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EDUCATION & TRAINING

Mobile Learning in Medical Education

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Abstract
Currently, mobile learning is a new trend in medical education. Therefore, the aim of this study is to examine the use of m-learning in medical education and discuss its effect on student learning process in order to help future medical professionals deliver better care for patients and populations. This was done by conducting a literature search in the databases Web of Science, Scopus, and MEDLINE, and consequently by evaluating the findings of the selected studies. The results of this study confirm that mobile learning is efficient, especially in the acquisition of new knowledge and skills. Nevertheless, so far, the role of mobile learning has been perceived as an appropriate complement to traditional learning. Therefore, more research should be conducted on the efficacy of the use mobile learning in medical education, as well as to explore the unique features of mobile devices for the enhancement of learning outcomes.

Keywords Mobile learning · Medical students · Education · Efficacy · Limitations

Introduction

Currently, information and communication technologies (ICT) are used in all spheres of human activities, including education. The use of ICT radically affected traditional learning approaches such as teacher-centered learning, mass instruction, once pace to all, using only textbooks and learning only in classrooms. Students' learning began to be supported electronically in the form of e-learning. The learning approaches have become learner centered, flexible in sense of accessing it from anywhere and any-time, collaborative, or interactive [1]. However, with the emergence of mobile devices, such as netbooks, tablets or smart phones, the so-called mobile learning (m-learning) has become a new approach to traditional learning [2].

There are many definitions of m-learning. One of them is provided by Crompton [3] who defines m-learning as educating across various contexts via social and content interactions by using personal electronic devices. Park, Nam, and Cha [4] expand that m-learning is a new and independent part of e-learning where the education contents are handled solely by mobile technology devices. The important aspect of m-learning is that educational resources, tools and materials can be accessed at anytime and anywhere by using a mobile device [5]. Traxler [6] lists the main characteristics that define m-learning and differ it from e-learning. These include: spontaneity; privacy; portability; situation; informality; bite size; light weight; context awareness; connectivity; personalized device; and interactivity. It is especially the portability and light weight which enable learners to carry them easily and thus access the learning content *on the go* via simple navigation, when they travel by bus or train or waiting for their courses, i.e. independent of their location. In addition, its content is also shorter, more personalized and interactive than traditional e-learning materials, whose content is more linear and consists of longer compact units [7]. Therefore, it seems that e-learning is mainly suitable for dissemination of knowledge, its in-depth analysis and retention, as well as for the training of busy professional staff, while m-learning appears to be suitable for fast acquisition of knowledge and skills, its assessment and immediate feedback [8].

As research shows [9, 10], both e-learning and m-learning have a positive effect on the educational process, particularly when compared with no intervention. In fact, they seem to have effectiveness similar to traditional learning methods [9]. However, Sung, Chang, and Lie [11] claim that the overall effect of using mobile devices in education is better than when using desktop computers or not using mobile devices as an intervention, with a moderate effect size of 0.523. Ciampa [12] emphasizes its motivational role in the whole process of learning because ownership of the device increases commitment to using and learning from it. Lee, Han, and Lee [13]

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expand that m-learning positively affects learning attitude, improving education interest and concentration.

Mobile devices have also become ubiquitous in medical education, where they are used, for example, for the assessment, examination, collection of supervisory reports and student feedback, or downloadable course-specific materials [14]. As Masika et al. [15] point out, mobile learning is popular among medical students and should be used in promoting access and quality of medical education. In addition, 80% of doctors in the USA currently use a smartphone or a medical app in their practice [16].

Therefore, the aim of this study, on the basis of the literature review of randomized controlled trials, is to examine the use of m-learning in medical education and discuss its effect on student learning process in order to help future medical professionals deliver better care for patients and populations.

Methods

The methodology of this review study is based on Moher, Liberati, Tetzlaff, Altman [17]. The methods used for this review study include a literature search in the world's acknowledged databases Web of Science, Scopus, and MEDLINE. The search was based on the key words: *mobile technologies* AND *medical education*; *mobile learning* AND *medical education*. The search was done for the period of 2010 till December 2017. The selection period starts with the year of 2010 because this is the year when mobile learning started to penetrate into medical education. In addition, methods of comparison and evaluation of the findings from the selected studies were applied. The study was included if it matched the corresponding period, i.e., from 2010 up to December 2017; if it was aimed at the research topic, i.e., at the use of mobile learning in medical education, especially for those studying medicine, as well as for doctors and other healthcare personnel; if it was a randomized controlled trial (RCT); and if it was written in English. Therefore, survey studies, e.g. [15], or the articles dealing with general public, e.g. [18], were excluded. Thus, theoretical articles, review articles and book chapters were excluded. Nevertheless, the review articles and other descriptive research studies were then used in other parts of this manuscript (i.e., Introduction or Discussion) in order to describe and compare the findings.

Findings

Altogether ten RCT [19–28] were detected. Four studies analyzed the impact of text messaging via mobile phones on the delivery of learning materials [20, 25, 26] and on personal guidance [27], two studies evaluated the effectiveness of mobile learning apps in the acquisition of new knowledge [21, 24], one focused on mobile augmented reality [19], one on the impact of a mobile device (netbook) on learning [22], one on the use of multimedia software app for mobile platforms and its effect on teaching and learning process [23] and one study evaluated the use of mobile learning videos on student performance [28]. Overall, all identified studies evaluated the effectiveness of a mobile device or mobile app as an educational tool on learning outcomes. In addition to that, several studies also concentrated on some unique features of mobile device or application such as its attractiveness [19], content interactivity [21], multimedia attractiveness [23], and personalized approach [27]. All of them used standardized methods of assessment such as pre- and post- tests, descriptive statistics, paired t-test, and multiple linear regression. Apart from one RCT [25], the samples of subjects were relatively small. In addition, the intervention period, depending on the type of mobile device and learning purpose, also significantly differed. However, predominantly, the intervention period was short. The findings of the RCT are summarized in alphabetical order of their first author in Table 1 below.

Discussion

As the results of this review show, all studies apart from two [25, 26] confirmed that the use of mobile device or mobile app as an educational tool had a positive effect on the acquisition of knowledge and skills among medical students. The reason is that these medical students, usually at the age of 18–26, use mobile devices, especially smartphones on a daily basis and therefore, they are willing to exploit them in their studies [21]. Mobile devices are nowadays available and easily accessible. Albrecht et al. [19] and Bruce-Low et al. [22] also point out that these are especially attractiveness and interactivity that prompt student engagement in using these mobile devices.

Furthermore, the findings reveal that the acquisition and retention of new knowledge are particularly efficient when using a mobile device [19, 21–23, 27, 28]. This is also supported by de Sena et al. [23] who claim that the personal computing landscape is currently characterized by increasingly widespread access to content on mobile devices. The availability and portability of knowledge can enhance learning, which seems particularly valuable as it can optimize the teacher's role in solving the specific difficulties of each student. The findings also show that mobile devices and apps were found efficient in learning new medical procedure [23] and acquiring new skills [24], as well as improving practice behavior of general practitioners in the management of a disease [27]. This is also confirmed by other studies. Masters and Al-Rawahi [29] report that their medical students use the mobile apps for learning clinical guidelines and for obtaining medical reference tools. Masika et al. [15] in their study state that the most accessed mobile app types were disease management apps (88% of respondents),

Table 1 An overview of the main findings from the detected RCT (author's own processing)

Study	Objective	Number of subjects	Type of mobile learning intervention	Intervention period	Findings	Limitations
Albrecht et al. [19]	To compare the impact of the heightened realism of a self-developed mAR blended learning environment (mARble) on learners to textbook material.	10 third-year medical students, randomized into a control and intervention group.	One iPhone with a preinstalled copy of mARble.	30 min.	The mARble group (6/10) showed greater knowledge gain than the control group (4/10) (Wilcoxon z = 2.232, $P = .03$).	A small sample group; short-term intervention.
Alipour et al. [20]	To compare effects of the traditional face-to-face method with mobile learning delivered as text messages by cell phone.	60 female nurses, randomized into a control and intervention group.	Short messages sent via a mobile phone.	17 days.	Teaching via SMS may probably replace traditional face-to-face teaching for continuing education in working nurses.	A small sample group; short-term intervention.
Briz-Ponce et al. [21]	To examine the use of a mobile app as a tool to learn anatomy and the traditional method of teacher's explanation.	30 students the Medical School at the University of Salamanca, randomized into a control and intervention group.	Learning with an anatomic app.	Three sessions from June 2014 to November 2015.	The findings of the investigation suggest that the performance of learners using mobile apps is statistical better than the students using the traditional method.	A small sample group.
Bruce-Low et al. [22]	To examine whether learning using a mobile learning device (Samsung NC10 Netbook) loaded with interactive exercises promotes learning compared with a traditional library exercise.	55 students from an undergraduate sports science course ($n = 28$) and medical course ($n = 27$), randomized into a control and intervention group.	A Samsung NC10 Netbook (Samsung, Beijing, China). The device elicits an acceptable processing speed through a 1.6-GHz, loaded with a video detailing the ECG technique incorporating multi-choice questions and interactive exercises.	3 weeks.	The Netbooks were an effective additional learning tool, significantly enhancing knowledge and understanding in students.	A small sample group; short-term intervention.
de Sena et al. [23]	To develop and validate a multimedia software application for mobile platforms to assist in the teaching and learning process of design and construction of a skin flap.	50 sixth-year medical students divided into a control and intervention group with 25 subjects in each.	The control group was exposed for 5 min to a standard text-based print article, while the test group used multimedia software describing how to fashion a rhomboid flap.	5 min.	The computer-assisted learning (CAL) group had superior performance as confirmed by checklist scores (p,0.002), overall global assessment ($p = 0.017$) and post-test results (p,0.001).	A small sample group; short-term and only one type intervention.
Fernandez-Lao et al. [24]	To investigate whether a mobile application, as a supplement to traditional learning, is useful for physiotherapy students in the acquisition of palpation and ultrasound skills in the shoulder area.	49 students, randomized into a control and intervention group.	A mobile app with learning self-study materials.	One semester.	Scores were significantly higher in the experimental group than in the control group for the majority items in the ultrasound assessment; positioning of patient ($p < .001$), positioning of ultrasound probe ($p = 0.007$), handling of ultrasound probe ($p = .013$) and global OSCE ($p < .001$) and skills in palpation of the shoulder; position of patient ($p = .009$),	A small sample group; short-term intervention.

Table 1 (continued)

Study	Objective	Number of subjects	Type of mobile learning intervention	Intervention period	Findings	Limitations
					direction of palpation contact ($p = .021$) and global OSCE ($p = .034$).	
Gill et al. [25]	To test whether a Short Message Service (SMS)-based mobile CME (mCME) intervention could improve medical knowledge among a cadre of Vietnamese CHWs (Community Based Physician's Assistants±CBPAs).	638 graduates of an accredited 2-year medical training college program, and were active clinicians working in primary care at provincial Commune Health Centers in the North of Vietnam; they were divided into three groups: one control group, one passive intervention groups and one active intervention group.	Daily short text messages with medical facts.	Six months.	The SMS-based mCME intervention, while feasible and acceptable, did not result in increased medical knowledge.	Participants shared the same workplace; sms only in English; messages were randomized, not according to the thematic areas.
Hoonpongsimanont et al. [26]	To evaluate the effectiveness of text messaging versus email, as a delivery method to enhance knowledge retention of emergency medicine (EM) content in EM residents.	58 residents were randomized into one delivery group: text message or email.	Text messaging versus e-mails.	Two months.	The use of text messaging to deliver EM education material did not enhance resident knowledge retention when compared to email.	A small sample group; short-term intervention.
Schopf, Flytkjaer [27]	To investigate whether an interactive Web-based course including personal guidance via email or cellular phone texting may be used to improve practice behavior of general practitioners in the management of atopic dermatitis.	46 physicians: 24 doctors were allocated to the intervention group and 22 doctors to the control group.	A Web-based course on the management of atopic dermatitis, which was combined with guidance via email or multimedia messaging service (MMS) through mobile phones from a dermatologist.	Six months.	A Web-based educational intervention aimed at general practitioners combined with personal support can reduce the number of atopic dermatitis patient referrals to specialists.	A small sample group.
Tews et al. [28]	To evaluate medical students' case presentation performance and perception when viewing short, just-in-time mobile learning videos using the iPod touch prior to patient encounters.	22 fourth-year medical students divided into a control and intervention group.	Just-in-time videos with the iPod touch.	Four month.	There was a statistically significant improvement in presentations when the videos were viewed for the first time ($p = 0.032$). There was no difference when the presentations were summed for the entire rotation ($p = 0.671$).	A small sample group; a homogeneous group of students; short-term intervention.

procedure guides (88%), and medical dictionaries (87%). Walsh [30] indicates that a lot of medical education on mobile devices is aimed at assessments.

The results of this review (cf. [21, 22, 28]) also suggest that learning via mobile devices should be used as a supplement to traditional, face-to-face learning. In this way, it can far more contribute to the enhancement, retention, and facilitation of the acquired knowledge and skills, as well as it can promote and develop the constructivist type of learning. This finding was also confirmed in a study by Bert et al. [31]. Moreover, Lumsden et al. [14] indicate that medical teachers should reflect on the use of mobile devices in their teaching and attempt to find the most suitable way of their exploitation in the educational process to meet students' needs. In fact, there is no need of no-intervention-controlled studies or comparisons with traditional teaching modalities, but there is a need of research studies exploring the strengths and weaknesses of the use of mobile devices in the enhancement of learning, as well as its effective use (cf. [32]).

However, in spite of the benefits of mobile learning such as its time-saving, easy of access and use, portability, or interactivity of its content, there are also certain constraints which hinder its exploitation. These include the cost of device, the small size of its screen, limited memory and battery, technical problems, or security issues (cf. [15, 21, 29]). Furthermore, the results also revealed that delivery of learning material via text messaging was not that effective (cf. [20, 25, 26]). The reason might be busy schedules of medical professionals [26] or the fact that explicit instructions for self-study were missing [25].

The limitations of this study consist in a limited choice of the selected studies, as well as in small sample sizes and slightly different methodologies used in them.

Conclusion

This study aimed to explore the use of mobile learning, especially in medical education, and discuss its effect on student learning process. The findings revealed that mobile learning was becoming a new trend in the medical educational process. In addition, it confirmed that it was efficient, especially in the acquisition of new knowledge and skills. Nevertheless, so far, the role of mobile learning has been perceived as an appropriate complement to traditional learning. Therefore, more research should be conducted on the efficacy of the use mobile learning in medical education, as well as to explore the unique features of mobile devices for the enhancement of learning outcomes.

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Compliance with Ethical Standards

Conflict of Interest Author declares that she has no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by the author.

Informed Consent Not applicable.

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