Smartphones, Trainees, and Mobile Education: Implications for Graduate Medical Education

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Smartphones are one of the fastest-growing sectors in the technology industry, and they continue to evolve to combine faster processors, better memory, and more efficient operating systems into a compact handheld device. Smartphones also offer a dynamic tool for use in personal and professional environments.[1] The role of smartphones in medicine continues to expand as additional uses and applications emerge. An estimated 80% of physicians, trainees, and medical students use smartphones, and this percentage is expected to increase.[2–4] Smartphones provide a multifaceted platform for mobile health care, allowing users to access a vast amount of information and interact with resources conveniently and quickly.[5] Applications range from patient monitoring to use as a tool for diagnosis, to communication and medical education.

Recent advances in smartphone technology have led many educators to extend their teaching methods into the mobile learning environment, providing an "anytime, anywhere" approach to learning. Mobile learning has been shown to have efficacy within the traditional classroom environment, and brief communications via short message service (SMS) supplement interactive classroom sessions, resulting in enhanced interest in and attention to classroom activity.[6] Given the nature of graduate medical education (GME), where trainees are expected to assimilate a vast amount of information that is constantly evolving, and often are away from traditional classroom settings, the benefits of mobile learning with its uninterrupted access to educational resources can be particularly advantageous.

In this perspective, we characterize the current and potential uses of smartphone technology in GME and provide recommendations for future studies on incorporating smartphone technology as an educational platform.

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Smartphones and Education

The smartphone, in addition to having voice and text communication capabilities, is equipped with Internet access, a high-quality camera, and a recording device. With each new generation, smartphones come with more memory, faster computing capabilities, bigger screens, and sharper resolution. These features allow for instant and reliable access not only to the Internet and its wealth of information, but also for constant social connectivity to personal and professional peer groups. Given these functionalities, the potential for smartphone technology to enhance traditional educational methods is tremendous.

Smartphones provide several mechanisms through which educational interventions can be administered (TABLE). Mobile learning makes use of web-based and mobile-based platforms already in common use among young adults and the public. In fact, up to 35% of Americans use a smartphone,[7] and development of educational material into text messages, applications (apps), or mobile website formats has the potential to target a broad audience. Incorporation of information on social networking sites into curricula also is feasible. The trend toward universal smartphone ownership and trainees' willingness to use this technology offer a viable avenue to improve and augment current educational practices.

Current Use of Smartphone Technology in GME

To date, research on use of smartphones in GME is limited, and there is a lack of high-quality studies investigating the outcomes of smartphone educational interventions.[1] Previous studies have shown that SMS interventions have led to increased quality of life, improved patient management, and overall improved learner satisfaction.[8–10] These studies showed use of SMS interventions overcame external barriers such as time and distance, but faced challenges with response rate as well as technical difficulties.[8] One study found that an SMS educational intervention had a significantly better effect on breast cancer knowledge in obstetrics-gynecology residents compared with traditional paper-based teaching.[11] This mobile learning method also generated more interest in the subject material, with 60% of participants reporting they found SMS more interesting and were more motivated by SMS than by information conveyed via a traditional booklet.

TABLE **Descriptions of Various Mechanisms of Delivering Educational Interventions via Smartphones**

Mechanism	Description	Examples
Short message service	▪ More commonly referred to as text messaging ▪ Instantly transmits information; may contain URL hyperlinks or picture attachments ▪ Can be sent en masse to large quantities of phone numbers	None currently available
Applications	▪ A wide variety of social, entertainment, and educational platforms out on the market, including a large number of health care apps[12] ▪ Range from diagnostic tools for clinicians to scientific libraries to disease management tools for patients[13]	*iResus*, *Netter's Anatomy Atlas*, *SCAT2*
Web-based	▪ Advantages include learning on demand, decreased cost, and ability to learn at great distances[14] ▪ A vast variety of intervention designs (interactive teaching modules, discussion boards, live streaming video, and more) accessed through smartphones' Internet capabilities[15] ▪ Use through computers has been found to be complementary to the curriculum and beneficial to the learning process[16–19]	*PubMed for Handhelds*
Social media	▪ More than 72% of young adults (ages 18–49) maintain at least one social media account and 36% maintain at least two[20] ▪ Preliminary evaluation in medical education reveals that social networking incorporated into curricula has the potential to enhance collaboration, problem solving, and networking[21–25]	Facebook, Twitter, blogs, YouTube, LinkedIn

Current smartphone apps for trainees include a variety of anatomy and dissection apps, including *Gray's Anatomy*, *Netter's Anatomy Flash Cards*, and *Zollinger's Atlas of Surgical Operations*.[13] The *Oxford Handbook of Clinical Surgery* is popular among British trainees.[26] Trainees can also benefit from a variety of apps designed to provide support to physicians in writing hospital prescriptions.[27] Other educational platforms, such as the recently developed SCORE (Surgical Council on Resident Education) curriculum, a web-based program for surgical education, could easily be transitioned to a smartphone platform for immediate and convenient learning.

To date, the literature evaluating the use and efficacy of educational modules delivered via smartphone applications is sparse. Examples include a randomized control trial assessing use of *iResus* (a smartphone app for advanced life support guidelines) by trainees during a cardiac arrest simulation test, which found significantly better performance for *iResus* users compared with the control group.[28] Participants reported this real-time training increased their confidence in making decisions during such an emergency, and they did not believe use of the app would indicate poor training.[28] Given that errors are more likely to be made during such high-stress emergencies or during periods of flow disruption,[29] applications like *iResus* can provide access to algorithms and drug doses for appropriate management plans that memory alone may not support.

In another category of smartphone functionalities, Hardyman et al[30] investigated the use and perceived value of a smartphone with a library of medical textbooks preloaded onto a micro secure digital card to support workplace learning. The electronic library provided constant access to information sources and was judged to be most useful for newly qualified physicians.[30] Participants reported the smartphone library assisted with patient care by supporting accurate prescribing and management, especially when senior physicians were not immediately available. However, the authors of the study cautioned that smartphone technology can only supplement, not replace, interaction and dialogue between trainees and their senior colleagues.[30]

In another study, a community hospital provided internal medicine residents with smartphones, allowing real-time access to evidence-based resources through the National Library of Medicine and other medical websites.[31] Participants reported high satisfaction with ease of use and found the information retrieved through their smartphones to both help with patient care and enhance academic activities. Social media, although increasingly integrated into medical education, has largely been documented in the undergraduate setting, with sparse data in the medical education literature.[32] A review of social media blogs in nephrology GME suggests that social networking can help to increase specialty interests, but use of social media as a teaching tool remains to be evaluated.[16]

Across these different mechanisms of incorporating smartphone technology into GME, common benefits include convenience, speed, usability, and portability.[11,28,30,31] In comparison with other cognitive aids, such as wall posters or flashcards, smartphone technology allows immediate access anywhere in a compact form.[33] Especially for just-in-time

information needs during clinical emergencies, smartphone training aids provide rapid access to medical resources and tools. Native applications for smartphones can be particularly beneficial in rural areas without wireless networks by providing a platform for wireless-free access to medical literature.[31]

Barriers to incorporating smartphone technology into GME include the financial cost of smartphones and apps, along with concerns about appearing unprofessional while using smartphones in the workplace or in front of patients.[3] Smartphone use can also distract clinicians from effective patient care or from the collaborative work environment.[32] With the possession of identifiable patient information, there are also legal and ethical factors to consider in order to ensure patient confidentiality. Dependence on mobile technology for just-in-time education could come at the expense of acquiring key clinical knowledge or skills, or detract from the senior-trainee teaching relationship.[30,34] Additionally, there are inherent limitations to the smartphone technology itself. Given the increasing availability of different smartphone resources from a vast number of organizations, accuracy and quality control can be difficult to assess, and low-quality or incorrect information could negatively impact learning and patient care.[27] Problems with wireless connectivity can also impact accessibility, a concern for using smartphones as a just-in-time educational resource for time-sensitive patient care.

Recommendations for Future Studies

Incorporation and use of mobile learning tools has been well documented in undergraduate education,[35,36] nursing education,[37] and the workplace.[38] Addition of mobile educational resources through smartphones may present an ideal way to augment learning for medical trainees and would be well-suited to "an environment which requires high mobility . . . and a sphere of activity that alters frequently."[39] Use of smartphone technology could improve the efficiency of asynchronous learning, an important feature in the era of the 80-hour workweek,[40] where lecture and didactic times have become limited.

Studies should focus on the efficacy of specific smartphone interventions in improving knowledge and outcomes by comparing their use to traditional didactic teaching methods, as well as to other technology-enhanced methods. To pinpoint efficacy, studies should start with simple intervention designs that can be compared to traditional methods. Because many mobile interventions can be accessed through other devices, such as tablets or laptop computers, studies should compare use of the same app or web-based intervention using different devices to determine whether smartphones are the most effective platform for specific learning activities. The next step would be to consider how different combinations of intervention methods could interact with each other in different dimensions of GME. Potential combinations include pairing diagnostic smartphone app use with relevant educational videos from a YouTube community channel, or posting quiz questions on Twitter to be answered using a smartphone database of evidence-based research. Given the diversity of learning in GME, interventions also need to be tailored to the target audience, specialty, environment, and educational topic. More complex interventions will require attention to ease of use to exclude poor usability as a reason for trainee nonacceptance.

BOX Next Research Steps—Areas of Focus

- Efficacy of smartphone interventions in improving knowledge/outcomes
- Cost-benefit analysis
- Eliminating barriers—public perception, distraction, overdependency, etc

In developing this new market of smartphone educational interventions, researchers need to consider the cost-effectiveness of implementing such programs. Smartphones are costly to purchase and upkeep, especially with monthly data plans as well as the added cost of purchasing smartphone applications. In particular, a school-wide or hospital-wide implementation would have a large economic impact on the organization's financial planning and budget. Cost-benefit analyses should compare outcomes from traditional teaching methods to smartphone interventions to assess whether it is financially feasible to incorporate smartphone technology into the curricula.

Finally, barriers to smartphone educational interventions should be addressed. The negative perception of smartphone use in clinical areas needs to be further explored, as do ways to shift public perception of such use (BOX). Here are some potential questions to consider: Would a verbal disclaimer (eg, "I need to use my phone to check this database for the correct treatment plan") reassure patients of clinically relevant smartphone use? How do patients view smartphone use compared to use of a tablet or laptop computer to access the same web-based interventions? Additionally, monitoring the negative side effects of smartphone use—distractions, overdependence, loss of senior-trainee relationship—could help direct techniques to avoid them and to regulate use in clinical arenas. Finally, trainees' self-reported willingness to use smartphone technology as part of their clinical education is important to understand as a factor that can impact use and efficacy.

Conclusion

The smartphone has dramatically changed the way we communicate. It will likely revolutionize medical communication, learning, and decision supports as well. Mobile teaching through use of smartphone technology offers an anytime, anywhere method of learning, with high potential for improved efficiency and satisfaction among trainees. These educational methods provide an adjunct to didactic lecture and allow for asynchronous trainee learning. Smartphone use by trainees is prevalent and will only continue to increase. Incorporating this technology into GME may improve trainee knowledge, patient care, and communications. Research to understand practices that will most benefit trainee learning and patient care is essential.

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