ORIGINAL ARTICLE

Investigating the effect of an educational mobile application on the learning of medical interns in the general surgery ward

Reza Shojaeian[1], Ali Moradi[2], Seyed Hassan Tavousi[3], Mohammad Etezadpour[3], Lida Bahramian[4], Fariba Zabihi[3,*]

[1]Department of Pediatric Surgery, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Orthopedic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
[3]Endoscopic and Minimally Invasive Surgery Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
[4]Dental Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

[*]Department of Surgery, Ghaem Hospital, Ahmad Abad Blvd, Mashhad, 9164654694 Iran

Tel: +98 915 558 0743
Email: zabihi2010@yahoo.com

Background: This study aimed to determine the effect of using mobile phone-based educational aid software on the learning rate of medical interns in the general surgery department.

Method: This study was conducted on two groups of 70 general medicine interns in the general surgery department during two 8-month periods. The first and second group was educated using traditional and application-based method, respectively.

Results: The mean±SD age of the participants were 24.71 ± 3.19 and 25.25 ± 2.07 years for the app-based group and the traditional group, respectively. There were no significant differences between the two groups in terms of age (P = 0.247) or gender (P = 0.175). The score of the basic science test (App-group: 124.59 ± 26.56 vs. Traditional group: 119.06 ± 16.02) and the score of the pre-internship test (App-group: 122.06 ± 22.12 vs. Traditional group: 120.16 ± 16.13) did not show a significant difference between the intervention and control groups (P =0.139, P =0.562). Still, the time elapsed since the internship in the intervention group (8.46 ± 3.46 months) was significantly more than the control group (6.29 ± 4.10 months, P=0.001). A significant increase in the post-test score was found in both groups (P<0.001). There was no significant difference regarding the pre-test results (P=0.731); however, the post-test score was significantly higher in the intervention group compared to the controls (P<0.001).

Conclusion: This study showed that training based on mobile software can be an effective role in training program's medical intern in general surgery department.

Keywords: Educational Technology, General Surgery, Medical Education

دراسة تأثير تطبيق جوال تعليمي على تعلم الأطباء المقيمين في جناح الجراحة العامة

ملخص: هدفت هذه الدراسة إلى تحديد تأثير استخدام برامج المساعدة التعليمية المعتمدة على الهاتف المحمول على معدل التعلم لدى الأطباء المقيمين في قسم الجراحة العامة.

الطريقة: أُجريت هذه الدراسة على مجموعتين، تضم كل منهما ٧٠ طبيبًا متدربًا في الطب العام بقسم الجراحة العامة، على مدى فترتين، مدة كل منهما ثمانية أشهر. تلقّت المجموعتان الأولى والثانية تدريبًا بالطريقة التقليدية والتطبيقية، على التوالي.

النتائج: بلغ متوسط أعمار المشاركين ± الانحراف المعياري ٢٤,٧١ ± ٣,١٩ و٢٥,٢٥ ± ٢,٠٧ سنة في المجموعة التطبيقية والمجموعة التقليدية على التوالي. ولم تُلاحظ فروق جوهرية بين المجموعتين من حيث العمر (P = 0.247) أو الجنس (P = 0.175). ولم تُظهر نتيجة اختبار العلوم الأساسية (مجموعة التطبيق: ١٢٤,٥٩ ± ٢٦,٥٦ مقابل المجموعة التقليدية: ١١٩,٠٦ ± ١٦,٠٢) ونتيجة اختبار ما قبل التدريب (مجموعة التطبيق: ١٢٢,٠٦ ± ٢٢,١٢ مقابل المجموعة التقليدية: ١٢٠,١٦ ± ١٦,١٣) أي فرق جوهري بين مجموعتي التدخل والضبط (P = 0.139، P = 0.562). مع ذلك، كان الوقت المنقضي منذ التدريب في مجموعة التدخل (٨,٤٦ ± ٣,٤٦ شهرًا) أطول بكثير من المجموعة الضابطة (٦,٢٩ ± ٤,١٠ شهرًا، قيمة P=0.001). لوحظت زيادة ملحوظة في نتيجة الاختبار البعدي في كلتا المجموعتين (قيمة P<٠,٠٠١). لم يكن هناك فرق كبير في نتائج الاختبار البعدي (قيمة P=0.731)؛ ومع ذلك، كانت نتيجة الاختبار البعدي أعلى بكثير في مجموعة التدخل مقارنةً بالمجموعة الضابطة (قيمة P<٠,٠٠١).

الاستنتاج: أظهرت هذه الدراسة أن التدريب المبني على برامج الهاتف المحمول يمكن أن يكون له دور فعال في برنامج تدريب المتدربين الطبيين في قسم الجراحة العامة.

الكلمات المفتاحية: تكنولوجيا التعليم، الجراحة العامة، التعليم الطبي

بررسی تأثیر اپلیکیشن آموزشی تلفن همراه بر یادگیری کارورزان پزشکی در بخش جراحی عمومی

زمینه و هدف: اخیراً آموزش پزشکی مبتنی بر اپلیکیشن ها، یکی از موضوعات مهم در مطالعات مختلف بوده است. این مطالعه با هدف تعیین تأثیر استفاده از نرم افزار کمک آموزشی مبتنی بر تلفن همراه بر میزان یادگیری کارورزان پزشکی در بخش جراحی عمومی انجام شد.

روش: این مطالعه بر روی کارورزان پزشکی عمومی در بخش جراحی عمومی بیمارستان‌های آموزشی طی دو دوره ۸ ماهه انجام شد. این مطالعه شامل ۱۴۰ داوطلب در دو گروه ۷۰ نفری بود. گروه اول مطالعه آموزش با روش سنتی و گروه دوم از روش مبتنی بر نرم افزار استفاده کردند.

یافته‌ها: میانگین و انحراف معیار سن شرکت‌کنندگان در گروه مبتنی بر نرم افزار ۲۴,۷۱±۳,۱۹ سال و در گروه سنتی ۲۵,۲۵±۲,۰۷ سال بود. تفاوت معناداری بین دو گروه از نظر سن (P=۰/۲۴۷) یا جنسیت (P=۰/۱۷۵) مشاهده نشد. نمره آزمون علوم پایه (گروه نرم افزار: ۱۲۴,۵۹±۲۶,۵۶ در مقابل گروه سنتی: ۱۱۹,۰۶±۱۶,۰۲) و نمره آزمون پیش‌کارورزی (گروه نرم افزار: ۱۲۲,۰۶±۲۲,۱۲ در مقابل گروه سنتی: ۱۲۰,۱۶±۱۶,۱۳) تفاوت معناداری بین گروه مداخله (P=۰/۱۳۹) و کنترل (P=۰/۵۶۲) نشان ندادند. با این حال، مدت زمان سپری شده از کارورزی در گروه مداخله (۸,۴۶±۳,۴۶ ماه) به طور معناداری بیشتر از گروه کنترل (۶,۲۹±۴,۱۰ ماه) بود (P=۰/۱۷۵). افزایش معناداری در نمره آزمون پس از مداخله در هر دو گروه مشاهده شد (P<۰/۰۰۱). تفاوت معناداری در نتایج آزمون پیش از مداخله وجود نداشت (P=۰/۷۳۱)، اما نمره آزمون پس از مداخله در گروه مداخله به طور معناداری بالاتر از گروه کنترل بود (P<۰/۰۰۱).

نتیجه‌گیری: آموزش مبتنی بر نرم‌افزار تلفن همراه می‌تواند به طور مؤثری به کارورزان پزشکی در بخش جراحی آموزش دهد.

واژه های کلیدی: فناوری آموزشی، جراحی عمومی، آموزش پزشکی

جنرل سرجری وارڈ میں میڈیکل انٹرنز کی تعلیم پر تعلیمی موبائل ایپلی کیشن کے اثر کی تحقیقات

پس منظر: اس مطالعے کا مقصد جنرل سرجری کے شعبہ میں میڈیکل انٹرنز کی سیکھنے کی شرح پر موبائل فون پر مبنی تعلیمی امدادی سافٹ ویئر کے استعمال کے اثر کا تعین کرنا تھا۔

طریقہ: یہ مطالعہ جنرل سرجری کے شعبہ میں ۷۰ جنرل میڈیسن انٹرن کے دو گروپوں پر ۸ ماہ کے دوران کیا گیا۔ پہلے اور دوسرے گروپ کو بالترتیب روایتی اور درخواست پر مبنی طریقہ استعمال کرتے ہوئے تعلیم دی گئی۔

نتائج: ایپ پر مبنی گروپ اور روایتی گروپ کے لیے شرکاء کی اوسط ± SD عمر بالترتیب ۲۴٫۷۱ ± ۳٫۱۹ اور ۲۵٫۲۵ ± ۲٫۰۷ سال تھی۔ عمر (P = 0.247) یا جنس (P = 0.175) کے لحاظ سے دونوں گروہوں کے درمیان کوئی خاص فرق نہیں تھا۔ بنیادی سائنس ٹیسٹ کا اسکور (ایپ گروپ: ۱۲۴٫۵۹ ± ۲۶٫۵۶ بمقابلہ روایتی گروپ: ۱۱۹٫۰۶ ± ۱۶٫۰۲) اور پری انٹرنشپ ٹیسٹ کا اسکور (ایپ گروپ: ۱۲۲٫۰۶ ± ۲۲٫۱۲ بمقابلہ روایتی گروپ: ۱۶ ± ۱ کے درمیان اہم فرق نہیں دکھایا گیا: ۱۲۱۶ ± ۱۶) مداخلت اور کنٹرول گروپ (P = 0.139، P = 0.562)۔ پھر بھی، مداخلت گروپ (۸٫۴۶ ± ۳٫۴۶ ماہ) میں انٹرنشپ کے بعد سے گزرا ہوا وقت کنٹرول گروپ (۶٫۲۹ ± ۴٫۱۰ ماہ، P = 0.001) سے نمایاں طور پر زیادہ تھا۔ دونوں گروپوں (P <۰٫۰۰۱) میں پوسٹ ٹیسٹ سکور میں نمایاں اضافہ پایا گیا۔ پری ٹیسٹ کے نتائج کے حوالے سے کوئی خاص فرق نہیں تھا (P=0.731)؛ تاہم، کنٹرولز (P <۰٫۰۰۱) کے مقابلے مداخلت گروپ میں پوسٹ ٹیسٹ سکور نمایاں طور پر زیادہ تھا۔

نتیجہ: اس تحقیق نے ظاہر کیا کہ موبائل سافٹ ویئر پر مبنی تربیت جنرل سرجری کے شعبہ میں تربیتی پروگرام کے میڈیکل انٹرن میں ایک موثر کردار ادا کر سکتی ہے۔

مطلوبہ الفاظ: تعلیمی ٹیکنالوجی، جنرل سرجری، طبی تعلیم

INTRODUCTION

A medical student's teaching involves a combination of theoretical and experimental factors, and both should be paid attention to (1, 2). Traditionally, medical students were provided with a lecture, and they examined all the requisites according to their curriculum in a clinical setting (3). The traditional frame of teaching in medical school suffered from different limitations, such as the need for the presence of a lecturer, being passive and less involvement of the students, and also the absence of a redo lecture in case the students needed a repeat in some topics (4, 5). The advent of the internet and advancements in telemedicine have revolutionized medical education, offering new opportunities for remote learning. Moreover, with the emergence of COVID-19, online teaching has become more prevalent among different fields of study (6-8).

Various methods of teleteaching, including audio programs, television programs, and films, have been proposed (9). Moreover, some used available social media for tele-teaching, and many online platforms have been developed in this regard (10). Furthermore, some platforms were created only for medical education (11). In some cases, simulators of physical examinations were developed. However, the most used part of remote and online medical teaching is medical app development, as a person spends a long-time using cell phones (12).

Online platforms and medical apps benefit from scalability, an inherent strength that facilitates a multitude of learners at the same time (13). Additionally, the cost-effectiveness of the process is celebrated through reduced expenses like travel, materials, and infrastructure, democratizing access to education (14). Learning can be personalized through online platforms and medical apps that adapt content delivery according to each learner's unique aptitudes and areas of development. Medical apps integrate feedback mechanisms that enable learners to gauge their progress, enabling continuous improvements (15-17). However, amidst advancements in the extent of medical application and online platforms, a web of challenges surfaces (18). Digital inequities may amplify educational disparities due to uneven access and digital literacy (19). The vast expanse of online information carries the risk of misinformation, underscoring the need for robust validation mechanisms (20). While digital platforms excel in delivering theoretical knowledge, they struggle to replicate the depth of practical skills and hands-on training inherent to medical education (21). Technical glitches and disruptions could impede the seamless flow of learning, necessitating dependable infrastructure (22). Data privacy concerns loom large as sensitive medical information is collected, demanding stringent security measures (23). The transition to digital mediums could marginalize interpersonal skills crucial for effective medical practice. Striking a balance between technological integration and compliance with medical regulations is intricate, while the absence of hands-on training might compromise practical application (24). Constant technological evolution mandates continuous updates to keep pace. Preserving the essence of traditional medical education while leveraging digital platforms requires a thoughtful and balanced approach. Despite the increasing use of digital tools in medical education, there is a lack of comprehensive research evaluating their effectiveness, particularly in the field of mobile applications for training medical interns. This study aimed to assess the usefulness of a mobile application as an educational method for medical interns, addressing the gap in the literature regarding the practical application and effectiveness of such tools in medical education.

METHODS

Study design and sample

This quasi-experimental study was conducted over a period of 16 months and divided into two phases of eight months each. The study population consisted of all medical interns who completed a general surgery rotation at five educational hospitals. Interns were allocated into two groups: intervention and control. In the first eight months, all interns received traditional teaching methods. In the second eight months, interns utilized a newly developed educational application as the teaching method.

Inclusion criteria were defined as the participants had to own a smartphone and be able to install the application. Moreover, exclusion criteria included interns repeating the surgery ward rotation for any reason, interns who withdrew consent, and interns who failed to complete either the pre-test or post-test. Due to concerns that unveiling the software prematurely could influence students outside the study, participants were not randomly assigned to groups. Instead, the control group was assessed first, followed by the intervention group once the software was introduced. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Data Collection

Demographic data, including age and gender, were recorded. Moreover, additional academic performance data, including the duration of internship, basic science test scores, and pre-internship test scores, were also collected and compared between groups. Among these data, the study status of the topics was assessed and compared according to the response status of the participants in the pre-and post-test exams (including complete, incomplete, and wrong/absent).

Application design

The educational application was designed to cover essential surgical topics required for medical interns.

The topics included general, burn, pediatric, and vascular surgery, with a focus on conditions such as hemorrhoids, inguinal hernias, mastitis, anal fissure, peptic ulcer, pyloric hypertrophy, appendicitis, bowel obstruction, acute limb ischemia, and burn management. Furthermore, it contained practical surgical skills videos, such as different suturing techniques, abscess drainage, nasogastric tube insertion, urinary catheterization, intubation, arterial blood sample preparation from the peripheral artery, central venous (CV)-line insertion, and central venous pressure measurement (CVP). Moreover, the software also included an introduction to surgical instruments. All educational materials were sourced from references approved by the national health ministry. The application was developed for both iOS and Android platforms and allowed real-time tracking of student engagement with assigned topics. Figure 1 provides pictures of the outfit of the software.

Assessments via Pre-test and post-test

Pre- and post-test evaluation was used to assess and compare the efficacy of traditional and app-based methods. The pre-test and post-test consisted of 10 questions, which were designed clinically with the guidance of the professors of the general surgery department and aligned with the national internship training protocols. The topics covered general surgery, vascular surgery, and pediatric surgery, and the number of questions on each topic was based on the volume of its content. There were answers to the questions in the educational content section of the software. A specific score was not considered the limit for the pre-test and post-test, but only the scores before and after were compared.

Statistical analysis

All the extracted data were analyzed using SPSS version 20. The frequency and percent of categorical data and the mean ±standard deviation (SD) of the quantitative data were calculated. The categorical data were compared between the two study groups using the Chi-square or Fisher's exact test. Moreover, quantitative variables were assessed using an independent sample t-test or Mann-Whitney U test, depending on the data distribution. Furthermore, for within-group comparisons of pre-test and post-test results, paired t-tests or Wilcoxon signed ranked test was used. P-values less than 0.05 were considered significant.

RESULTS

140 volunteers were enrolled, including 70 cases in the App-based and traditional groups. The included cases showed no significant difference regarding age (P=0.247), gender (P=0.175), basic science test score (P=0.139), and pre-internship test score (P=0.562). However, the months that passed from the start of the internship were significantly higher in the app-group

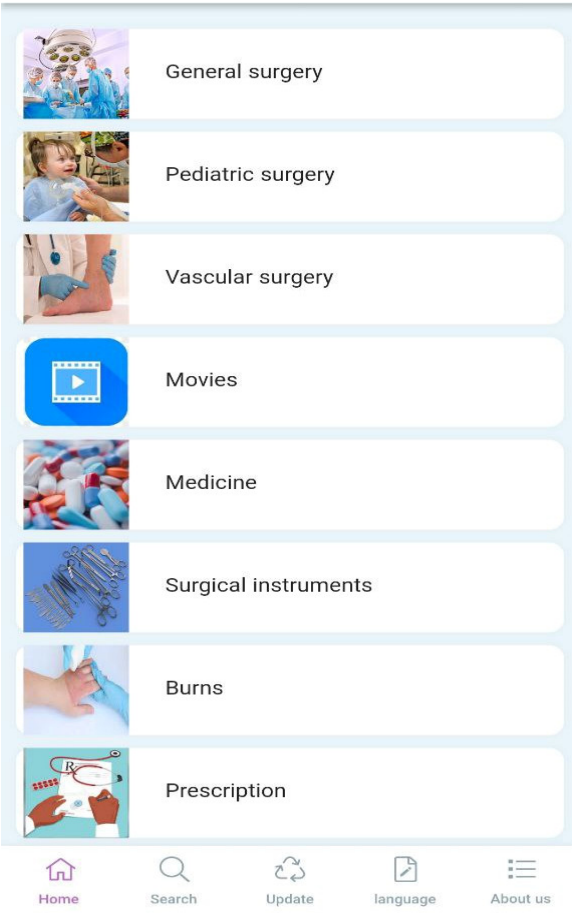

Figure 1. A screen shot of application

Table 1. Comparison of age, gender, months from the internship start, basic science, and pre-internship test scores between App-based and traditional groups

Variable		App-group	Traditional group	P
Age (years; Mean ± SD)		24.71±3.19	25.25±2.07	0.247
Gender	Male	33 (47.1)	40 (60.0)	0.175
	Female	37 (52.9)	28 (40.0)	
Basic science test score (mean ± SD)		124.59±26.56	119.06±16.02	0.139
Pre-internship test score (mean ± SD)		122.06±22.12	120.16±16.13	0.562
Months passed from the start of the internship (months; mean ± SD)		8.46±3.46	6.29±4.10	0.001

compared to the traditional group (P=0.001) (Table 1). Table 2 also compared the pre-test and post-test scores according to the study groups. A significant increase in the post-test score was found in both groups (P<0.001). In comparing the pre-test scores, post-test scores, and the score changes between the two intervention and control groups, the pre-test score did not show a significant difference between the two groups (p=0.731). However, the intervention group's post-test score and score changes were significantly higher (p<0.001). Table 3 shows the comparison of pre-test scores, post-test scores and between the intervention and control groups.

Table 4 also demonstrates the status of responses to the questions according to the study status of the topic. As it is evident, the response rate was significantly higher in the group that studied those topics (P<0.001).

Table 2. Comparison of pre and post-test results in a before-after manner evaluation in intervention and control groups

Variable	Pre-test score	Post-test score	p-value
Intervention group (Mean ± SD)	26.65±10.07	58.02±12.18	<0.001
Control group (Mean ± SD)	27.33±13.15	36.18±12.78	<0.001

Table 3. Comparison of pre-test, post-test, and score changes between intervention and control groups

Variable	Intervention	Control	p-value
Pre-test score (Mean ± SD)	26.65±10.07	27.33±13.15	0.731
Post-test score (Mean ± SD)	58.02±12.18	36.18±12.78	<0.001
Score changes (Mean ± SD)	31.36±14.67	8.85±11.33	<0.001

Table 4. Comparing the relevance of studying the material based on the headings provided in the software with the answers to the questions

Topic	Response	Studied N (%)	Not-studied N (%)	p-value
General surgery (hemorrhoid)	Complete	42 (100.0)	0 (0.0)	<0.001
	In-complete	14 (56.0)	11 (44.0)	
	Wrong/absent	0 (0.0)	3 (100.0)	
General surgery (inguinal hernia)	Complete	22 (100.0)	0 (0.0)	<0.001
	In-complete	21 (46.7)	24 (53.3)	
	Wrong/absent	0 (0.0)	3 (100.0)	
General surgery (mastitis)	Complete	23 (100.0)	0 (0.0)	<0.001
	In-complete	19 (43.2)	25 (56.8)	
	Wrong/absent	0 (0.0)	3 (100.0)	
Burn surgery	Complete	53 (100.0)	0 (0.0)	<0.001
	In-complete	11 (73.3)	4 (26.7)	
	Wrong/absent	0 (0.0)	2 (100.0)	
General surgery (anal fisher)	Complete	44 (97.8)	1 (2.2)	<0.001
	In-complete	12 (57.1)	9 (42.9)	
	Wrong/absent	0 (0.0)	4 (100.0)	
General surgery (peptic ulcer)	Complete	13 (92.2)	1 (7.1)	<0.001
	In-complete	26 (50.0)	26 (50.0)	
	Wrong/absent	0 (0.0)	4 (100.0)	
Pediatric surgery (Pyloric hypertrophy)	Complete	18 (90.0)	2 (10.0)	<0.001
	In-complete	17 (37.8)	28 (62.2)	
	Wrong/absent	0 (0.0)	5 (100.0)	

Table 4. Comparing the relevance of studying the material based on the headings provided in the software with the answers to the questions

Topic	Response	Studied N (%)	Not-studied N (%)	p-value
General surgery (Appendicitis)	Complete	28 (100.0)	0 (0.0)	<0.001
	In-complete	29 (74.4)	10 (25.6)	
	Wrong/absent	0 (0.0)	3 (100.0)	
General surgery (Bowel obstruction)	Complete	10 (100.0)	0 (0.0)	<0.001
	In-complete	27 (50.9)	26 (49.1)	
	Wrong/absent	0 (0.0)	7 (100.0)	
Vascular surgery (acute limb ischemia	Complete	8 (100.0)	0 (0.0)	<0.001
	In-complete	22 (46.8)	25 (53.2)	
	Wrong/absent	0 (0.0)	15 (100.0)	

DISCUSSION

The current study demonstrated that adding mobile application education was more effective than the traditional teaching method in the general surgery ward. The results showed that although the score of pre-tests had no significant difference between the two study groups, post-test scores were significantly higher in the Application group. Moreover, the results of answers to the test questions were significantly better in those who studied the topics.

Online platforms and medical apps offer numerous advantages, including scalability that accommodates a wide array of learners simultaneously and cost-effectiveness by eliminating expenses like travel and infrastructure (25, 26). This democratizes access to education and equips learners with tools to navigate the evolving medical landscape. Personalized learning becomes feasible through adaptable content delivery and feedback mechanisms that promote continuous improvement. However, these advantages come with challenges (27). Digital literacy disparities and accessibility issues can hinder equal participation. Ensuring the credibility of information in a sea of online content is a concern (28). Practical skills and hands-on experience may be compromised in the absence of face-to-face interactions (29). Technical glitches and data privacy vulnerabilities threaten the reliability and security of these platforms (30, 31). Striking a balance between technological advancement and adherence to medical standards presents an ongoing challenge. Moreover, the risk of isolation, depersonalization, and information overload underscores the importance of maintaining human connection and mentorship in medical education (32-34).

The results of the present study were in line with some of the previously published studies. Daliri et al. (35) conducted a similar study using an application for the orthopedic training of medical interns. The designed application by Daliri et al. covered five main parts of medication, common order samples, common prescriptions, cast and splint types, and educational movies. They reported that final exam scores were significantly higher in mobile application students. Moreover, the satisfaction rate in the teaching method was significantly higher in those who used the application. Samra et al. (36) also showed similar results with their application designed for tympanic membrane diseases. The application provided pathologic features of the ophthalmologic view as pictures. This pilot study found that students who used the app understood images of the TM better than those who did not use it.

Liu et al. (37) also developed another app to train fungal infection of skin medical students and the residents of the dermatology clinic. The application changed the wallpaper of the smartphone for a duration of three weeks and, with this mean, tried to educate the students. They reported that after using the app, medical trainees had a significantly higher score than the baseline. Although they proposed that the application was useful in the case of teaching the students, the absence of a control group made the study conclusion less valuable.

However, an opposing study was also present. Bonabi et al. (38) conducted app-based teaching for pediatric oral health care teaching in public health service physicians. There were two study groups in this regard, the application group received a newly designed evidence-based smartphone application, and those in the control group received a booklet, a CME seminar, and a pamphlet. They reported that although the increase in post-exam scores of all fields of knowledge, attitude, and practice was higher in the intervention group; there was no statistically significant difference. Still, their study's sample size was lower than ours.

Smartphone usage is becoming a part of daily habits in different societies and populations. It is reported that over 80% of people cannot spend a single time without smartphones (39). Moreover, an online survey reported a mean duration of about 3 hours of cell phone use. Alongside this, the accessibility to the

Internet has increased by several folds during the last decade (40, 41). Many people use the internet and social media, especially during the ban time of COVID-19 (42, 43). A revolution comes in many aspects of daily life (44, 45). More and more adolescents and students become addicted to smartphones, which is to provide beneficial effects of the teaching method. An analysis reported that 84.5 to 94 percent of physicians spend considerable time with smartphones (46). Smartphones are not only cell phones that are used for vocal communication, but they are small computers that can be easily carried off (47). In this regard, this device is beneficial. It can access many resources with just one touch on the screen. Therefore, it can substitute the heavy and hard-to-use textbooks. Moreover, the applications in mobile phones can provide movies that are more useful in practice. Furthermore, despite the traditional teaching method, you are provided once by the teaching materials of the teacher (48). In the application-based method, you can access the training material whenever the student wants (49, 50).

Despite its strengths, the present study had some limitations. First, a few students had insufficient data or dropped out mid-study, which excluded them from the analysis. Second, the data were collected in one center, and the sample size was relatively low, which may have led to a decrease in the accuracy of the results. In addition, due to the observational design of the study, randomized allocation of participants was impossible, which can be considered a shortcoming. These factors should be considered when interpreting the findings.

CONCLUSION

The use of application-based education can help improve medical knowledge of medical interns in surgery wards. The designed app in the present study covered the must-learn topics of a medical intern in the surgery ward. Still, there is a way to complete remote learning methods in a medical setting. The COVID-19 pandemic triggered app-based education more powerfully. It is advised to try the condition in other settings and simulate the medical setting in a more real fashion, such as virtual medical apps.

Ethical Considerations

The protocol of the present study was approved by Mashhad University of Medical Sciences Ethics Committee under the code IR.MUMS.MEDICAL.1401.123 and was registered with the Iranian Registry of Clinical Trials with code IRCT20230820059194N1. Additionally, this study complied with the ethical considerations outlined in the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. It is worth noting that written informed consent was obtained from all participants before enrollment.

Financial Support: This study was funded by Mashhad University of Medical Sciences.
Conflict of interest: None

REFERENCES

1. Franz A, Oberst S, Peters H, Berger R, Behrend R. How do medical students learn conceptual knowledge? High-, moderate-and low-utility learning techniques and perceived learning difficulties. BMC Med Educ. 2022; 22(1):1-8.
2. Khadem Rezaiyan M, Omranzadeh A, Akhavan Rezayat A, Youssefi M. From Prestige to Humanism: The Experiences of Medical Students about Motivational Factors. Journal of Medical Education Development. 2019;12(34):14-21.
3. Jiang Q, Horta H, Yuen M. International medical students' perspectives on factors affecting their academic success in China: a qualitative study. BMC Med Educ. 2022;22(1):1-16.
4. Roskvist R, Eggleton K, Goodyear-Smith F. Provision of e-learning programmes to replace undergraduate medical students' clinical general practice attachments during COVID-19 stand-down. Education for Primary Care. 2020;31(4):247-54.
5. Rodis OM, Locsin RC. The implementation of the Japanese Dental English core curriculum: active learning based on peer-teaching and learning activities. BMC Med Educ. 2019;19(1):1-7.
6. Henriques S, Correia JD, Dias-Trindade S. Portuguese primary and secondary education in times of covid-19 pandemic: An exploratory study on teacher training and challenges. Educ Sci. 2021;11(9):542.
7. Aziz A, Saddhono K, Setyawan BW. A parental guidance patterns in the online learning process during the COVID-19 pandemic: case study in Indonesian school. Heliyon. 2022;8(12).
8. Octaberlina LR, Muslimin AI. EFL students perspective towards online learning barriers and alternatives using Moodle/Google Classroom during COVID-19 pandemic. Int J High Educ. 2020;9(6):1-9.
9. Senbekov M, Saliev T, Bukeyeva Z, Almabayeva A, Zhanaliyeva M, Aitenova N, et al. The recent progress and applications of digital technologies in healthcare: a review. Int j telemed appl. 2020;2020.
10. Nicolau C, Henter R, Roman N, Neculau A, Miclaus R. Tele-education under the COVID-19 Crisis: Asymmetries in Romanian education. Symmetry. 2020;12(9):1502.
11. Felszeghy S, Pasonen-Seppänen S, Koskela A, Nieminen P, Härkönen K, Paldanius KMA, et al. Using online game-based platforms to improve student performance and engagement in histology teaching. BMC Med Educ. 2019;19(1):273.
12. Chandran VP, Balakrishnan A, Rashid M, Pai Kulyadi G, Khan S, Devi ES, et al. Mobile applications in medical education: A systematic review and meta-analysis. PLoS One. 2022;17(3):e0265927.
13. Duraku ZH, Hoxha L. The impact of COVID-19 on education and on the well-being of teachers, parents, and students: Challenges related to remote (online) learning and opportunities for advancing the quality of education. Manuscript submitted for publication Faculty of Philosophy, University of Prishtina. 2020.
14. Qazi A, Qazi J, Naseer K, Zeeshan M, Qazi S, Abayomi-Alli O, et al. Adaption of distance learning to continue the academic year amid COVID-19 lockdown. Child Youth Serv Rev. 2021;126:106038.
15. Ozamiz-Etxebarria N, Berasategi Santxo N, Idoiaga Mondragon N, Dosil Santamaría M. The psychological state of teachers during the COVID-19 crisis: The challenge of returning to face-to-face teaching. Front psychol. 2021;11:620718.
16. Krishnan IA, Ching HS, Ramalingam S, Maruthai E, Kandasamy P, De Mello G, et al. Challenges of learning English in 21st century: Online vs. traditional during Covid-19. Malaysian Journal of Social Sciences and

Humanities (MJSSH). 2020;5(9):1-15.
17. Qazi A, Naseer K, Qazi J, AlSalman H, Naseem U, Yang S, et al. Conventional to online education during COVID-19 pandemic: Do develop and underdeveloped nations cope alike. Child Youth Serv Rev. 2020;119:105582.
18. Coenen L, Poel LV, Schoenmakers B, Van Renterghem A, Gielis G, Remmen R, et al. The impact of COVID-19 on the well-being, education and clinical practice of general practice trainees and trainers: a national cross-sectional study. BMC Med Educ. 2022;22(1):1-12.
19. Gupta MM, Jankie S, Pancholi SS, Talukdar D, Sahu PK, Sa B. Asynchronous environment assessment: A pertinent option for medical and allied health profession education during the COVID-19 pandemic. Educ Sci. 2020;10(12):352.
20. Asgari S, Trajkovic J, Rahmani M, Zhang W, Lo RC, Sciortino A. An observational study of engineering online education during the COVID-19 pandemic. Plos one. 2021;16(4):e0250041.
21. Ahmed FRA, Ahmed TE, Saeed RA, Alhumyani H, Abdel-Khalek S, Abu-Zinadah H. Analysis and challenges of robust E-exams performance under COVID-19. Results Phys. 2021;23:103987.
22. Almazova N, Krylova E, Rubtsova A, Odinokaya M. Challenges and opportunities for Russian higher education amid COVID-19: Teachers' perspective. Educ Sci. 2020;10(12):368.
23. Salari F, Sepahi V. Challenges of virtual medical sciences education during the COVID-19 pandemic: a systematic review. Educational Research in Medical Sciences. 2021;10(1).
24. Al-Fodeh RS, Alwahadni AM, Abu Alhaija ES, Bani-Hani T, Ali K, Daher SO, et al. Quality, effectiveness and outcome of blended learning in dental education during the Covid pandemic: Prospects of a post-pandemic implementation. Educ Sci. 2021;11(12):810.
25. Weerathunga PR, Samarathunga W, Rathnayake H, Agampodi S, Nurunnabi M, Madhunimasha M. The COVID-19 pandemic and the acceptance of e-learning among university students: The role of precipitating events. Educ Sci. 2021;11(8):436.
26. Harmon DJ, Attardi SM, Barremkala M, Bentley DC, Brown KM, Dennis JF, et al. An analysis of anatomy education before and during Covid-19: May-August 2020. Anat Sci Educ. 2021;14(2):132-47.
27. Pham MT, Luu TTU, Mai THU, Thai TTT, Ngo TCT. EFL students' challenges of online courses at Van Lang University during the COVID-19 Pandemic. International Journal of TESOL & Education. 2022;2(2):1-26.
28. Mncube V, Mutongoza BH, Olawale E. Managing higher education institutions in the context of COVID-19 stringency: Experiences of stakeholders at a rural South African university. Perspectives in Education. 2021;39(1):390-409.
29. Celik B, Bilgin R, Yildiz Y. The views of instructors in foreign language teaching with distance education model during the Covid 19 pandemic process: A study at Tishk International University in Erbil, Iraq. International Journal of Social Sciences & Educational Studies. 2022;9(1):148-76.
30. Kristianto H, Gandajaya L. Offline vs online problem-based learning: A case study of student engagement and learning outcomes. Interactive Technology and Smart Education. 2023;20(1):106-21.
31. Alvi AH, Muhammad Bilal S, Abdul Rahim Alvi A. Technology, pedagogy & assessment: Challenges of COVID19-imposed E-teaching of ESP to Saudi female PY students. Arab World English Journal (AWEJ) Special Issue on Covid. 2021;19.
32. Salarvand S, Mousavi M-S, Rahimi M. Communication and cooperation challenges in the online classroom in the COVID-19 era: a qualitative study. BMC Med Educ. 2023;23(1):1-12.
33. Zou C, Li P, Jin L. Online college English education in Wuhan against the COVID-19 pandemic: Student and teacher readiness, challenges and implications. PloS one. 2021;16(10):e0258137.
34. Aljarrah AA, Ababneh MA-K, Cavus N. The role of massive open online courses during the COVID-19 era: Challenges and perspective. New Trends and Issues Proceedings on Humanities and Social Sciences. 2020;7(3):142-52.
35. Daliri BO M, M Majd H, Moradi A. Investigating a Newly Developed Educational Orthopedic Application for Medical Interns in a Before-after Quasi-clinical Trial Study. BMC Med Educ. 2021;21(1):1-10.
36. Samra S, Wu A, Redleaf M. Interactive iPhone/iPad app for increased tympanic membrane familiarity. Ann Otol Rhinol Laryngol. 2016;125(12):997-1000.
37. Liu R-F, Wang F-Y, Yen H, Sun P-L, Yang C-H. A new mobile learning module using smartphone wallpapers in identification of medical fungi for medical students and residents. Int J Dermatol. 2018;57(4):458-62.
38. Bonabi M, Mohebbi S, Martinez-Mier E, Thyvalikakath T, Khami M. Effectiveness of smart phone application use as continuing medical education method in pediatric oral health care: a randomized trial. BMC Med Educ.. 2019;19(1):1-7.
39. Parasuraman S, Sam AT, Yee SWK, Chuon BLC, Ren LY. Smartphone usage and increased risk of mobile phone addiction: A concurrent study. Int J Pharm Investig. 2017;7(3):125.
40. Deng T, Kanthawala S, Meng J, Peng W, Kononova A, Hao Q, et al. Measuring smartphone usage and task switching with log tracking and self-reports. Mob Media Commun. 2018;7(1):3-23.
41. Rinekso AB, Muslim AB. Synchronous online discussion: teaching English in higher education amidst the covid-19 pandemic. JEES (Journal of English Educators Society). 2020;5(2):155-62.
42. Akram H, Aslam S, Saleem A, Parveen K. The challenges of online teaching in COVID-19 pandemic: A case study of public universities in Karachi, Pakistan. Journal of Information Technology Education Research. 2021;20:263.
43. Nieto-Escamez FA, Roldán-Tapia MD. Gamification as online teaching strategy during COVID-19: A mini-review. Front Psychol. 2021;12:648552.
44. Chemnad K, Alshakhsi S, Almourad MB, Altuwairiqi M, Phalp K, Ali R, editors. Smartphone Usage before and during COVID-19: A Comparative Study Based on Objective Recording of Usage Data. Informatics; 2022: MDPI.
45. Alam GM, Asimiran S. Online technology: Sustainable higher education or diploma disease for emerging society during emergency–comparison between pre and during COVID-19. Technol Forecast Soc Change. 2021;172:121034.
46. Mosa ASM, Yoo I, Sheets L. A systematic review of healthcare applications for smartphones. BMC Med Inform Decis Mak. 2012;12(1):1-31.
47. Oulasvirta A, Rattenbury T, Ma L, Raita E. Habits make smartphone use more pervasive. Pers Ubiquitous Comput. 2012;16:105-14.
48. Hakim B. Technology integrated online classrooms and the challenges faced by the EFL teachers in Saudi Arabia during the COVID-19 pandemic. International Journal of Applied Linguistics and English Literature. 2020;9(5):33-9.
49. Mohamed HA. Using Mobile Applications to Enhance ESL Learning: Greensboro College; 2022.
50. Farrah M, Abu-Dawood A. Using mobile phone applications in teaching and learning process. 2018.