Smartphones are a recent technology similar to PDAs but with expanded functions and greater Internet access. This article explores the potential uses and issues surrounding the use of smartphones in nursing education. While the functions of smartphones, such as sending text messages, viewing videos, and access to the Internet, may seem purely recreational, they can be used within the nursing curriculum to engage students and reinforce learning at any time or location. Smartphones can be used for quick access to educational materials and guidelines during clinical, class, or clinical conference. Students can review instructional videos prior to performing skills and readily reach their clinical instructor via text message. Downloadable applications, subscriptions, and reference materials expand the smartphone functions even further. Common concerns about requiring smartphones in nursing education include cost, disease transmission, and equipment interference; however, there are many ways to overcome these barriers and provide students with constant access to current clinical evidence.

Key words

Computer • Education • Evidence-based practice • Handheld • Nursing • Smartphone • Telecommunications

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synchronize the smartphone to a desktop computer or another server at a distant location, sometimes known as cloud computing.

**PREVALENCE OF SMARTPHONE USE**

Scarce literature is available on the use of smartphones in clinical education. A June 2009 search of the keyword “smartphone” in the CINAHL database revealed only 11 citations; four of these were reviews of the same book. PubMed listed 15 citations; five of these were the same book review. ERIC, the educational database, listed five articles. This may be related to this topic being new or the MeSH headings not incorporating the new technology. A search for “PDA” in PubMed reveals well more than 3000 records; many of these discuss the use of PDAs with additional technologies including wireless connectivity.

While the use of smartphones is innovative, PDAs have been well utilized by nurses and nursing schools. A study of PDAs published in 2009 found that 70% of medical students used PDAs or PDA-like devices while learning. The use of PDAs has been associated with high levels of student satisfaction. However, a 2008 literature review of 73 articles on PDA use in nursing education did not reveal a large, randomized controlled trial showing a change in learning outcomes for those students who used PDA technology within their program of study. Much of the literature on PDAs involves case studies or anecdotal experiences, which limits the ability to make concrete recommendations, although the case studies are almost uniformly positive.

Manufacturers are phasing out PDAs in favor of cell phones as many people, especially students, desire to keep only one device. The leading manufacturer of PDAs, Palm, has stopped producing traditional PDAs and, instead, manufactures smartphones. McLeod reports the only digital assistant currently produced without cell service is the iPod Touch.

Smartphones are a growing share of the cell-phone market, with 42% of cell-phone owners using their phones for a nonvoice purpose each day. While in 2009 smartphones represent only 14% of current cell-phone sales, their market share is increasing. In a 2006 Pew Internet and American Life Project survey of cell-phone users, 47% stated they would use additional functions on their phones if available.

**USES OF SMARTPHONES IN NURSING EDUCATION**

While many of the functions of the smartphone are designed for leisure activities, they can be adapted for use in nursing education. For instance, the video player shows instructional videos, a downloadable ruler assists students in metric measurements of lesions, and the music player can subscribe to Centers for Disease Control and Prevention (CDC) podcasts. The development of uses for the smartphone is rapid, and nursing education can benefit from the access to a diversity of educational aids.

Texting, or sending text-based messages, is one function of smartphones that is highly associated with younger users, leading to the term generation Texting. Texting can be used in the clinical setting to communicate with students who are providing patient care in different rooms and areas of the hospital. Students can text the instructor when they need the instructor to observe a procedure or cosign a note. The instructor can Twitter to students to give them a notice to finish charting and meet for clinical conference. This can streamline instructor time in the clinical setting and allow students to easily call for assistance.

Smartphone applications, known as “apps,” are another valuable tool for nursing education. Many generic programs can be used by students to study, such as flashcard programs, while others are more specific to discipline or content. There are more than 1200 applications under the category of health and fitness and more than 600 applications designed for medical professionals. These applications have a wide range of uses. One free program, Epocrates, allows professionals to look up patient drugs by physical characteristics, such as color, shape, and scoring, to determine medication through patient report, which is especially helpful to students as they gather patient histories. Another app allows quick calculations of body mass index with CDC weight classification. Internet links to national care guidelines and searchable, interactive drug references are also available. With these programs, students enter patient characteristics and receive a list of appropriate preventive screenings from multiple national guidelines.

Resources similar to pocket references can be purchased for the phone. Computer-based references have easy search functions to allow students to find topics of interest. These e-books can be easily updated through the purchasing site, thus eliminating outdated copies with the most current version. Access to current resources is increasingly important to providing evidence-based care. Since the evidence on which care is based is constantly changing, giving students accurate sites for reference will help prepare them for future practice and encourage self-directed learning. In a high-paced clinical environment, quick access can influence whether a nurse or practitioner verifies his/her clinical knowledge. Students reported that having a PDA increased their use of reference materials while in the clinical setting. The smartphone format expands the reach of access to areas without wireless Internet, including hospitals, doctors offices, and community health centers.
Some clinicians have criticized student reliance on references, believing that expert clinicians should have information memorized. However, much of patient care changes rapidly with guideline updates, new Food and Drug Administration warnings, and new national standards. Frequently accessing updated and current reference materials meets the goal of providing high-quality care based on current recommendations, as outlined in the IOM’s report, Crossing the Quality Chasm.\textsuperscript{29,30} Since medical errors kill more people per year than automobile accidents,\textsuperscript{39} checking a reference is like buckling a seat belt and should be reinforced for all levels of care providers, from novice to expert.

Encouraging smartphone use also encourages self-directed learning by allowing learners to research questions as they arise and solicit help from peers.\textsuperscript{26,31,32} These behaviors may continue to be beneficial after graduation as nurses improve clinical knowledge and perform ongoing training, especially for rural clinicians.\textsuperscript{33}

Videos and podcasts can also be accessed in the clinical setting using the smartphone. Many schools produce videos of key skills for students, which are made available on the Web. National sites are following this trend to provide high-quality training videos for subscribers. The New England Journal of Medicine has released evidence-based skill videos.\textsuperscript{34} Since the videos are short, often less than 5 minutes, students can view these videos during clinical training to refresh their memory prior to performing patient procedures. Students who reinforce their knowledge by accessing information have reduced anxiety and may be able to recall previous knowledge more readily.

\textbf{Case Vignette}

A clinical instructor oversees nursing students on a post-surgical floor. A student needs to insert a nasogastric tube, but he is unable to state critical details about placement. The instructor refers him to a video tutorial that can be viewed on his smartphone, then receives a text from a student who needs to give an injection. The instructor observes the injection and returns to find the student prepared to answer questions and visibly less anxious about performing the skill.

Smartphones can also assist students during the debriefing period following clinical or simulation experience. Often, providing care and debriefing about the care provided underscore those skills and content areas that need refining. One or two students in the clinical group can use their devices to search national databases for answers, providing immediate feedback on the correct answer. This helps model the behavior of quick reference to national guidelines instead of guessing. Encouraging smartphone use also decreases the role of the faculty as content expert and moves the student to self-directed learning, which can benefit the student’s progression toward independence.\textsuperscript{35,36}

Smartphones can also be used in the classroom setting both as a reference and as interactive devices. With a paid subscription, students can use their smartphones as response devices, similar to classroom response systems or clickers, and respond to class-related polls and quizzes (ResponseWare from Turning Technologies, Youngstown, OH). Using the Internet, faculty can collect responses and display the results quickly during lecture. This technology works for on-site or distance classes. Clicker technology encourages student involvement with the content and serves as a method of formative assessment.\textsuperscript{37–39} Using the smartphone as a clicker decreases the need for a student to purchase additional handheld devices and encourages full use of their smartphone.

\textbf{Case Vignette}

A physiology course had low student attendance and poor evaluations and test scores in previous years. As part of a course revision, a 10-question ungraded quiz using Response-Ware was added to the end of each class to encourage application of knowledge and teach test-taking skills. The students used their smartphones and Web-enabled devices to respond to the quiz, and the class participation grade was linked with student involvement as captured by the response system. Student evaluations of the course were positive, and test scores and content application improved.

Smartphones have a great deal to offer nursing students and faculty, including faster communication, access to current resources, and on-site knowledge reinforcement. However, many schools are reluctant to adopt the devices. Many of the problems and concerns can be addressed with careful planning and clear boundaries and expectations.

\section*{COMMON CONCERNS IN NURSING EDUCATION}

Cost, frequent releases of new products, accessibility, interference, disease transmission, and confidentiality are common concerns of faculty when discussing implementation of new technology. Many of these topics have been addressed in the literature; however, further research is needed to clarify safe implementation practices.

Cost is an issue with the adoption of any technology, and smartphones are no exception. The devices have a cost ranging from $99 upward and require a cell and data plan to pay for calls, texts, and data transfer, which is charged monthly. Additional services, such as wireless synchronization, have additional fees. Some schools of nursing treat
smartphones and PDAs as if they are required texts, allowing students to use student loans to cover the initial costs.\textsuperscript{18} Group buying and using the educational institution’s cell-phone discount can translate to substantial cost savings for students.\textsuperscript{19} Since 91\% of Americans own a cell phone, it does not seem unreasonable to ask students to purchase a phone-enabled device,\textsuperscript{40} although the phone is the least functional portion of a smartphone within the clinical setting. Many students would purchase devices, such as cell phones, calculators, and pocket references, to use during their education. If students are required to purchase smartphones upon entering the program, then the application should be integrated throughout the curriculum and reduce the need for additional devices that duplicate smartphone functions.\textsuperscript{18}

Devices are constantly being updated and quickly become obsolete. For instance, Palm, the leading manufacturer of PDAs, introduced their first product in 1996 and discontinued their line of PDAs in favor of smartphones in 2009.\textsuperscript{11,19,20} While device turnover is a concern for nurse faculty, it may have minimal impact on the student experience. A student who enters a program and purchases a required smartphone will likely graduate before the technology becomes obsolete. As students graduate with older smartphones, new cohorts of students enter each year and purchase the most current devices. The nursing faculty must adjust to new devices, but the students will not have to bear the cost burden of more than one device.

In implementing new technology, accessibility is an important concern. The interface should be easily mastered so the learner can focus on the intended content with minimal frustration.\textsuperscript{41} The ease of use of smartphones has been tested by nurses in one study, and the iPhone and Blackberry were selected as the ideal phones in the healthcare setting because of their ease of use, smooth design for easy cleaning, and the availability disinfection covers or shells.\textsuperscript{42} The popularity of the iPhone confirms its ease of use.\textsuperscript{22}

Since smartphones are frequently handled, carried into multiple patient rooms, and taken home with the student, a clear disinfection protocol is necessary. Currently, manufacturers have not released a cleaning guide outlining appropriate chemicals for disinfection. A shell can be used to protect the device from cleaning solutions, but this is possible only for smooth devices without a built-in keyboard.\textsuperscript{42} Cleaning supplies and procedures need to be available for students at the clinical placement.

Interference with medical equipment is a concern with smartphones, especially in the critical-care settings.\textsuperscript{43} BlackBerrys and iPhones have been listed as approved devices in some hospitals as they present a minimal interference risk to sensitive medical equipment,\textsuperscript{18} as evidenced by several studies.\textsuperscript{44,45} However, one study found that smartphones cause interference if within 3 cm of critical-care equipment; the researchers recommended smartphones be kept out of the critical-care patient room but allowed within all other areas of the hospital.\textsuperscript{43} Even with this precaution, students could use their devices at the nurses’ station in all settings.

Patient confidentiality is another consideration when devices with cameras are brought into an information-secure area. However, students should be reminded that removing any patient information from the clinical site in any format, including data stored on the smartphone, is a violation of their confidentiality agreement with the healthcare facility and the educational institution. In this respect, the smartphone is no different than a photocopier. The use of nonidentifiable pictures for case presentations and other educational activities should be dependent on institutional policy.

Many opponents of technology in academia claim that devices distract from learning. Since the students use their device for social and academic purposes, there is the risk that students will receive personal calls, texts, or e-mails during class or clinical time. This problem should be addressed similar to other classroom nuisances, with clear boundaries and high expectations at the beginning of the course.\textsuperscript{46} With the availability of constant communication, learners may need clear guidelines on technology etiquette.

CONCLUSION

The smartphone is a popular accessory already in the pocket of many nursing students. It has many uses beyond cell-phone technology, including Internet-based resources, learning applications, and texting. As educators, one of our goals is independent learning and critical thought.\textsuperscript{26} With a smartphone, students have a multitude of tools and references readily available to enhance their learning in the clinical setting. The smartphone promotes self-directed learning and encourages students to reach out for accurate information without stigma.

The vast majority of nursing information is changing rapidly. Preferred treatments, drug dosages, postsurgical care, and preventive healthcare regimens change dramatically every few years, and if experienced nurses relied solely on their memory, they would provide substandard care. Teaching nursing students a culture of reference can assist them in providing evidence-based care across their careers. With the large quality of materials to be learned by nursing students, it is ineffective to require students to memorize rapidly changing data. Consistent with the IOM Guidelines, budding nurses should be encouraged not to rely on their memory alone, but to consistently verify critical information.\textsuperscript{30} Smartphones allow students to rapidly confirm information, and supporting the use of smartphones teaches and fosters active learning and safe behaviors.
The smartphone can easily be integrated in nursing curricula. Students can use the smartphone to tally their clinical experience in terms of hours or patient encounters in real time. They can reference materials during clinical and clinical conference to enhance debriefing and student reflection. They can communicate with their instructor through texting and Twitter alerts. Applications can be used to make calculations and conversions quicker and more accurate. The proliferation of applications for specific tasks is expected to be enormous. Students can use study guide applications, access online textbooks, and even get directions to their clinical site. Classes can incorporate the device in 2-minute consults or interactive quizzes, when students use the device to answer a clinical question and energize classroom learning.

While there is a cost associated with the device, the initial cost can often be counted as a textbook and included in financial aid packages. The continued cost of maintaining a cell phone can be decreased by negotiating lower rates for university employees and students. Also, many people are forgoing a landline in favor of a cell-only phone service, further decreasing cost burden for students. Healthcare strives to be an evidence-based field. While there is scant evidence on smartphones, nursing should pioneer the use of this technology to encourage students to utilize all possible resources to expand and validate their knowledge base for patient care. When the life span of a technology is less than 10 years, it is counterproductive to wait several years before implementing promising technologies. Smartphones can encourage self-directed learning, decrease medical errors, and enable rapid communication. While cost is a consideration, any technology that can enhance hands-on learning is worth further investigation.

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