Research Article

Evaluation of the Medical Students' Satisfaction with Learning About Diabetes Through the Mobile App During the COVID-19 Pandemic

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Abstract

Background: The use of technology in distance education can help cross the borders of space and time for lifelong learning. One of the active learning methods is the use of the mobile apps with the potential to develop medical education.

Objectives: The aim of this study was to evaluate the efficacy of using diabetes educational mobile app in the endocrine physiology virtual classroom during the COVID-19 pandemic.

Methods: In the present study, an educational mobile app for diabetes, including the information modules, as well as educational videos made by the researchers of this study, was designed for 32 medical students of Abadan University of Medical Sciences who had endocrine physiology courses in the first semester of the academic year 2019 - 2021. A researcher-made questionnaire consisting of 10 questions about learning the educational content of diabetes through the application containing educational videos in the virtual classroom of endocrine physiology, scoring based on a five-point Likert scale, was provided. The data were analyzed by SPSS 21 using descriptive statistics.

Results: The results obtained based on the highest satisfaction percentage were as follows: creativity in learning (90.625%), fast learning (87.5%), accessible learning (84.375%), practical learning (81.25%), sustainable learning (81.25%), eagerness to learn (78.78%), attractive learning (78.125%), accurate learning (78.125%), reducing the student's dependence on the teacher (75%), and feeling more confident (75%).

Conclusions: Using educational applications along with other teaching methods can lead to fast, creative, practical, accurate, and lasting learning, and due to its attractiveness, it creates a desire to learn in people.

Keywords: Mobile Applications, Diabetes, Medical Education

1. Background

The year 2020 was spent with the deadly coronavirus, which has threatened our existence and disrupted our daily lives. The virus may change our whole life, but it forced us to find other sources to cope with our lives. Virtual classes will be a new norm for our educational institutions. Online courses are gradually accelerating. There comes a time when a full degree is awarded to students without attending university or college (1).

Distance education is believed to be as effective in higher education as traditional education (2). The use of technology in distance education can help cross the borders of space and time for lifelong learning (3, 4). Many academic institutions invest heavily in technology-based classes to adapt to the new generation of students whose technology is an important part of their lives (5). Active learning is defined as any instructional method that engages students in the learning process (6). Tools such as mobile devices and applications or "apps" can help engage students and improve learning (7). Therefore, one of the most effective tools for active learning is using a mobile device (8).

Diabetes is a progressive and chronic disorder that has become a major health problem worldwide, especially in developing countries (9, 10). Medical students should be well educated to prevent possible misdiagnosis that may lead to the patient's death in the future (11).

Medical students use mobile devices in their daily activities (12). There are about 3.8 billion mobile users worldwide (13). Mobile learning (m-learning) is becoming a new method in the field of medical education (12). It is defined as the use of wireless small and portable devices, such as cell phones, smartphones, personal digital assistants, tablets, and personal computers, for communication and educational purposes (14).

With the advent of mobile technologies, educators can

adapt their traditional teaching methods to the 21st century digital learning environment (7). Mobile technologies, without time and space constraints, can increase students' enthusiasm for learning and provide the opportunity to learn in dead and dynamic times. Other benefits include accuracy and ease of teaching, 24-hour teaching, the reduced workload of the face-to-face education system, and reduced face-to-face education costs (15-17). Most users of m-learning are higher education students (18). Many medical students and educators use mobile technologies in education and have a good attitude toward using m-learning (19, 20), and have the potential to develop medical education (21).

2. Objectives

Here, we need to prove the effectiveness of using mobile educational applications in the education process so that in the future, this method can be used to promote not only medical education but also other fields. The purpose of our study was to investigate the effectiveness of learning diabetes educational content through a mobile-based app in medical students of the Abadan University of Medical Sciences during the coronavirus disease 2019 (COVID-19) pandemic.

3. Methods

In the present descriptive study, an educational mobile app for diabetes, including the information modules, as well as educational videos made by the researchers of this study, was designed for 32 medical students of Abadan University of Medical Sciences who had endocrine physiology courses in the first semester of the academic year 2019-2021 during the COVID-19 pandemic. This educational application, along with other virtual teaching methods, was provided to students through links as well as the Navid Learning Management System (LMS). The structure of the pancreas, a history of diabetes, familiarity with diabetes, types of diabetes, risk factors, complications, diagnosis and treatment, calorie intake, diabetes and lifestyle, and diabetes and exercise were some of these modules.

3.1. App Preparation

The research team designed and produced the content of the diabetes application by purchasing the 'JoApp' App Builder produced by Sepahan Data Tools Company. The application was purchased by researchers and designed and developed by the application developer. This application is powered by the Java language:

- App Name: Diabetes

- Package Name: ir.abadan.diabetes
- Version: V1.0
- Size: 78 MG
- Category: Educational
- The execution environment: Android
- Language: Persian

To prepare the content for the application, the categories were first defined, and after reading many articles and simplifying the content, we drew a mind map, based on which we included the educational content in the subcategories defined in a language understandable to the students and general population.

We tried to use pictures and infographics as much as possible to understand more in less time. To increase the attractiveness of the application, educational videos made with different animation software were produced by the researchers, and some of them were included inside the app. The rest of the educational videos were included in Aparat, the video-sharing service, to prevent the increase in the size of app and were constantly updated. This application was developed by the research team, and all property rights belong to the research team.

A researcher-made questionnaire consisting of three parts was prepared. The first part was about the purpose of the project and how to complete the questionnaire, the second part included students' demographic information, and the third part contained 10 questions about learning the educational content of diabetes through a mobile app containing educational videos in the virtual classroom of endocrine physiology, and the questionnaire was scored based on a five-point Likert scale (strongly agree, agree, neutral, disagree, and strongly disagree).

The questionnaire was reviewed by 10 faculty members of the university and students in terms of face validity and content validity, and its reliability was assessed on 24 students by Cronbach's alpha method. To measure the reliability of the questionnaire, in two intervals of 2 weeks, the designed questionnaire assessing the prepared app for diabetes distance learning was given to students, and its Cronbach's alpha was 0.881.

This study was performed on a group of medical students (32 students) selected by census method.

The questionnaires were designed online, and the link was provided to 53 medical students who had endocrine physiology courses in the first semester of 2019 - 2021, of whom 32 students answered the questionnaires. Filling in the questionnaire was optional for the students, and this issue did not affect the students' evaluation results. After collecting data and organizing them, they were analyzed by Statistical Package for the Social Sciences (SPSS) software version 21 using descriptive statistics.

4. Results

In the present study, 32 medical students of the Abadan University of Medical Sciences participated. Students were in the age range of 19 to 35 years (mean: 21.65 $\pm$ 3.86), and 43.75% of them were male, and 56.25% were female.

Table 1 presents the statements of the designed mobile app, and the frequency of students rated the statements. The statement "learning the educational content of diabetes through the mobile application containing educational videos increases the creativity of students" was found with the highest level of satisfaction from the perspective of medical students.

Overall, the following results were obtained based on the highest satisfaction levels: (1) creativity in learning (90.625%); (2) fast learning (87.5%); (3) accessible learning (84.375%); (4) practical learning (81.25%); (5) sustainable learning (81.25%); (6) eagerness to learn (78.78%); (7) attractive learning (78.125%); (8) accurate learning (78.125%); (9) reducing the student's dependence on the teacher (75%); and (10) feeling more confident (75%).

5. Discussion

The findings of the present study showed that the educational mobile app facilitated learning and was accessible. Gangaiamaran and Pasupathi stated that mobile assisted language learning (MALL) is easily accessible for students with no space or time limits (22). In a study by Hashim et al., the off-line feature helped users to access learning content via the application, which had been installed on their mobile devices (23). The students found that their interaction with the educational apps enhanced their qualifications (24). On the other hand, some students did not understand the use and the easiness of usage of educational apps on mobile devices (24).

In our study, most students believed that educational mobile apps speed up learning. In a study by Chang et al., the speed of learning and near transfer are interrelated and identify the neural mechanisms by which faster learners transmit their information better (25). On the other hand, Doghonadze stated that fast learning seldom stimulates students' creativity, and unless they are very intellectual, they may try to memorize the content, instead of trying to understand it (26). Keney et al. assessed the effects of using apps in clinical practice and showed that such apps speed up access to healthcare information. They believed that access to mobile apps during medical procedures was not a barrier to provide services, and they offer effective and continuous services (27).

We made educational videos to make the learning more interesting. In this study, the majority of medical stu-

dents believed that using the educational videos of the diabetes app would make them more interested in learning. Hussain et al., in a systematic review, showed that teaching and learning by mobile educational apps have become mobile and attractive by playing videos in the classroom and using interesting content (28). This finding is in line with our results. Animations, which were developed by Demir and Akpınar, had a positive effect on students' learning and motivated them to learn (29). Calderon et al. showed that diabetes education through animation had a positive effect on improving health literacy about diabetes in the Latino population with limited knowledge about health (30). Sporrong reported that animations can help to improve user interaction in terms of speed to perform specific tasks (31). In our review, we did not find a study that undermines the attractiveness of education with mobile learning apps.

According to our study, the use of such an app containing educational videos reduces the student's dependence on the teacher in learning diabetes. This finding is consistent with the findings of Klímová and Kacetl and Klímová studies (32, 33). According to a meta-analysis using a standard statistical mean difference (SMD), due to the different measurement tools, students who learned through mobile apps were more confident than those who used traditional learning methods (34). Osman and Abdel Haliem declared that using mobile apps empowers students by creating a sense of autonomy and helping them to develop self-directed learning skills (35). Hidayati and Diana reported that students' positive response to the use of an educational app was a sign of enhanced independent English learning outside the classroom. They revealed that the teacher is no longer the only learning source for the students. The students can learn English while spending time on social media or involving in various other pop-culture categories; thus, teachers should encourage them to make use of the available resources to help them improve their English (36). Motivation is the most important advantage of independent learning (37). Jou et al. (38), Baby (39), and Khan et al. (40) showed that the use of mobile apps strengthens students' motivation, which was in line with our study. Demeir and Akpınar reported that mobile learning may significantly increase students' motivation by creating a positive impact on academic achievement and performance (29). Students' intrinsic motivation was enhanced by mobile apps through continuous assessment of individual progress, increased curiosity in learning, and enhanced control over the study (41).

In our study, the majority of students agreed that the use of mobile educational apps boosts creativity in learning. Creativity is essential to innovation, novelty, and sustenance (42). Creativity can cause teachers to develop the

Table 1. The Satisfaction Level of the Medical Students of the Abadan University of Medical Sciences About the Designed Mobile App for Diabetes Distance Learning [a], [b]

Statement	A	B	C	D	E
The designed mobile app for diabetes containing educational videos provides fast learning.	10 (31.250)	18 (56.250)	4 (12.5)	0 (0)	0 (0)
The designed diabetes mobile app for diabetes containing educational videos provides accurate learning.	9 (28.125)	16 (50)	6 (18.750)	1 (3.125)	0 (0)
Learning about diabetes through the designed mobile app containing educational videos is practical.	9 (28.125)	17 (53.125)	6 (18.750)	0 (0)	0 (0)
Learning about diabetes through the designed mobile app containing educational videos is more accessible.	11 (34.375)	16 (50)	3 (9.375)	2 (6.250)	0 (0)
Learning about diabetes through the designed mobile app containing educational videos is attractive.	6 (18.750)	19 (59.375)	4 (12.5)	2 (6.250)	1 (3.125)
The designed mobile app for diabetes containing educational videos provides sustainable learning.	7 (21.875)	19 (59.375)	5 (15.625)	1 (3.125)	0 (0)
The designed mobile app for diabetes containing educational videos increases the creativity of students.	9 (28.125)	20 (62.5)	3 (9.375)	0 (0)	0 (0)
The designed mobile app for diabetes containing educational videos reduces the student's dependence on the teacher.	6 (18.750)	18 (56.250)	4 (12.5)	4 (12.5)	0 (0)
The designed mobile app for diabetes containing educational videos makes the student feel more confident.	10 (31.250)	14 (43.750)	7 (21.875)	1 (3.125)	0 (0)
The designed mobile app for diabetes containing educational videos increases the eagerness to learn.	10 (30.303)	16 (48.485)	6 (18.182)	0 (0)	0 (0)

[a] A = strongly agree; B = Agree; C = Neutral; D = Disagree; E = strongly disagree.
[b] Values are expressed as No. (%).

skills of their students without their curriculum lag behind (43). Studies seldom describe how higher education educators use mobile devices to boost the student's creativity (22). Jahnke and Liebscher reported that in-depth analysis using the creative approach reveals three types of creativity that enhance meaningful learning with the mobile app (24).

Accuracy and practicality were other advantages of the designed mobile app in our study mentioned by students. The main factor determining the value of an application may be its ability to provide meaningful, accurate, and timely information to the user (44). Tucker et al. assessed the effectiveness of health mobile apps for new mothers during the postpartum period and showed that the current general apps do not provide enough information about maternal health, but those providing more evidence-based information with functional design meet most of these standards, however, they are unlikely to be downloaded by users (45). Therefore, it seems that although most of the apps reviewed were not specialized for students, most studies have emphasized the need to include evidence-based information to foster the accuracy of the information contained (46). Practicality is another parameter that influences teaching (47). According to Payne et al., medical students, the medical apps were used from 1 to 30 min by mostly on disease diagnosis/management and medication reference. They suggested the development of more apps to support their training and clinical

practice (48). In a study by Rowe and Sauls, most clinicians used apps in their practice (60%) and reported their benefits (49). In a study by Chase et al., students were more likely to use devices in 'down-time' rather than as part of their clinical learning (50).

In addition to the benefits mentioned, there are problems in using such apps, including the use of e-learning by organizations and individuals, the technological limitations of mobile devices, and cultural issues (51). Although the majority of college students own a smartphone, there may be students who do not own one (52). Individual limitations include the lack of initiation, no willingness to try new events, relatively inadequate training of the personnel of new technologies and their applications, and low stakeholder participation in the transition to e-learning (53-55). Providing examples of successful implementation of mobile apps as well as online apps in the curriculum of the universities is urgently needed, which will enhance the creativity of all those involved in learning through technology (56).

5.1. Conclusions

Using mobile educational apps along with other teaching methods can lead to fast, creative, practical, accurate, and lasting learning, and due to their attractiveness, it creates a desire to learn in people. As educational apps are mostly interesting and motivate students to learn, instructors should use them alongside their teaching to have bet-

ter assessment results, provided that these apps are intelligently designed.

Footnotes

Authors' Contribution: Study concept and design, Esmat Radmanesh, Seyedeh Zeinab Ghaheri, and Alireza Hazbehnezhad; Analysis and interpretation of data, Esmat Radmanesh, and Fatemeh Maghsoudi; Drafting of the manuscript, Esmat Radmanesh, Seyedeh Zeinab Ghaheri; Critical revision of the manuscript for important intellectual content, Esmat Radmanesh; Statistical analysis, Fatemeh Maghsoudi.

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References

1. Alhat S. Virtual classroom: A future of education post-COVID-19. *Shanlax Int J Educ*. 2020;**8**(4):101–4. doi: 10.34293/education.v8i4.3238.
2. Stephens ML, Coryell J, Pena C. Adult education-related graduate degrees: Insights on the challenges and benefits of online programming. *Adult Education Research Conference*. Oklahoma, USA. New Prairie Press; 2017.
3. Narciss S, Proske A, Koerndle H. Promoting self-regulated learning in web-based learning environments. *Comput Hum Behav*. 2007;**23**(3):1126–44. doi: 10.1016/j.chb.2006.10.006.
4. Lozano R, Lukman R, Lozano FJ, Huisingh D, Lambrechts W. Declarations for sustainability in higher education: Becoming better leaders, through addressing the university system. *J Clean Prod*. 2013;**48**:10–9. doi: 10.1016/j.jclepro.2011.10.006.
5. Nicol AAM, Owens SM, Le Coze SSCL, MacIntyre A, Eastwood C. Comparison of high-technology active learning and low-technology active learning classrooms. *Act Learn High Educ*. 2017;**19**(3):253–65. doi: 10.1177/1469787417731176.
6. Huang CD, Tseng HM, Jenq CC, Ou LS. Active learning of medical students in Taiwan: A realist evaluation. *BMC Med Educ*. 2020;**20**(1):487. doi: 10.1186/s12909-020-02392-y. [PubMed: 33272263]. [PubMed Central: PMC7713042].
7. Luna-Nevarez C, McGovern E. On the use of mobile apps in education: The impact of digital magazines on student learning. *J Educ Technol Syst*. 2018;**47**(1):17–31. doi: 10.1177/0047239518778514.
8. Gallegos C, Gehrke P, Nakashima H. Can mobile devices be used as an active learning strategy? Student perceptions of mobile device use in a nursing course. *Nurse Educ*. 2019;**44**(5):270–4. doi: 10.1097/NNE.0000000000000613. [PubMed: 30394996].
9. Shrivastava SR, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. *J Diabetes Metab Disord*. 2013;**12**(1):14. doi: 10.1186/2251-6581-12-14. [PubMed: 23497559]. [PubMed Central: PMC3599009].
10. World Health Organization. *Definition, diagnosis and classification of diabetes mellitus and its complications: Report of a WHO consultation; Part 1, diagnosis and classification of diabetes mellitus*. Geneva, Switzerland: World Health Organization; 1999.
11. Seiden SC, Galvan C, Lamm R. Role of medical students in preventing patient harm and enhancing patient safety. *Qual Saf Health Care*. 2006;**15**(4):272–6. doi: 10.1136/qshc.2006.018044. [PubMed: 16885252]. [PubMed Central: PMC2564025].
12. Briz-Ponce L, Juanes-Mendez JA, Garcia-Penalvo FJ, Pereira A. Effects of mobile learning in medical education: A counterfactual evaluation. *J Med Syst*. 2016;**40**(6):136. doi: 10.1007/s10916-016-0487-4. [PubMed: 27098779].
13. Statista. *Number of smartphone users from 2016 to 2021*. Hamburg, Germany: Statista; 2021. Available from: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/.
14. Crompton H. A historical overview of mobile learning: Toward learner-centered education. In: Berge ZL, Muilenburg L, editors. *Handbook of Mobile Learning*. Oxfordshire, United Kingdom: Taylor & Francis; 2013. p. 3–14.
15. Ford M, Leinonen T. MobilED–Mobile tools and services platform for formal and informal learning. In: Ally M, editor. *Mobile learning: Transforming the delivery of education and training*. Athabasca, Canada: Athabasca University Press; 2009. p. 195–214.
16. Colley A, Comber C. Age and gender differences in computer use and attitudes among secondary school students: What has changed? *Educ Res*. 2010;**45**(2):155–65. doi: 10.1080/0013188032000103235.
17. Kadijevich D. Gender differences in computer attitude among ninth-grade students. *J Educ Comput Res*. 2016;**22**(2):145–54. doi: 10.2190/k4u2-pwqg-re8l-uv90.
18. Chee KN, Yahaya N, Ibrahim NH, Hasan MN. Review of mobile learning trends 2010-2015: A meta-analysis. *J Educ Techno Soc*. 2017;**20**(2):113–26.
19. Briz-Ponce L, Pereira A, Carvalho L, Juanes-Méndez JA, García-Peñalvo FJ. Learning with mobile technologies – Students' behavior. *Comput Hum Behav*. 2017;**72**:612–20. doi: 10.1016/j.chb.2016.05.027.
20. Kim KJ. Enhancing students' active learning and self-efficacy using mobile technology in medical English classes. *Korean J Med Educ*. 2019;**31**(1):51–60. doi: 10.3946/kjme.2019.118. [PubMed: 30852861]. [PubMed Central: PMC6589634].
21. Masters K, Ellaway RH, Topps D, Archibald D, Hogue RJ. Mobile technologies in medical education: AMEE guide No. 105. *Med Teach*. 2016;**38**(6):537–49. doi: 10.3109/0142159X.2016.1141190. [PubMed: 27010681].
22. Gangaiamaran R, Pasupathi M. Review on use of mobile apps for language learning. *Int J Appl Eng Res*. 2017;**12**(21):11242–52.
23. Hashim AS, Wan Ahmad WF, Ahmad R. Mobile learning course content application as a revision tool: The effectiveness and usability. *2011 International Conference on Pattern Analysis and Intelligence Robotics (ICPAIR 2011)*. Kuala Lumpur, Malaysia. IEEE; 2011. p. 184–187.
24. Jahnke I, Liebscher J. Three types of integrated course designs for using mobile technologies to support creativity in higher education. *Comput Educ*. 2020;**146**:103782. doi: 10.1016/j.compedu.2019.103782.
25. Chang H, Rosenberg-Lee M, Qin S, Menon V. Faster learners transfer their knowledge better: Behavioral, mnemonic, and neural mechanisms of individual differences in children's learning. *Dev Cogn Neurosci*. 2019;**40**:100719. doi: 10.1016/j.dcn.2019.100719. [PubMed: 31710975]. [PubMed Central: PMC6974913].
26. Doghonadze N. Slow education movement as a student-centered approach. *6th International Research Conference on Education, Language & Literature*. Tbilisi, Georgia. Academia; 2016. p. 65–73.
27. Keney G, Achampong EK, Attah NS. The effects of mobile phone use in clinical practice in Cape Coast Teaching Hospital. *Online J Public Health Inform*. 2018;**10**(2). e210. doi: 10.5210/ojphi.v10i2.9333. [PubMed: 30349628]. [PubMed Central: PMC6194100].

28. Hussain A, Mkpojiogu EOC, Babalola ET. Using mobile educational apps to foster work and play in learning: A systematic review. *Int J Interact Mob Technol*. 2020;**14**(18):178. doi: 10.3991/ijim.v14i18.16619.

29. Demir K, Akpınar E. The effect of mobile learning applications on students' academic achievement and attitudes toward mobile learning. *Malays Online J Educ Technol*. 2018;**6**(2):48–59. doi: 10.17220/mojet.2018.02.004.

30. Calderon JL, Shaheen M, Hays RD, Fleming ES, Norris KC, Baker RS. Improving diabetes health literacy by animation. *Diabetes Educ*. 2014;**40**(3):361–72. doi: 10.1177/0145721714527518. [PubMed: 24676274]. [PubMed Central: PMC6309339].

31. Sporrong K. How animations in a mobile web application impact user interaction.In: Bensch S, Hellstrom T, editors. *21st Student Conference in Computing Science*. Umeå, Sweden. USCCS; 2017. p. 139–58.

32. Kacetl J, Klímová B. Use of smartphone applications in English language learning—a challenge for foreign language education. *Educ Sci*. 2019;**9**(3):179. doi: 10.3390/educsci9030179.

33. Klimova B. Impact of mobile learning on students' achievement results. *Educ Sci*. 2019;**9**(2):90. doi: 10.3390/educsci9020090.

34. Chen B, Wang Y, Xiao L, Xu C, Shen Y, Qin Q, et al. Effects of mobile learning for nursing students in clinical education: A meta-analysis. *Nurse Educ Today*. 2021;**97**:104706. doi: 10.1016/j.nedt.2020.104706. [PubMed: 33360012].

35. Osman R, Abdel Haliem R. Mobile ESL apps and students motivation: A case study. *The European Conference on Language Learning*. Japan. The International Academic Forum; 2018.

36. Hidayati T, Diana S. Students' motivation to learn English using mobile applications: The case of duolingo and hello English. *Journal of English Education and Linguistics Studies*. 2019;**6**(2):189–213. doi: 10.30762/jeels.v6i2.1233.

37. Meyer B, Haywood N, Sachdev D, Faraday S. *What is independent learning and what are the benefits for students?* London, UK: Department for Children, Schools and Families Research Report; 2008. Available from: http://www.curee.co.uk/files/publication/[site-timestamp]/Whatisindependentlearningandwhatarethebenefits.pdf.

38. Jou M, Lin YT, Tsai HC. Mobile APP for motivation to learning: An engineering case. *Interact Learn Environ*. 2015;**24**(8):2048–57. doi: 10.1080/10494820.2015.1075136.

39. Baby K T. Generating internal motivation through mobile application technology. *IntechOpen*. 2019. doi: 10.5772/intechopen.88346.

40. Khan T, Johnston K, Ophoff J. The impact of an augmented reality application on learning motivation of students. *Advances in Human-Computer Interaction*. 2019;**2019**:1–14. doi: 10.1155/2019/7208494.

41. Li KC, Lee LYK, Wong SL, Yau ISY, Wong BTM. Effects of mobile apps for nursing students: Learning motivation, social interaction and study performance. *Open Learning: The Journal of Open, Distance and e-Learning*. 2018;**33**(2):99–114. doi: 10.1080/02680513.2018.1454832.

42. Kaplan DE. Creativity in education: Teaching for creativity development. *Psychology*. 2019;**10**(2):140–7. doi: 10.4236/psych.2019.102012.

43. Ahmadi N, Besançon M. Creativity as a stepping stone towards devel   oping other competencies in classrooms. *Educ Res Int*. 2017;**2017**:1–9. doi: 10.1155/2017/1357456.

44. Ventola CL. Mobile devices and apps for health care professionals: uses and benefits. *P T*. 2014;**39**(5):356–64. [PubMed: 24883008]. [PubMed Central: PMC4029126].

45. Tucker L, Villagomez AC, Krishnamurti T. Comprehensively addressing postpartum maternal health: A content and image review of commercially available mobile health apps. *BMC Pregnancy Childbirth*. 2021;**21**(1):311. doi: 10.1186/s12884-021-03785-7. [PubMed: 33879089]. [PubMed Central: PMC8059182].

46. Kamaruzaman MF, Zainol IH. Behavior response among secondary school students development towards mobile learning application. *IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*. Penang, Malaysia. IEEE; 2012. p. 589–92.

47. Donoghue T, Voytek B, Ellis SE. Teaching creative and practical data science at scale. *Journal of Statistics and Data Science Education*. 2021;**29**(sup1):S27–39. doi: 10.1080/10691898.2020.1860725.

48. Payne KB, Wharrad H, Watts K. Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): A regional survey. *BMC Med Inform Decis Mak*. 2012;**12**:121. doi: 10.1186/1472-6947-12-121. [PubMed: 23110712]. [PubMed Central: PMC3504572].

49. Rowe M, Sauls B. The use of smartphone apps in clinical practice: A survey of South African physiotherapists. *S Afr J Physiother*. 2020;**76**(1):1327. doi: 10.4102/sajp.v76i1.1327. [PubMed: 32391442]. [PubMed Central: PMC7203535].

50. Chase TJG, Julius A, Chandan JS, Powell E, Hall CS, Phillips BL, et al. Mobile learning in medicine: an evaluation of attitudes and behaviours of medical students. *BMC Med Educ*. 2018;**18**(1):152. doi: 10.1186/s12909-018-1264-5. [PubMed: 29945579]. [PubMed Central: PMC6020287].

51. Almaiah MA, Jalil MA, Man M. Extending the TAM to examine the effects of quality features on mobile learning acceptance. *J Comput in Educ*. 2016;**3**(4):453–85. doi: 10.1007/s40692-016-0074-1.

52. Diliberto-Macaluso K, Hughes A. The use of mobile apps to enhance student learning in introduction to psychology. *Teach Psychol*. 2015;**43**(1):48–52. doi: 10.1177/0098628315620880.

53. Krotov V. Critical success factors in M-learning: A socio-technical perspective. *Commun Assoc Inf Syst*. 2015;**36**. doi: 10.17705/1cais.03606.

54. Şad SN, Göktaş Ö. Preservice teachers' perceptions about using mobile phones and laptops in education as mobile learning tools. *Br J Educ Technol*. 2014;**45**(4):606–18. doi: 10.1111/bjet.12064.

55. Lee P. Are mobile devices more useful than conventional means as tools for learning vocabulary? *IEEE 8th International Symposium on Embedded Multicore/Manycore SoCs*. Aizu-Wakamatsu, Japan. IEEE; 2014. p. 109–15.

56. Knohova L. The Art of Teaching with Mobile Applications. *International Conference on Distance Learning, Simulation and Communication 2017*. Brno, The Czech Republic. University of Finance and Administration; 2017. p. 147–53.