these applications help students improve their critical thinking abilities and skills by introducing innovative learning approaches and designs (11).

Key points of the design of mobile learning and education

Mobile learning can significantly enhance students' learning engagement and collaborative learning, while students' proactive attitudes towards mobile learning also contribute to improved learning engagement (12).

Usability is a critical factor in the design of learning-oriented mobile applications, enhancing their operability and user acceptance. Therefore, it is imperative to consider usability from the design phase onward to enhance the performance of these applications (13).

Moreover, user feedback is crucial for the design and improvement of mobile applications for health and education. Factors such as visual attractiveness and ease of use are essential in enhancing user engagement (14).

The acquisition of basic skills is also an essential aspect of the design of educational applications. This study compared five learning-oriented applications, identifying six educational features—autonomous learning, mobile skills, task structures, engagement, language requirements, and personalization—as the most effective ones in supporting basic skill acquisition (15).

If mobile devices offer personalized, scenario-based, and associative learning experiences, students can learn effectively at the right moments and in the right places (16). Applications can substantiate learning processes and support meaningful, student-oriented learning, particularly in terms of creativity, collaboration, and critical thinking.

Despite significant progress in mobile device technologies, educational institutions still face challenges in deploying these technologies for teaching.

It is necessary to reduce repeated errors in educational applications to optimize learning achievements, as repeated errors are significantly negatively correlated with learning achievements.

The more repeated errors students make, the lower their learning benefits, negatively impacting learning processes. Application developers can implement automatic detection and feedback

mechanisms to help students correct repeated errors, thereby supporting and enhancing their learning (17).

To build an application-based medical skill training platform, it is necessary to establish a basic framework that allows learners to autonomously study relevant materials anytime and anywhere, thereby offsetting temporal and location limitations.

Methods

This study adopted a mixed-methods approach, combining qualitative and quantitative research methods to develop, implement, and evaluate a mobile-based educational application aiming at enhancing medical skill training for healthcare professionals.

Study Population and Sampling

The study population consisted of nurses specializing in cardiac surgery and senior nursing administrators from hospitals in southern Taiwan. Through purposive sampling, nursing staff from the nursing department were recruited, ensuring a diversity of experience levels and backgrounds.

Surveys and interviews were validated through review by experienced nursing administrators and nursing experts, which was considered acceptable for system validation. Ongoing training and support were provided to participants throughout the study period.

System Design

The system design phase began with a comprehensive needs assessment, involving in-depth interviews with cardiac surgery nurses and administrators. These interviews were crucial in identifying the key training needs and challenges specific to the cardiac surgery environment. Based on the insights collected, the team developed an educational content that focused on three primary areas: cardiac surgery procedures, equipment operation, and risk management.

This content was tailored to address the identified gaps in knowledge and skills among the nursing staff. To ensure accessibility and ease of use across various devices, we designed the user interface using Flutter, a cross-platform development framework.

This choice of technology allowed for creating a user-friendly interface that could be consistently deployed on both iOS and Android platforms, maximizing the application's reach and usability among the target users.

System Validation

To ensure the robustness and validity of the evaluation process, we implemented a comprehensive approach to system validation and participant support throughout the study period. The cornerstone of this approach was the rigorous validation of surveys and interview protocols by a panel of experienced nursing administrators and nursing experts. This validation process involved careful review and refinement of the assessment tools, ensuring that they accurately captured the relevant aspects of cardiac surgery knowledge and skills while aligning with the current best practices in the field. The involvement of these seasoned professionals lent credibility to the evaluation instruments and helped tailor them to the specific context of cardiac surgery nursing. Complementing this validation process, the study design incorporated ongoing training and support for participants. This continuous support mechanism was critical in maintaining engagement and ensuring that participants could effectively utilize the mobile application throughout the study period. Regular training sessions were conducted to address any emerging issues, provide clarification on application features, and offer guidance on integrating the tool into daily practice. Additionally, a dedicated support system was established to promptly address technical difficulties or questions that arose during the study. This combination of expert-validated assessment tools and comprehensive participant support not only enhanced the reliability of the data collected but also fostered a supportive learning environment that maximizes the potential benefits of the mobile-based educational application for all participants.

System implementation process

System implementation began with Flutter, an open-source development toolkit for user interface (UI) software developed and released by Google in 2017. Flutter can also be used to develop cross-platform mobile applications that operate on operating systems such as iOS, Android, Windows, Mac, Linux, and Google Fuchsia. It allows the developers to use a single codebase to create natural, smooth, and expressive UIs, enabling applications to maintain their narrative performance across different platforms. The core design concept of Flutter is to achieve cross-platform application development through a single codebase, thereby saving time and resources during development. Flutter adopts Dart as its main programming language, providing rich modules and tools to facilitate UI design and development.

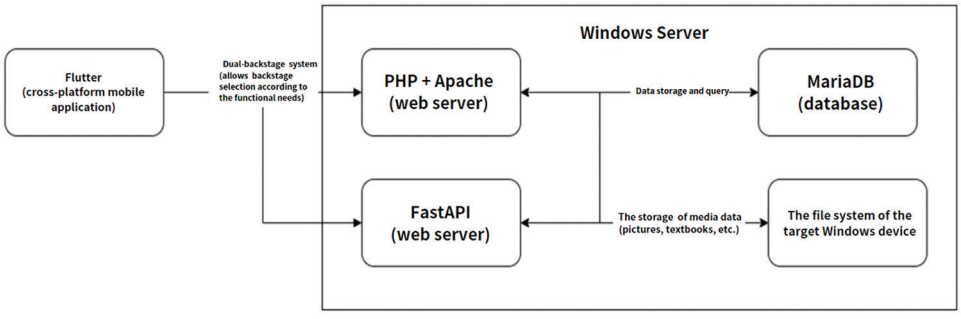

Figure 1: System implementation process

As shown in Figure 1, the Windows server represents the operating system for the entire server architecture. The PHP (hypertext preprocessor) + Apache module combines the PHP scripting language and the Apache HTTP server to process and respond to web service requests. FastAPI is a modern, fast, high-performance web framework for building application programming interfaces (APIs) and exchanging data with other services. The layout of these modules illustrates a typical web application architecture that comprises the client end (application developed with Flutter), the web server (PHP + Apache), the database (MariaDB), and, possibly, a component that allows data exchange between different applications (FastAPI). The server-side is deployed on Windows Server and includes two web server components: PHP+Apache and FastAPI. PHP+Apache serves as the primary web server, handling most of the application logic and client requests while interacting with the MariaDB database for data storage and retrieval. FastAPI acts as an auxiliary web server, directly interfacing with the target Windows device's file system to provide more efficient performance for specific functions. MariaDB is chosen as the open-source database solution, responsible for data storage and management across the entire system. It integrates closely with the PHP+Apache server, ensuring secure data storage and rapid retrieval. Additionally, the system includes a dedicated file system component for storing media data such as images and teaching materials, accessible efficiently through FastAPI.

System program implementation

As shown in Figure 2, the user's data, the difficulty level of the selected test chapter, and the version of the question bank should be defined to structure the test data (denoted by ExamData). Since questions (denoted by problems) may originate from different versions of question banks, the question type is set to be dynamic (denoted by <dynamic>). A notable feature of the ExamData class is the 'problems' field, defined as a List<dynamic>. This design choice allows for flexibility in handling questions from various question bank versions, accommodating potential differences in format or content. The dynamic typing enables the system to adapt to different question structures without requiring extensive code modifications. When implementing the question display functionality, the system distinguishes between text-based and image-based questions. For image-based questions, the implementation leverages the InkWell widget

```dart
import 'user.dart';
import 'chapter.dart';
import 'difficulty.dart';

class ExamData {

  User user;
  Chapter chapter;
  Difficulty difficulty;

  int timeLimit;
  int timeUsed = 0;

  List<dynamic> problems;
  String problemVersion;

  ExamData(this.user, this.chapter, this.difficulty, this.problems, this.timeLimit, this.problemVersion);
}
```

Figure 2: Structuring data for testing and recording

in combination with the onLongPress function. This feature enhances user interaction by allowing examinees to zoom in on images by long-pressing the question interface, facilitating a closer examination of visual details that might be critical for answering the question accurately.

The MultiSelectChipField package is employed to create the question options interface. This package likely offers a user-friendly way to present multiple-choice options. When creating each option, the system first determines whether it is text- or image-based. This decision affects how the option is displayed and interacted with. The selection status of each option is then recorded, allowing the system to track user responses accurately. The user interface is designed to provide clear visual feedback. When an option is selected, its background becomes blank, offering an immediate visual cue to the user about their selection. This design choice likely improves the user experience by making it easy to identify which options have been chosen.

Two key interactions are programmed for the question options:

1. Click interaction: When an option is clicked, it is marked as selected, recorded in the system, and its background changes to blank. This provides visual feedback and ensures the user's choice is captured accurately.

2. Long-press interaction for images: If an option contains an image and is long-pressed, the image zooms in. This feature is particularly useful for examining detailed graphics or small text within images, enhancing the user's ability to make informed choices.

As shown in Figure 3, the questions can be purely texts or images. The ExamProblemV2 class represents individual questions. It contains fields for unique identification (uuid), indexing (index), and the content of the question itself, which can be either text (titleText) or an image (titleImage).

This flexibility enables the system to accommodate various question formats, catering to different learning styles and assessment needs.

Question options are managed through two List objects: 'options' and 'responses'. The 'options' list stores all possible answers for a given question, while the 'responses' list is used to record the user's selections.

Each option is an instance of ExamProblemV2Option, which can contain either text or image content, as indicated by its 'text' and 'image' fields.

The ExamProblemV2Option class includes an overridden equality operator (==), which compares options based on their id. This feature is crucial for accurately tracking and validating user responses, especially in scenarios where options might have similar content but represent different answers.

Additional fields such as 'timeUsed' and 'timeStatus' suggest that the system also tracks the time spent on each question, potentially for analysis of user performance or to enforce time limits on responses.

```
class ExamProblemV2{

  String uuid;
  String index;
  String titleText;
  String titleImage;

  List<ExamProblemV2Option> options = [];
  List<ExamProblemV2Option> responses = [];

  int timeUsed = 0;
  String timeStatus = "unanswered";


  ExamProblemV2(this.uuid, this.index, this.titleText, this.titleImage);
}
class ExamProblemV2Option{

  String id;
  String text;
  String image;


  ExamProblemV2Option(this.id, this.text, this.image);


  @override
  bool operator ==(Object other) {

    return (other is ExamProblemV2Option && this.id == other.id);
  }
}
```

Figure 3: A relatively complex question data structure adopted by the system

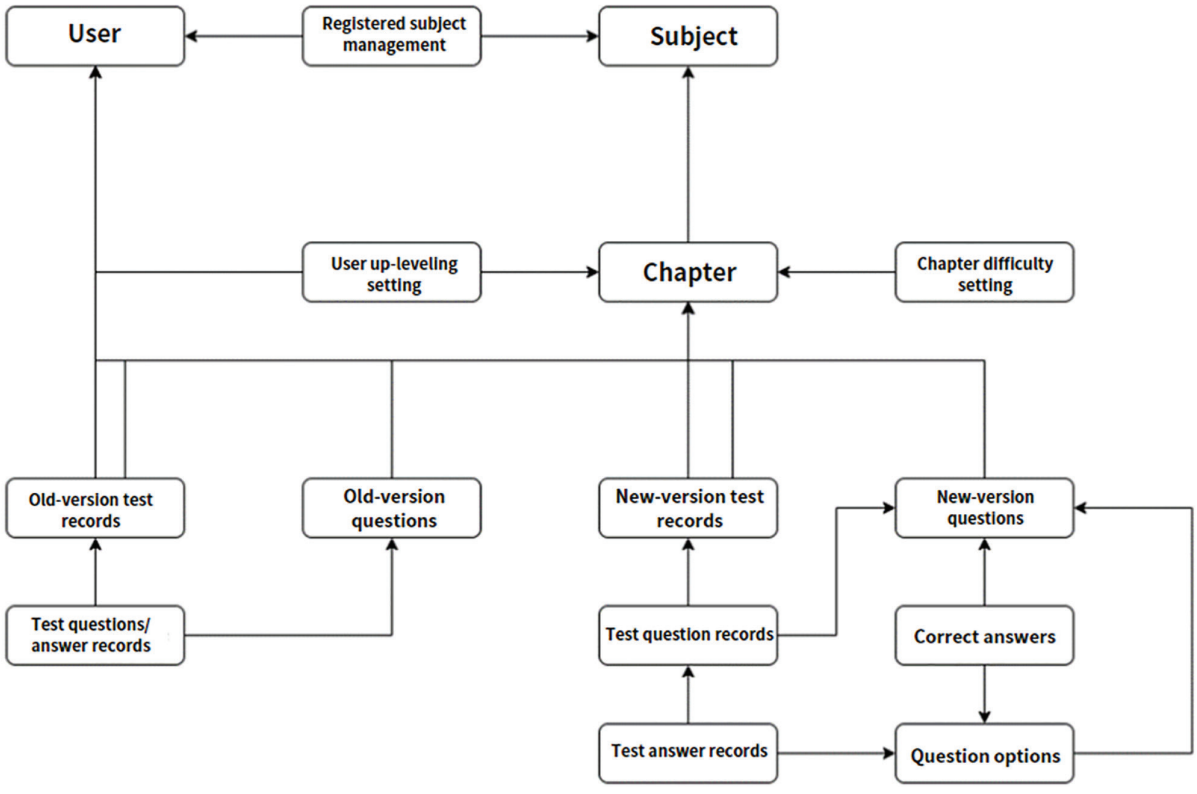

Figure 4: Illustrates the user flow

Figure 4 describes the learning management and test evaluation system, mapping the relationships among the user, subject management, question records, and the setting of correct answers. First, the user must register and manage the subject to be tested.

The user completes subject registration via "registered subject management" and sets the subject information. Following this initial step are the pre-test preparation setting and the teacher setting. The teacher needs to prepare the subject to be tested so that all teaching resources and plans are available. As the system allows updates, old-version test records will be retained. The new-version test records provide basic foundations for the subsequent test procedures. During the test, these questions will be recorded as corresponding "test records," and each question will be assigned a correct answer and corresponding question options to ensure that the selection questions and their answers are accurately recorded. These records serve a dual purpose: they provide immediate feedback on the user's performance and contribute to the system's data pool for future improvements. After the test is completed, all answers will be returned and recorded as "test answer records." These records can be fed back to the procedure of the user information setting process, or "new-version test records," to form a closed-loop system, This feedback loop allows for continuous refinement of the testing process, ensuring that questions are relevant, appropriately challenging, and aligned with learning objectives. This system structure shows an effectively interconnected learning management and evaluation framework that ensures comprehensive monitoring and management from registration to test results.

Ethical Consideration

This study was approved by the Ethics Committee of National Chiayi University. The study was conducted in accordance with ethical research principles, with careful consideration given to participant privacy and confidentiality throughout the development and implementation process. All surveys and interviews were validated through proper review channels, receiving approval from experienced nursing administrators and nursing experts. Participation was voluntary, and informed consent was obtained from all participating nurses and administrators.

Results

Design Outcomes

As shown in Figure 5, the sign-in interface will appear when the application is started. The first screen presents the initial login page, entitled "Medical Skills Training".

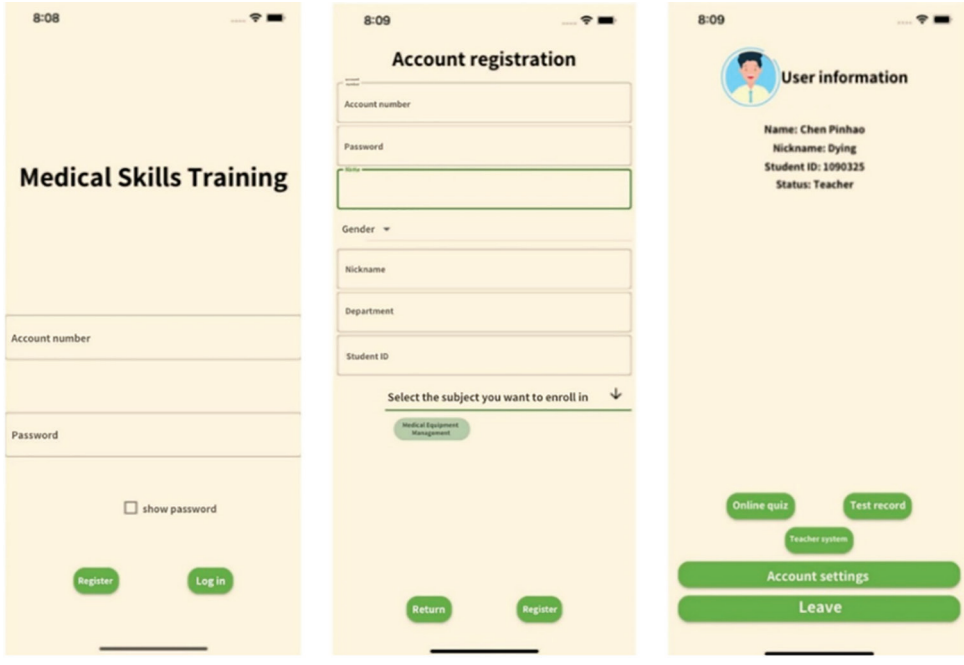

Figure 5: The start page of the application

This page requires users to input their account number and password, with an option to show the password if needed. Two buttons are prominently displayed at the bottom: "Register" for new users and "Log in" for existing ones.

If a user doesn't have an account, he/she can navigate to the registration page by clicking the "Register" button. The registration interface, labeled "Account registration", is more comprehensive.

It requests various details including account number, password, gender, nickname, department, and student ID.

Additionally, users must select a subject they wish to enroll in, with "Medical Equipment Management" shown as an example option. When the status of a subject becomes "open for registration," everyone can register and prepare for tests on that subject. After successful login, users are directed to their information page. This screen displays the user's profile, including their name, nickname, student ID, and status (in this case, "Teacher" for Chen Pinhao). The interface offers several options for interaction: "Online quiz", "Test record", and "Teacher system".

These features likely provide access to training materials, assessment tools, and administrative functions for educators. The "Account settings" and "Leave" buttons at the bottom allow for profile management and logging out of the application.

As shown in Figure 6, the two images illustrate the procedure of "selecting test questions." The procedure starts by clicking the upper left to select the registered subject to be tested. This is followed by clicking the "search" to display all questions in the question banks for the subject. After selecting the question bank, the user must enter the difficulty selection page. When a question bank contains questions with different difficulty levels, the user can select the test difficulty.

Based on the research objective, the following question categories can be established:

1. Questions about cardiac operation room procedures and equipment operation: This category introduces operational procedures in the cardiac operation room, identifies normal equipment and instruments, and covers relevant operational techniques to familiarize paramedics with their tasks.

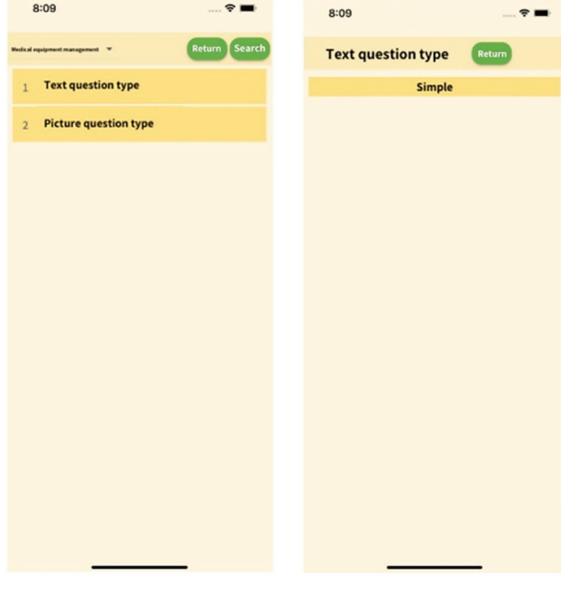

Figure 6: Test question selection

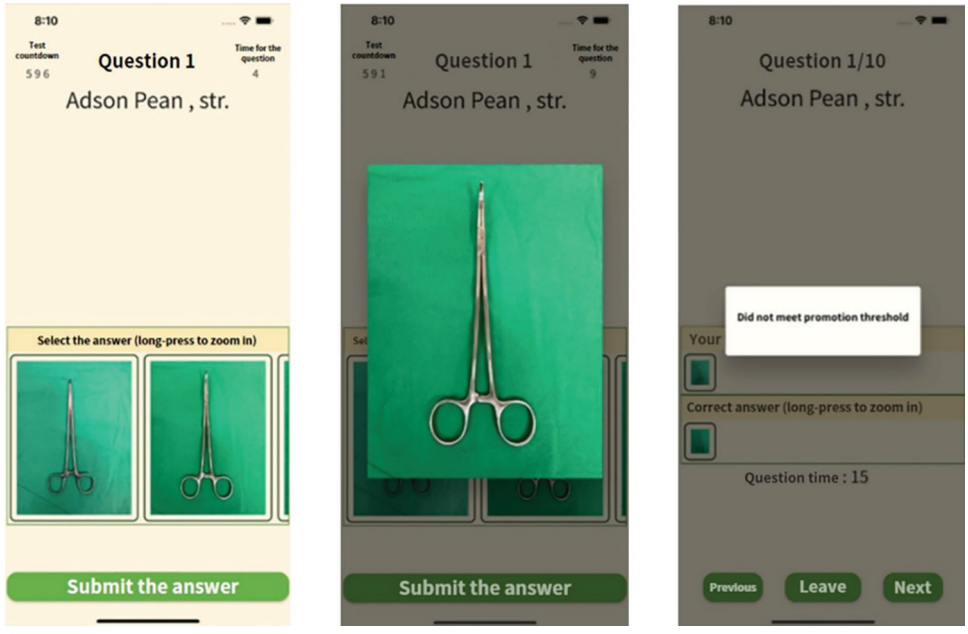

Figure 7: Test interface

2. Questions about normal heart surgery cases and treatment techniques: This category discusses normal heart surgery cases and corresponding treatment techniques to help paramedics develop the ability to cope with changes.

3. Questions about medical safety and risk management: This category emphasizes the medical safety measures, risk assessment, and emergency treatment in the cardiac operation room to improve the paramedics' professional literacy.

4. Questions about teamwork and communication techniques: This category cultivates teamwork among paramedics and enhances their ability to effectively communicate and collaborate with medical teams to ensure smooth surgical performance.

Implementation Outcomes

As shown in Figure 7, the two images depict a real test interface. The text or images of the question are displayed in the upper part, while the text or image options are presented in the lower part. Since the image resolution in the test may be affected by the size of the mobile device, the images are specially processed so that when the user long-presses an image, it can be zoomed in to become easier to recognize. After a section of the test is completed, that the user passes the part depends on the answers submitted by the user. If the user fails to pass, a prompt will appear indicating that the advancement criteria have not been met ("Did not meet promotion threshold"). Otherwise, the user will be notified that he/she can advance to face more challenging questions. Additionally, the user can check the correct answers for each question and compare them with his/her own answers in the test result interface. This section describes the resulting application structure, features, and initial user feedback from the implementation phase. Educational outcomes will be assessed and reported in subsequent studies.

System Validation Results

The research team received enthusiastic feedback from nursing administrators and experts on the survey and interview instruments. They highly commended the comprehensiveness and specificity of these evaluation tools, noting their effectiveness in capturing key aspects of cardiac surgery nursing knowledge and skills. This collaborative process not only improved the quality of the assessment instruments but also ensured they accurately reflected the unique context and challenges of cardiac surgical nursing.

Discussion

In the history of modern medicine, the specialization, and precision of tasks for operating room paramedics have increasingly become significant trends in paramedic development. This study aimed to enhance the professional skills of paramedics. Through surgical instrument identification and management training using this system, paramedics can engage in autonomous learning and training anytime and anywhere via smart devices such as smartphones.

User Satisfaction and App Effectiveness

Several studies have shown high levels of satisfaction and perceived usefulness among medical students using educational mobile applications:

Charani et al. (2013) reported that medical students found a smartphone application for antimicrobial prescribing policy to be user-friendly and effective in improving their knowledge. The app's success was attributed to its easy accessibility and up-to-date information, which are features we've prioritized in our own design (18).

In dentistry, Rung et al. (2014) found that Australian dental students widely adopted smartphones for learning purposes, with high satisfaction rates. Students particularly appreciated the instant access to information and the ability to use apps for self-directed learning, which aligns with the goals of our cardiac surgery training app (19).

Chang et al. (2012) observed that resident physicians in Botswana showed high engagement with mobile learning tools, reporting improved access to medical resources and enhanced learning experiences. This suggests that our app could potentially benefit not just students but also practicing professionals seeking continued education (20).

Khalifian et al. (2013) noted high satisfaction rates among medical students using a plastic surgery education app, with students reporting increased confidence in their knowledge and skills. This positive feedback reinforces the potential of mobile apps in specialized medical fields, similar to our focus on cardiac surgery (4).

In the field of oral pathology, Babazade et al. (2016) found that mobile-based education significantly improved dental students' learning outcomes in practical courses. Students reported high satisfaction with the flexibility and accessibility of mobile learning, which are key features of our application as well (21, 22).

Implicationsof our Application

The developed system integrates management and training functionalities into a mobile platform, designed to provide personalized education solutions for paramedics in cardiac surgery. Key features include real-time feedback mechanisms on user performance, and backstage analysis capabilities for tracking user progress and tailoring guidance on surgical instrument management.

These features were implemented with the goal of addressing the demand for efficient, accessible professional training in modern healthcare. However, it is important to note that the current study focused on the design and implementation phases of this system.

Objective evaluation of its educational outcomes, such as improvements in knowledge, skills, and decision-making abilities, will require further research. Future studies should include pre- and post-implementation assessments of paramedics' knowledge and skills, as well as comparative analyses with traditional training methods to quantify the effectiveness of the system in improving operational proficiency and surgical efficiency.

A key limitation of this study is the current lack of quantitative and qualitative data on the educational effectiveness of the intervention. While the development and implementation phases have been completed successfully, rigorous evaluation of the program's impact on paramedicine students' skills is necessary to fully achieve the objectives of the study. This evaluation is planned as the next phase of this research.

The limitations of the study

While the current study focuses primarily on the development and implementation of the mobile-based educational intervention, a comprehensive evaluation of its educational impact is planned for future work. This evaluation will employ a mixed-methods approach to provide a holistic understanding of the effectiveness of the intervention . The quantitative component will involve pre- and post-intervention skills tests to measure direct improvements in participants' knowledge and abilities related to cardiac surgery procedures. Additionally, in-depth analysis of app usage data will be conducted to understand patterns of engagement and identify features that contribute most significantly to learning outcomes. Performance metrics within the app, such as quiz scores and task completion rates, will also be examined to track progress over time. Complementing this quantitative data, a qualitative assessment will be undertaken through a series of interviews and focus group discussions with both students and instructors.

These sessions will explore perceived effectiveness of the intervention, usability of the application, and its impact on confidence and clinical decision-making skills. By combining these quantitative and qualitative approaches, the future evaluation aims to provide a comprehensive picture of the educational value of the intervention, its integration into existing training paradigms, and its potential for improving cardiac surgery education and practice.

Conclusion

This study has successfully designed and implemented an application-based system for enhancing medical skill training among paramedicine students. The next critical step is to conduct a thorough evaluation of its educational effectiveness, which will provide valuable insights

into the impact of this innovative approach on students' skills and confidence in cardiac surgery procedures.

With technology and data science integration, the system will continuously adjust and improve the care flow based on the large amounts of real-time data collected, enabling predictive maintenance and risk assessment. This advancement will enhance the quality of surgical care and improve resource allocation and risk control capabilities in the operating room. The innovative use of such technology is expected to make operating room care more automated and predictable, thereby allowing paramedics to focus more on clinical judgment and patient care.

Acknowledgment

The authors of this article thank and appreciate the sincere cooperation of all the Ditmanson Medical Foundation Chiayi Christian Hospital_ Nursing Department.

Authors' Contribution

All authors listed have contributed sufficiently to the project to be included as authors. To the best of our knowledge, no conflict of interest, financial or other, exists. All authors have agreed to the submission and that the manuscript is not currently under submission in any other journal.

Conflict of Interest

The authors declare no conflicts of interest.

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