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Mobile technologies in medical education

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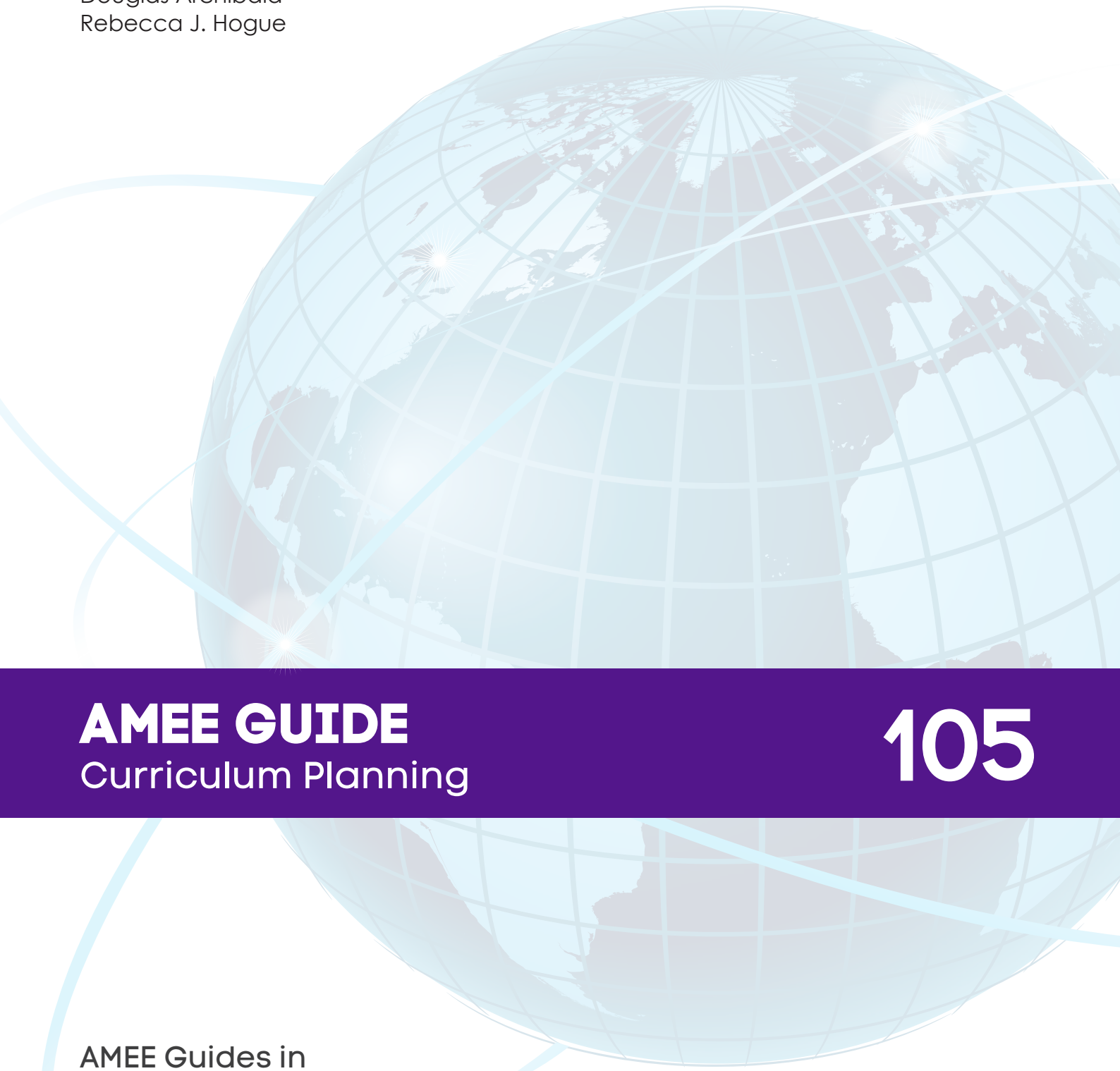

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Mobile technologies in medical education

Abstract

Mobile technologies (including handheld and wearable devices) have the potential to enhance learning activities from basic medical undergraduate education through residency and beyond. In order to use these technologies successfully, medical educators need to be aware of the underpinning socio-theoretical concepts that influence their usage, the pre-clinical and clinical educational environment in which the educational activities occur, and the practical possibilities and limitations of their usage.

This Guide builds upon the previous AMEE Guide to e-Learning in medical education by providing medical teachers with conceptual frameworks and practical examples of using mobile technologies in medical education. The goal is to help medical teachers to use these concepts and technologies at all levels of medical education to improve the education of medical and healthcare personnel, and ultimately contribute to improved patient healthcare.

The Guide begins by reviewing some of the technological changes that have occurred in recent years, and then examines the theoretical basis (both social and educational) for understanding mobile technology usage. From there, the Guide progresses through a hierarchy of institutional, teacher and learner needs, identifying issues, problems and solutions for the effective use of mobile technology in medical education. The Guide ends with a brief look to the future.

“ Mobile technologies (including handheld and wearable devices) have the potential to enhance learning activities from basic medical undergraduate education through residency and beyond ”

Take Home Messages

- Mobile technologies have developed rapidly, and medical teachers can harness their power to improve medical teaching.
- To do so, medical teachers need knowledge of some socio-theoretical concepts, pedagogy, availability of appropriate applications, and some basic technical expertise.
- They will also need to have the courage to implement changes to utilise these technologies.
- This Guide equips medical teachers with the tools to begin that process.

Introduction

AMEE's first Guide to e-learning (Ellaway & Masters 2008; Masters & Ellaway 2008) included a section on what we then called 'm-learning': the use of handheld mobile devices in medical education. At the end of that Guide, the prediction was made that "Mobile learning…will become mainstream." (Masters & Ellaway 2008). In the intervening eight years, the rapid development and widespread use of mobile technologies has expanded our opportunities for mediating medical education activities. Indeed, the speed of this development has been greater than our capacity to describe it. For instance, we still speak of "smartphones", when they are not phones at all. Many of these devices are sophisticated, hand-held computers: the "phone" part is merely one of the many applications (apps) that run on them, and, for many people, the phone may not be the most important app on their devices. Given the extensive use of mobile devices by learners, teachers, and patients, there is a pressing need for educators to understand the many ways in which mobile technologies can be, and are being, used in health professional education; this Guide aims to meet that need.

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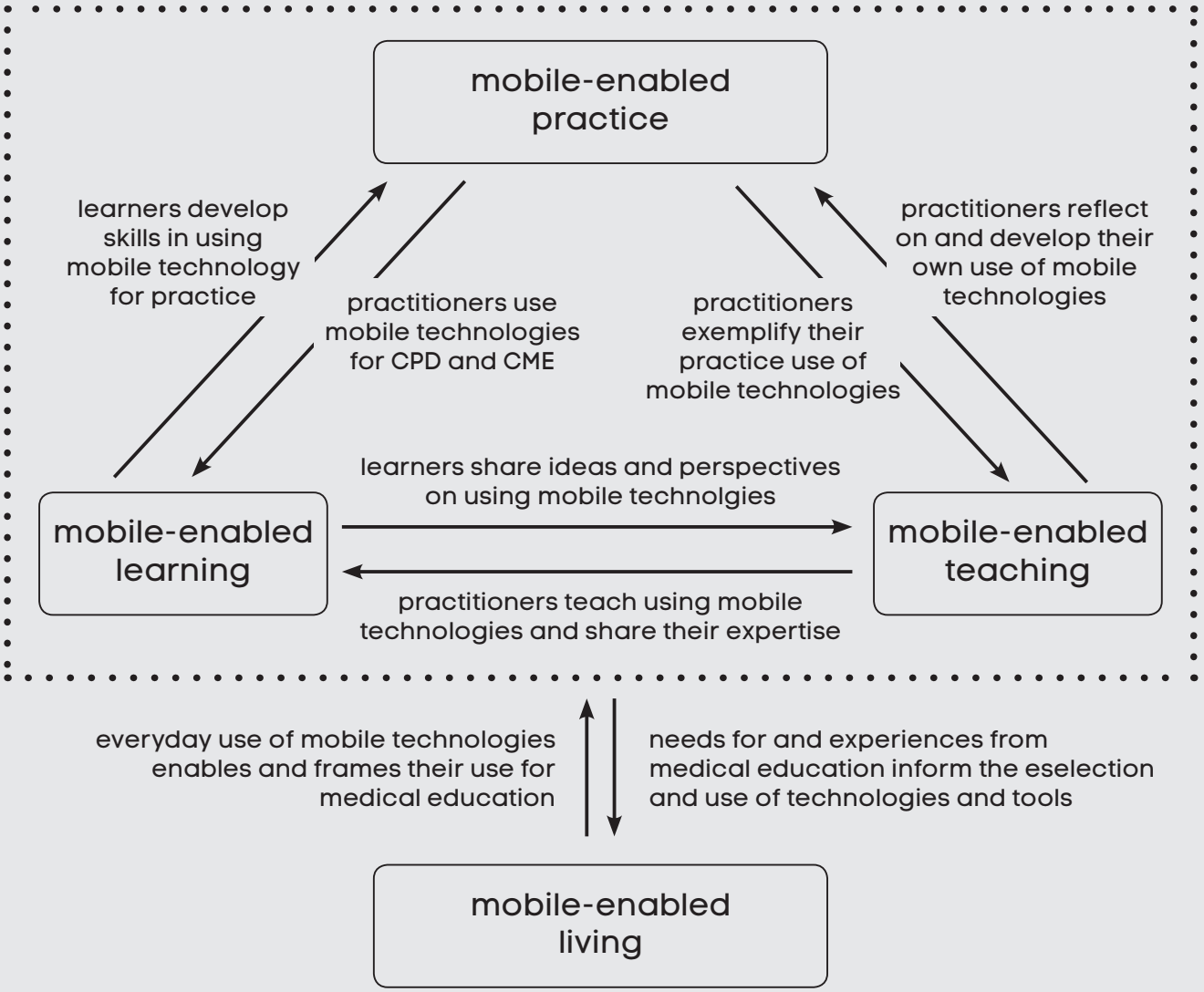
We should first consider the scope of this Guide and the range of technologies on which we will focus. In the previous Guide (Ellaway & Masters 2008; Masters & Ellaway 2008), we defined m-learning as the use of mobile, handheld electronic devices in education. Like the parent concept of 'e-learning', however, m-learning as a term has somewhat run its course, as the field is now more complex, not solely about learning, and is blended into everyday teaching, learning, and practice. Although there have been varying rates of mobile device adoption, it is apparent that mobile technologies are being diffused throughout most of the general population, and have become a standard tool in every-day life. As a result, we can think in terms of four interconnected domains of using mobile technologies: mobile-enabled learning; mobile-enabled teaching; and mobile-enabled medical practice, all underpinned by everyday mobile-enhanced living (the use of mobile technologies for everyday activities such as communications, calendaring, social media, etc.).

These four domains are interconnected and interdependent – see Figure 1; however, the devices and functions used can differ according to domain, and the translation between domains can explain much of the way in which they are used. As also noted in the previous Guide, the use of mobile technologies blurs the line between medical education and medical practice as they can be used for both in very similar ways. Although we will focus on medical education, there will be times when the discussion moves between both fields, and sometimes, we focus on medical practice only.

Finally, when we speak of mobile devices in this Guide, we usually refer specifically to the small piece of hardware, the actual item, and, sometimes, by inference, its functionality. When we speak of mobile technologies, we refer to a broader concept, one which includes software (apps), operating systems, and the related infrastructure and technical protocols that support mobile device usage.

Figure 1:
Some of the interdependencies of mobile-enabled learning, teaching and practice.



Background

Handheld technologies are not new to medical education. For instance, personal digital assistants (PDAs) were used in medicine and medical education for a decade or so before smartphones appeared (Topps et al. 2003; Tempelhof 2009). Portability and connectivity provide point of care access to decision-making tools (e.g. drug reference, medical calculators) and learning resources such as textbooks and journal articles (Chamessian 2011; Davies et al. 2012; Berkowitz et al. 2014). Resources not exclusively related to clinical use, such as time management and communications apps, can help to make work more efficient and effective (León et al. 2007).

Some studies have shown that handheld technologies have the potential to improve the use of evidence-based medicine (EBM) and clinical decision-making (Leung et al. 2003). They have also been shown to improve learners' working efficiency (Patel et al. 2012), the quality of the teaching they receive (Tanaka et al. 2012), and their exam performance (Comstock 2013). There is a growing interest in using handheld technologies to improve pre-clinical learning (Dolan 2011; George et al. 2013) and clinical learning (Mosa et al. 2012). There is, however, a critical difference between the efficacy of using these devices in general and their effectiveness in particular contexts and settings. For instance, the receptivity of preceptors or patients to learners' use of mobile devices in the clinical workplace can vary significantly between contexts (Ellaway et al. 2013; Pimmer et al. 2013). A key example of this is where a

“ Some studies have shown that handheld technologies have the potential to improve the use of evidence-based medicine (EBM) and clinical decision-making ”

medical education programme has no common policy or expectations regarding learners' use of mobile technologies. As a result, learners may be praised by one preceptor for their use of a mobile device in a consult while a second preceptor may criticise or even penalise the same learner just for using their mobile device in front of a patient (Ellaway, 2014).

Developments since the previous Guide

Much has changed since the 2008 Guide:

- Devices: Perhaps the largest change in the mobile world has been the move to phones, such as the iPhone® or Android™ devices, that are powerful handheld computers with extensive network capabilities (including cell, WiFi TM and Bluetooth® connectivity), excellent displays, a large range of third party software ("apps"), and high quality photographic, video and audio capabilities. Another significant game changer was the Apple iPad®, which accelerated the use of tablet computing. Handheld devices now range in size, from miniscule phones to phablets (smartphones with large tablet-like screens), and from a wide range of manufacturers with different operating systems. There has been widespread uptake of these devices around the world (Pew Research Center 2015).

❝ Handheld devices now range in size, from miniscule phones to phablets (smartphones with large tablet-like screens), and from a wide range of manufacturers with different operating systems ❞

- Usability: some of the disadvantages of the mobile devices we noted in 2008 are still relevant today: entering data can be laborious, and viewing text on a small screen can be problematic. However, the advent of tablets has provided devices large enough to use comfortably for reading while retaining their portability. Most new phones and tablets (with a simple adapter) can connect to a range of peripheral devices such as USB drives, keyboards and external displays (although this is not always as simple as connecting laptops, some technical configuration may be required, and printing also usually presents its own set of problems.) To avoid technical problems for storage, transfer and printing, many users prefer to use a "software as a service" (SaaS) or Cloud-based model (such as DropBoxTM), or sharing on a local network drive.

- Price: The limitations of usability notwithstanding, feature for feature, mobile devices are arguably cheaper than laptops and provide advantages over desktop computers, such as cameras, that can be used to scan documents, and bar codes or QR Codes® for data input.

❝ While basic mobile services like (such as SMS) still provide value, especially in areas where the infrastructure is relatively meagre (Masters 2005), the focus has shifted to 'apps,' small software applications that can be downloaded and run on the device ❞

- Services: While basic mobile services like (such as SMS) still provide value, especially in areas where the infrastructure is relatively meagre (Masters 2005), the focus has shifted to 'apps,' small software applications that can be downloaded and run on the device. At the time of writing, the Google Play™ and Apple® App Store® had more than 1.5 million apps each, while other stores (Microsoft® Windows®, Amazon® and Blackberry®) had approximately 1 million apps between them. Many mobile apps are as sophisticated as the programmes that run on desktop computers, and there are many mobile medical apps that can "be used as an accessory to a regulated medical device; or to transform a mobile platform into a regulated medical device" (FDA 2015). Increasingly, there is a trend for app and device makers to avoid regulatory issues by presenting their very sophisticated functions as consumer -oriented rather than provider-oriented. Current (2015) estimates put the total number of Apple and Android health-related and medical apps at more than 165,000 (Aitken and Lyle 2015), while some conservative estimates put the number at more than 100,000 (research2guidance 2014). These apps tend to be much cheaper than software for desktop or laptop computers, and many non-commercial teams and individuals develop their own apps, using free and relatively easy-to-use software development kits (SDKs).

- There has also been a shift in the research in this area from a focus on mobile devices to one that is more concerned with their educational uses and impacts. For example, in December 2007, a multi-database literature search

focusing on mobile learning terminology yielded 99 results (Masters 2008); papers that dealt with mobile learning activities were not found because they did not mention the term "mobile-learning" (or its synonyms). Instead, the papers discussed the technology, such as mobile-phones and PDAs, with the classroom acting as an experimental laboratory for testing the impact of these devices. The same search conducted in May 2015 yielded over 4,000 results, with many papers focusing on the educational uses of different mobile technologies across a much wider range of contexts. Clearly, mobile learning has become part of the educational mainstream.

> *"There has also been a shift in the research in this area from a focus on mobile devices to one that is more concerned with their educational uses and impacts"*

- People working in settings with limited resources need to take particular care that they do not over-reach their capacity to deliver on their promise. Nevertheless, with proper planning in these environments, valuable usage can be made of mobile technologies, and early pilots can form a basis on which to build more sophisticated projects (Masters 2005; Pimmer et al. 2012; Pimmer et al. 2013). In an ideal world, educational needs should drive the technology; in practice, however, one should take stock of the budget and technical realities, many of which are outside the teachers' area of influence (such as bandwidth, external provider charges and ubiquity of devices). In addition, the management of student and staff expectations needs careful attention, as they may have heard of highly-sophisticated systems, and will need to be appraised of what is realistically feasible.

Socio-theoretical contexts for using mobile technologies

Although this Guide is aimed primarily at providing practical advice, it is useful to first consider the use of mobile technologies from a socio-theoretical perspective, as an understanding of this perspective will allow readers to extend the application of this guide beyond the examples given here.

We can first draw on Engeström's model of Activity Systems (Engeström 1993; Engeström 2001). An activity system is the social construct within which activities are undertaken. An activity system is based around a subject (a person or group) from whose viewpoint the activity is performed, and an object (a person or group) that is the focus of the activity. The activity has one or more outcomes, and is informed and shaped by mediators and the social context within which it occurs. Traditional concepts of medical education tend to place the teacher in the role of subject and learners in the role of object. However, a more learner-centred focus (see Figure 2) places learners as subjects engaging with a medical education programme (object) to become a doctor (outcome). Given the relatively high degree of learner autonomy associated with using mobile devices in medical education, and even in the rare situations where learners are provided with a mobile device by their schools, there is relatively little central oversight or control over what is done with them (Ellaway et al., 2013). This isn't so much a learner-centred approach as a learner-autonomous approach or even (acknowledging teacher use of mobile devices) a user-autonomous approach.

> *"An activity system is based around a subject (a person or group) from whose viewpoint the activity is performed, and an object (a person or group) that is the focus of the activity"*

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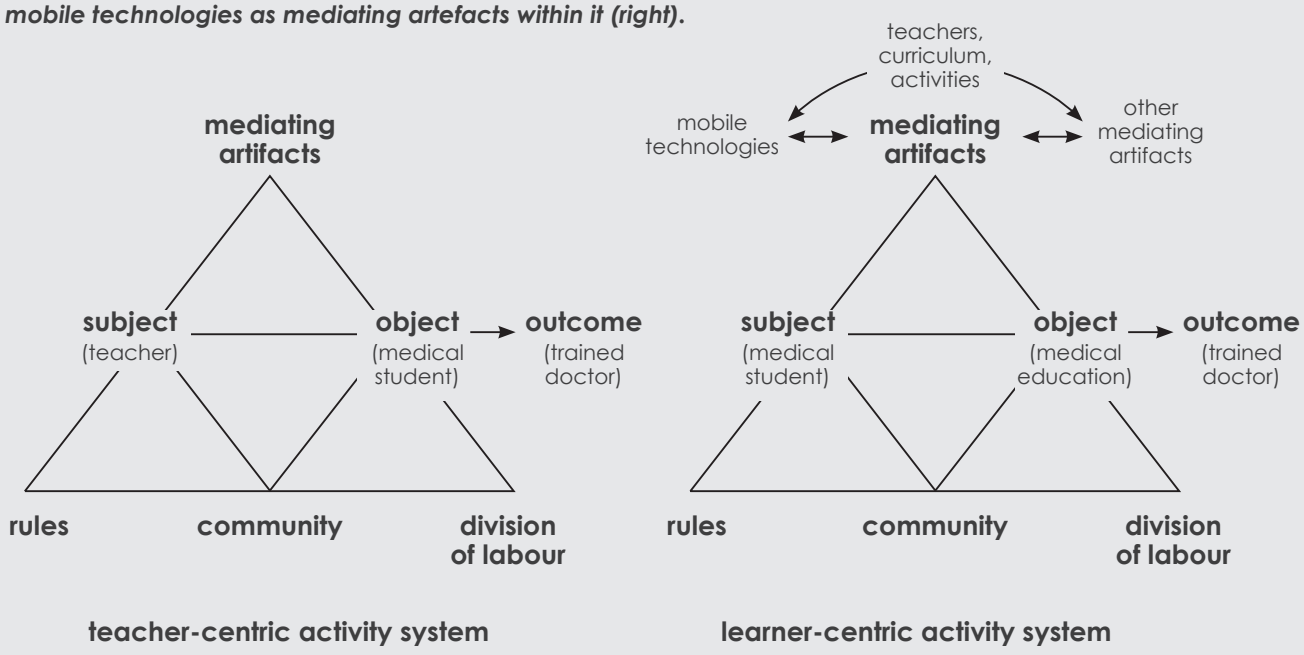
Although learners are relatively autonomous in their use of mobile devices, these devices affect the way that learners interact with the curriculum, their teachers, and other programme activities in which the learners are engaged. These activities take place in contexts defined in terms of the explicit rules (such as assessment regulations or codes of conduct), the implicit rules (such as norms and expectations regarding the use of mobile devices), the community (the culture of the school or departments), and the divisions of labour (the roles individuals take within different activities - learner, teacher, actor, mentor, etc.).

Let us take the example of a medical student using a mobile device on a clinical placement as an illustration of an activity system. The student (subject) is

engaging in a process of medical education (object) in order to complete her training and become a doctor (outcome). The student uses her mobile device's calendar to help manage her schedule, a communication app instead of a pager to get alerts from her preceptors and patients, the browser (and other apps) to find information, a memo (or word processing app) for taking notes and scanning documents, and other apps to access course resources such as the library and the encounter logging system. In doing so, she is using the device and the resources she accesses through it to mediate her learning.
She also uses the device to communicate with her colleagues using texts (mixing learning and social activity), interacting with students and others using social media, and she interacts with her tutors and the course chair by email.
This reflects her engagement with her learning community. As a student, she may not be allowed to access the hospital's electronic health record system on her device, but she does assist in some clinical situations by looking things up on the Internet for her preceptors when things get busy. This reflects the division of labour. Our student is also careful where and when she uses her device, as some of her preceptors encourage its use but others have criticised her and her peers for using their devices in clinic, and yet she is required to log all of the clinical procedures she is involved in using her device. This reflects the rules, both formal and informal in the activity system.

From this point of view, our focus is not on what mobile technology can do in medical education, but on how it is used and to what effect. We compare and contrast these two activity system perspectives in Figure 2.

Figure 2:
Activity systems from a traditional teacher-centric perspective (left) and a learner-centric perspective, showing mobile technologies as mediating artefacts within it (right).



There is much to suggest that mobile technologies have been a "disruptive technology" across the continuum of medical education (Christensen and Armstrong 1998). The extent to which this occurs, however, is dependent not only on the technology, but also on the educational culture of the institution.
We strongly suggest that mobile technologies should not become merely another technology reinforcing current teaching practices, as Virtual Learning Environments (VLEs) and Learning Management Systems (LMSs) have tended to do (Blint and Munro 2008). Technologies should not merely support current teaching methods (Robin et al. 2011); they should catalyse change and enable some healthy disruption. If we remain within the bounds of existing practice, then we cannot expect to gain much from using these technologies. In addition, we must take into account the lessons from both Rogers and Engeström that, because these devices belong to the learners, they will use them as they wish with all the

unpredictable outcomes that this implies (Rogers 1983, Engeström 1993). Failure to take this into account will add mobile devices to the list of educational technologies that have failed to live up to expectations (Conole et al. 2008).

We also need to allow for the attitudinal asymmetries and variations in practice around the use of mobile technologies in medical education (Ellaway et al. 2013). The 'Virtual Society?' project generated a useful theoretical model, which posited five rules around the use of digital technologies (Woolgar 2002):

1. The uptake and use of the technologies depend crucially on local social context.
2. The fears and risks associated with new technologies are unevenly socially distributed.
3. Virtual technologies supplement rather than substitute for real activities.
4. The more virtual the more real.
5. The more global the more local.

Translating this model to the specifics of mobile technologies in medical education, we can expect that not all learners will use mobile technologies to the same extent (Ellaway et al. 2013). In any class, there are likely to be champions and sceptics, early adopters and late adopters (Rogers 1983). This is equally true for teachers, learners and patients. We should not assume, as theories of digital natives and Net Generations do (Tapscott 1997; Prensky 2001), that all young people are avid mobile technology users and that older people are not (White and Le Cornu 2011). Moreover, we should not assume that, because someone uses a mobile device for other purposes, they know how to use the device to support teaching and learning (Koutropoulos 2011).

Another implication is that there will be power imbalances around the use of mobile technologies in medical education. For instance, while the tools in most workplaces are owned and controlled by the organisation, the diffusion of mobile technologies through the general population means that selecting and using mobile technology is a very personal undertaking. The device owner may have a higher level of expertise in its use than those around them, and will possibly use it for many activities outside of those anticipated in the workplace. To grasp the impact of this on the educational process, one should imagine how the dynamics of medical practice would be altered if every patient had a functional knowledge of every medical procedure and drug available (including some that were unknown to many health professionals), but did not understand their underlying processes, and did not have the necessary medical knowledge to properly use them to achieve the desired outcomes. This reflects the workplace of contemporary educators, whether or not they use mobile technologies in their teaching.

A hierarchy of needs

We have adapted Maslow's hierarchy of needs (Maslow 1943) to structure the next section of this Guide; positing that, in order for mobile technologies to be used for learning, teaching, assessment and practice, there is a hierarchy of needs that should be addressed – see Figure 3

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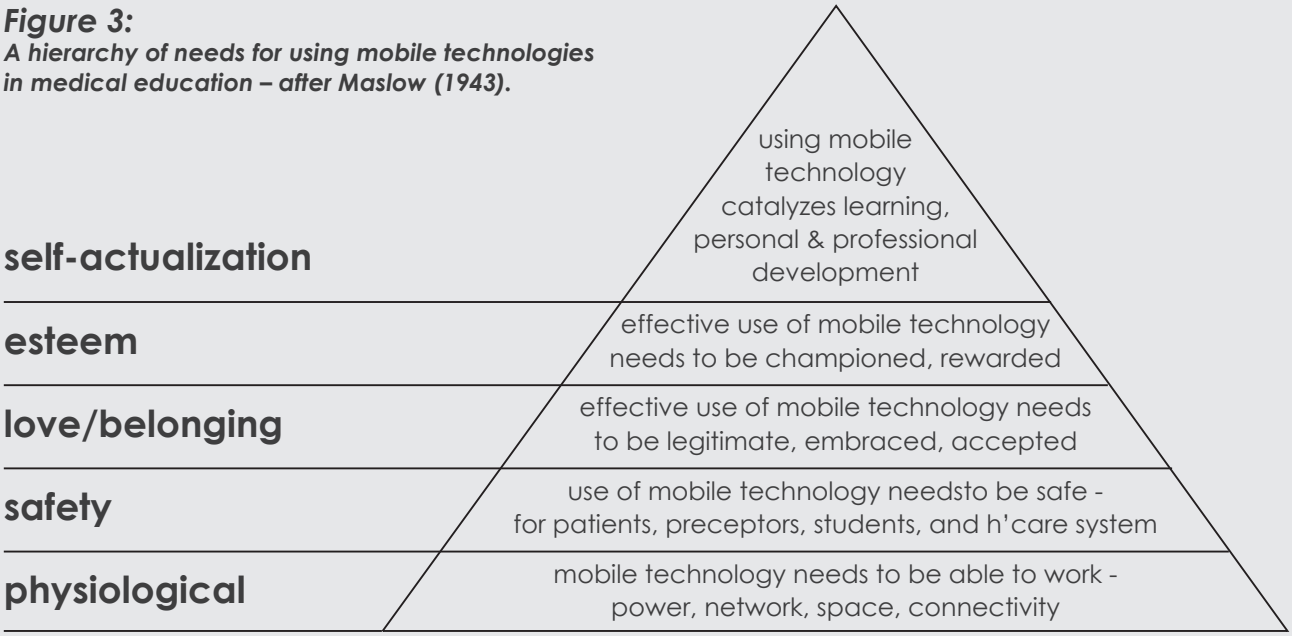
Figure 3:
A hierarchy of needs for using mobile technologies in medical education – after Maslow (1943).



Level 1: Physiological

The environment should allow mobile technologies to function:

"Greater device sophistication has a cost: although manufacturers provide optimistic figures for battery life, most users will need to charge their devices every day, and it is common to seek power boosts when possible during the day"

- Greater device sophistication has a cost: although manufacturers provide optimistic figures for battery life, most users will need to charge their devices every day, and it is common to seek power boosts when possible during the day. To that end, institutions should provide sufficient power outlets for learner devices. This problem may be somewhat alleviated by the use of a portable battery pack.

- Mobile devices need good network connectivity. However, while most universities provide WiFi for their learners to use, connecting to cell phone or WiFi networks in many hospital areas, particularly in the vicinity of imaging centres with their heavy radiographic shielding, is not possible. There may also be restrictions on the use of social media sites, media sites such as You Tube. Given that learning clinical procedures can be accelerated by YouTube access (Topps et al. 2012; Masters 2015a), healthcare facilities should expand coverage and access to support the needs of today's connected learners. If WiFi access is lacking, then mobile hotspots may provide a viable alternative.

"Mobile devices need to be carried, and male attire tends to be more capable in this regard, as large pockets and belts are less common in female attire"

- Mobile devices need to be carried, and male attire tends to be more capable in this regard, as large pockets and belts are less common in female attire. Shoulder bags can be inconvenient in busy clinical environments, while constant mobility in most clinical environments makes lockers and drawers impractical. A supportive mobile learning environment needs to address these issues.

- The diversity of devices in the learning environment (especially if learners and teachers are using their own) can place a high demand on technical support staff. Given the importance of mobile technologies, it is crucial that medical education programmes clearly distinguish between the users' and the institution's responsibility. Depending on the level of assumed technical responsibility, schools may need to put robust technical support systems in place.

- Finally, mobile-mediated activities should integrate with the existing use of educational technology. In particular, the institutional LMS or VLE, e-portfolio, and encounter logging systems must be mobile-friendly. Comprehensive testing (checking practical aspect such as such as image sizes, video file types, pop-up displays, etc.) should be performed on these systems with mobile devices.

Level 2: Safety

Using mobile technology needs to be safe for users and for those around them:

- Mobile devices can be lost, stolen or hacked, and this can be both a material loss and an educationally debilitating one. All mobile device users should prevent unauthorised access to their information and make regular backups of data. Devices should always be password- and/or biometric -protected. Devices should also be encrypted so that crucial data cannot be read if somebody gains access to the device. Tools for remotely wiping the device if it is stolen is another important consideration.

- The protection of clinical information is a serious responsibility. As a rule of thumb, any information on a patient should be treated with the same level of confidentiality afforded to actual patients (Ellaway 2011; Masters 2014). Clinical data should therefore never be stored on learners' devices. Access to clinical records, such as EMRs, through mobile devices should have appropriate security safeguards, including using a secure app rather than a standard browser. Two-factor authentication (typically, verification through something the user knows, such as a password, and something the user has, such as a thumbprint) is recommended.

- Although tablet computers and smartphones are less likely than laptops to be compromised by computer viruses, they are not immune to attack. We recommend a prophylactic approach to device security, which includes keeping operating systems and software up to date, using reputable anti-virus and anti-spyware apps (e.g. AVGTM and MalwarebytesTM), and being careful about who is "friended" (this involves making a link between your profile and someone else whom you identify as a 'friend') and what is shared with these friends. Medical teachers should ensure that learners are well informed and careful in using their devices in this regard.

- Unsecured networks (especially "Free Public WiFi" networks) should generally be avoided. If these are used, then a Virtual Private Network (VPN) should be used to increase security.

- Real viruses are as much of an issue as technological viruses (Manning et al. 2013). As with stethoscopes and other paraphernalia, infection control principles and using proper sterilisation techniques are just as important with mobile devices that are to be used at the point of care, especially at the bedside. Not using them in these environments would be counter -productive, but care must be taken. Devices should be used according to the local organisation's disinfection policies for non-critical items before and after interaction with patients, while users should establish which disinfectants can be safely applied to their devices. An alarm can be set on the device to remind its user to disinfect it at regular intervals, and hand hygiene policies of the organisation should also be followed. These precautions should obviously be undertaken in all settings where contamination is a risk, including in OSCEs (because they may also involve live volunteers / simulated patients), and with learners working in mortuaries or dissection rooms.

- If learners do use their own devices, then it is unlikely that they will have separate devices for work and personal uses. A key principle of digital professionalism, however, is to keep some separation between one's public and private online persona (Ellaway et al. 2015), and this must include the use of mobile devices, as they can act as bridges between the professional and personal aspects of one's life. This means not storing patient or other confidential data on a device where others can access it, and it also means approaching even casual personal use of the device with a professional perspective on the potential risks it may afford.

“ Mobile devices can be lost, stolen or hacked, and this can be both a material loss and an educationally debilitating one ”

“ Real viruses are as much of an issue as technological viruses ”

- Internet addiction (Young 1996) and electronic social media addiction has been noted amongst medical students (Kuss and Griffiths 2011; Masters 2015a). This obsessive behaviour can have a negative impact on their personal and professional lives, reducing situational awareness, and be deleterious to relationships and learning. Whether learners are using their devices too much can be difficult to assess, and there should not be a knee-jerk reaction to seeing learners using their devices, as learners frequently use their devices for work-related activities (Masters 2015a). Complaining that a learner is using a mobile device excessively might be like complaining that a learner is using the library too much.

Level 3: Belonging

“To be effective, the use of mobile technology needs to be legitimate, embraced, and accepted:”

To be effective, the use of mobile technology needs to be legitimate, embraced, and accepted:

- Integration with educational infrastructure and institutional systems (such as LMSs, portfolios and encounter tracking tools) and healthcare infrastructure (such as Electronic Medical Records (EMRs) and health information systems) needs to be appropriately facilitated. If such systems are to be accessed using a web browser on the device, it is important that these systems can support secure mobile use. This might be through a client app, although not all app designs are secure. The use of an app (rather than a standard browser) may have an added security advantage if the app designer ensures that user names and passwords cannot be stored in the mobile app. If an app is to be used, then, at the very least, iOS and Android versions need to be available to the learners. The spread of other operating systems will have to be monitored to see if a version for one of those is required. If websites need to support mobile learning, then they should embrace Responsive Web Design (RWD) principles so that they scale and adjust to whatever screen is on the device.

“Medical education institutions need to advise their learners on the opportunities and challenges of integrating the use of their mobile devices with their working environments.”

- Medical education institutions need to advise their learners on the opportunities and challenges of integrating the use of their mobile devices with their working environments. This could be done by having a medical informatics course in the undergraduate degree, or a specific set of sessions or course of instruction followed up with systematic use of mobile technologies across the programme. If this is not possible, principles of device, app or social media usage (e.g. http://adjacentpossiblemed.blogspot.com/2012/05/social-media-for-medical-students.html?m=1) should be integrated into existing teaching and learning practices, but there is a danger that ad hoc app teaching will repeat some information while ignoring other aspects. To avoid this, teaching staff could undergo proper training in the form of workshops or full courses on the use of technology in their teaching. Even in the absence of such courses, teachers should not simply abrogate all responsibility, and they should advise learners in the care and usage of their devices.

- Although a few institutions provide their learners with a mobile device, this is not the norm (Masters and Ng’ambi 2007; Masters and Al-Rawahi 2012; Ellaway et al. 2013). The more common approach adopted by many schools is that learners are invited to ‘bring your own device’ (BYOD - Dahlstrom and diFilipo 2013). The advantages of this are that the institution does not have to support BYOD to any great extent (at least in theory), and that learners are self-directed in the use of their devices (Gidda 2014). The disadvantage is that a BYOD approach encourages the use of mobile devices in all settings and at all times (Gidda 2014), and many of the costs for this are pushed back to the learner, including: buying, fixing, and replacing their devices, paying for apps and other digital content, and paying for a data plan. With new devices and tools continually entering the market, the imperative to keep up to date can be expensive. Whichever approach the institution chooses, care will need to be taken regarding the availability of apps for particular platforms. In the BYOD approach, it is incumbent on the institution to ensure that all apps (or

equivalents) required by learners are available at least for iOS and Android. As the field of platforms changes, any shifts will have to be accommodated.

- Appropriate use of mobile devices during classes or rounds needs to be clarified. For instance, a lecturer's instruction to learners to "look it up" might imply "after this class." Many learners, however, take that to mean "right now," and they reach for their mobile devices. Even without being directed to do so, many learners regularly use mobile devices for fact-checking, or seeking s impler explanations during lectures (including YouTube videos). Consequently, a balance needs to be found: even when learners are using their devices for work-related activities, this behaviour can appear to be disrespectful (in particular to teachers and patients). The appropriate use of mobile devices is therefore bound up with teaching professionalism and communication skills as well as with the particular task in hand. Medical teachers need to advise their learners about the tactful and tactical use of mobile devices and help them to balance their use with their other duties, situating their use in the context of becoming a caring and competent health professional.

- Learners with disabilities: As design and accessibility standards on apps have not yet settled (in the same way, for example, that web-pages have), and some app screen-readers are very rudimentary, learners with disabilities may find many of the apps difficult or impossible to use. In these cases, there is an institutional responsibility for these learners to be provided with alternatives or accommodations for their disability. See Box A for more information on this topic.

"Even without being directed to do so, many learners regularly use mobile devices for fact-checking, or seeking simpler explanations during lectures (including YouTube videos)."

Box A. Learners with disabilities and mobile devices

Learners with disabilities

Particular care should be taken with learners with disabilities. Various apps may prove useful for such learners (e.g. Be my Eyes, Captions, Google's "Back" Series, Keyboard for Dyslexics, Speak Screen, Spread Signs, Voice Dream Reader and WalkyTalky. See the Americans with Disabilities Act Reference app for more suggestions). In addition, there may be legislation affecting your use of such mobile apps, and, if your country does not have such legislation, then it is useful to refer to the following, particularly if you are individually responsible for your learners' mobile device use:

- The US Americans with Disabilities Act of 1990, with later updates. (http://www.ada.gov/pubs/ada.htm)

- Section 508 (and Section 255) of the US Rehabilitation Act (http://www.access-board.gov/508.htm) (Note: At the time of writing this guide, updates were being proposed. See http://www.access-board.gov/guidelines-and-standards/communications-and-it/about-the-ict-refresh/proposed-rule for more information).

- The UK Special Needs and Disability Act of 2001 (http://www.legislation.gov.uk/ukpga/2001/10/contents).

Level 4: Esteem

The effective use of mobile technology needs to be championed and valued:

"The effective use of mobile technology needs to be championed and valued"

- Although mobile devices may be used with little explicit curriculum integration, there are distinct advantages to incorporating their use into a more explicit activity within the curriculum. For instance, mobile devices may be included in simulation and clinical skills activities as a source of diagnostic or pharmacological information; for example using the British National Formulary app to check drug names or interactions. They may also be used to interact with a lecturer through live polls such as www.polleverywhere.com), instead of "clickers," and can be used in conjunction with other teaching methods beyond the standard lecture, such as Team-Based Learning (TBL) (Simonson 2014). Mobile devices can also be used as a way of working with patients by reviewing information resources, anatomic or physiologic diagrams together. Many clinical decision support apps now incorporate simple graphics that act as powerful motivators during patient education. Some apps even make clever

use of device sensors, such as accelerometers and cameras, to assist with diagnostic and therapeutic manoeuvres for vertigo, tremors and other conditions. As practising physicians undertake many of these tasks, the use of mobile devices in medical education functions as both medium and message. Curriculum alignment can also be explored in terms of mapping mobile device use to curriculum objectives and outcomes. For instance, digital professionalism stresses the importance of being able to use technologies effectively and safely (Ellaway et al., 2015) while e-health competencies include the appro priate and constructive use of decision support tools that are increasingly being accessed through mobile devices (Ellaway et al. 2014).

- There are many implicit educational messages around the use of mobile devices in medical education. For instance, if a teacher has the same model of device as their learners, then they can share apps and experiences, but learners without that device may feel excluded and disadvantaged. Other teachers may object to their learners' using mobile devices, perceiving it as unprofessional activity, even though the learner may consider such use to be legitimate or even essential to their learning (Ellaway et al. 2013; Ellaway 2014). In these cases, a frank but respectful debrief on the issues involved, and the different interpretations that may be taken, is required to turn this in to a positive learning experience. Unaddressed, such experiences tend to rankle on all sides, potentially derailing the quality of the learning environment for everyone involved. For instance, Archibald et al. (2014) found that "show and tell" sessions by a faculty champion helped to increase the adoption of a specific app for clinical teaching.

"While many learners and institutions advocate for the use of mobile devices in medical education, the point has been made above that there will be a range of learners' interest and engagement in using mobile devices"

- While many learners (Korbage and Bedi 2012) and institutions (Sclafani et al. 2013) advocate for the use of mobile devices in medical education, the point has been made above that there will be a range of learners' interest and engagement in using mobile devices. One should be careful not to make the goal simply "using" the device, but rather highlighting the advantages and benefits to their learning and/or patient care so that they use their devices to meet an educational or medical goal. As with any tool, learners will tend to be strategic in their use of their mobile devices, using them when they confer an advantage but not otherwise (Ellaway et al. 2013).

"Medical teachers should ensure that their learners are able to function competently as physicians both with and without access to a mobile device"

- There are circumstances where mobile devices cannot or should not be used. For instance, power and network connections may be lost, devices may be mislaid, or patients may object to their use. Medical teachers should ensure that their learners are able to function competently as physicians both with and without access to a mobile device. At present, the great majority of examination settings exclude the use of any mobile devices, while allowing their use on the wards and in clinic. Not only is there a growing disconnect between assessment and practice, this is another contribution to the growing hidden curriculum around mobile devices. Medical teachers should consider a continuum of learner assessment between having no access to a device (as in most written exams) through to full access (rather like an open-book exam) in order to ensure their competence has been appraised in these different circumstances.

- In spite of their many capabilities, mobile devices are generally a little more constrained than desktop computers in the tools that are available and how their users can acquire them (apps are often only available from a dedicated online app store for the particular platform being used). This can diffuse learners' relationships with their medical school as they seek alternative advice and sources to support their learning. This, in turn, makes it harder to gauge the effects of medical education practices since most of these mobile platforms are closed to medical school tracking or analytics (Ellaway 2011).

- In the opening sections to the Guide, we mentioned the number of health -related apps available in the app stores. Learners frequently select app based

on peer recommendations and in-store descriptions. However, while they report obtaining many apps, they often use only a few on a regular basis (Ellaway et al. 2013). They may turn to the medical teacher for guidance, but the average medical teacher will not have the time to evaluate many apps. Medical associations generally do not recommend apps, but guidelines and certification standards (in order to address issues of quality, evidence, and accuracy) are available (Thompson 2013; BSI 2015; FDA 2015; Royal College of Physicians 2015;) although their ability to respond to the deluge of new apps is rather limited.

Level 5: Self-actualisation

Once the environment and the other enablers for using mobile technologies are assured, they can be used to catalyse learning and personal and professional development:

“ Once the environment and the other enablers for using mobile technologies are assured, they can be used to catalyse learning and personal and professional development ”

- Mobile devices can provide instant access to information resources that can be used to resolve questions, ambiguities, and disputes. These resources are either provided in the form of websites (accessible to a wide range of devices) or as apps (e.g. the ICD10, Medscape® and PubMed® apps). Hogue et al. (2014) grouped the use of Apps in terms of three key factors: apps that replace a physical object or activity such as a multimedia version of a textbook (e.g. RealWorld Orthopaedics); apps that enhance a physical object or activity (e.g. Heart Murmur Pro); and apps that provide something entirely new, such as making treatment decisions that would not be feasible or appropriate in real life and exploring the consequences.

- Mobile devices can be used to connect learners, tutors, patients and others in support of rich and dynamic learning processes. In general, the “anywhere,” “any place” advantage of e-learning is dramatically increased when mobile devices are used. Mobile devices are not the focus of such activities, but they are the enablers and mediators of these activities. This can range from using the device as a replacement for a pager, to the use of social media channels to discuss issues and questions that can be explored in the public domain. Non-medical-expert competencies such as advocacy and leadership, often largely ignored elements in the average curriculum, can benefit greatly from the social and collaborative aspects of mobile devices. For instance, students can look up information for a patient, they can use their devices to help the patient negotiate their journey through the health system by booking appointments or connecting them with other providers, or they could even lobby on their patient’s behalf for access to particular services (Scher 2012).

- Mobile devices can be used to capture aspects of the learning environment in terms of pictures, videos, and audio recordings, although this should be done with great care and discretion so as to maintain privacy, confidentiality, and professional standards. What happens on the web stays on the web, and recordings of less than desirable behaviours have had a powerful social influence (not always to the positive) on young healthcare professionals.

“ What happens on the web stays on the web, and recordings of less than desirable behaviours have had a powerful social influence (not always to the positive) on young healthcare professionals ”

- Given that learners soon become teachers, either formally or informally, some consideration should be given to how they teach the use of mobile technology to others. This should include teaching the implications of using mobile devices in education and healthcare (Ellaway et al. 2015).

- Although mobiles can do much that laptops and other devices can do, their portability means that opportunistic learning can be more easily layered into the learner’s day. For instance, taking formative quizzes on the way to and from class can help to introduce learners to the day’s topic, and help to rein force what has already been covered. Clinical students can practice a range of diagnostics cases with apps like Prognosis: Your Diagnosis. Mobile devices can also be useful in recording and tracking assessments, evaluations, and patient encounter logs. The convenience of mobile devices can make the capture and use of this data a lot more proximal to the provision of training and care.

Mobile devices and patients

"The use of the Internet has allowed many patients to be more directly involved in their own care and that of others around them"

The use of the Internet has allowed many patients to be more directly involved in their own care and that of others around them. These individuals (sometimes called 'e-patients' - Forkner-Dunn 2003; Ferguson et al 2007) make up a growing proportion of the population and medical schools will need to prepare their learners to work with them and to care for them; failure to do so puts patients' lives at risk (Masters et al 2010; Masters 2015b). Just as mobile devices have increased medical teachers' and learners' access to online tools, so e-patient access has also been increased. For instance, many mobile decision support tools now incorporate simple graphics to convey the implications of calculators (such as the Framingham risk score) in a manner that is meaningful both for the learner and the patient. There are also many apps aimed directly at patients, including simple medical calculators (e.g. BMI, risk calculators, medication reminders (e.g. MedHelper)), pharmacy locators, and even diagnosis tools. Just as the health professional should know drugs and procedures, there is now a responsibility to know how to guide patients in the selection and use of apps to help them manage their health (Masters et al 2010). There are many guides that can help with this (PatientView 2012; Aitken and Lyle 2015; BSI 2015; FDA 2015; Royal College of Physicians 2015) along with sites such as AppCrawler (http://appcrawlr.com/app/). Tools that enable our learners to more accurately assess the quality of the evidence they are presented with, such as Katie (a clinical significance calculator - http://ktcalc.cme.dal.ca/site/login.php) are more effective if available at the teachable moment. Finally, probably the best source of patient-apps is recommendations from patients themselves: patients know what patients want and use.

"The fact that some 50% of all health apps focus on information provision also means that many clinical health apps can be utilised for learner educational purposes."

Also, as communication apps like WhatsApp, Viber, Google Hangouts develop an increasing role in the work and personal environment, health professionals need to learn to interact with patients through them. This is important for dealing with all patients, and more important when dealing with younger patients (Ofcom 2013). Because of patient confidentiality concerns, such an approach can now be more safely achieved by using general features within the clinical environment, but mobile devices can still participate in such a mechanism without compromising patient confidentiality. The fact that some 50% of all health apps focus on information provision (Aitken and Lyle 2015) also means that many clinical health apps can be utilised for learner educational purposes.

Creating mobile resources: sometimes, there simply isn't "an app for that." As a result, people requiring apps for conditions that are not widespread, or in languages, cultures and even countries that do not have a large enough market, either use no apps, or use apps that are inappropriate for their conditions and circumstances. (For example, in Aitken & Lyle's (2015) assessment of health apps, more than 10,000 non-English apps were simply automatically excluded from the analysis). In addition, there is the overriding concern of medical apps being developed by people with little or no medical training, or at least show little appropriate medical input (Rosser & Eccleston 2011; Wallace & Dhingra 2014). One solution is to teach learners the basics of app development. This notion of the learner developer does require a fundamental shift from a learner as consumer of mobile learning content to a producer of such content. Although the reasons for, and benefits of, this shift will not be obvious to all, it is merely a natural development of technological usage in professional arenas. Publications like the Horizon Reports (Johnson et al. 2014; Johnson et al. 2015) and the Scottish Qualifications Authority (Kay et al. 2008) have increasingly emphasised the need for learners to move away from being only consumers to being creators of material and to become "digitally independent" (Kay et al. 2008). See Box B for development information on development tools for apps.

Box B. Development tools for creating apps.

Making Apps

Some app creation systems require little or no programming skill, such as Appery.io®, AppMakr, Appy Pie, Create My Free App, Game Salad®, and iBuildApp. These have been successfully used with medical and health sciences' learners building their own apps (Masters 2014). At a slightly more sophisticated level are the drag-and-drop, block-based programming tools like MIT App Inventor, Scratch and Starlogo. These tools require programming, but in a visual environment, can be used to develop professional apps, and are being used successfully in the non-computer science classroom at both high school and university level (MacKellar & Leibfried 2013; Wolber et al. 2014; Zhang 2014). Most of these app-building platforms are free, while others may charge their users to host their apps on the Internet. There may be additional costs if developers wish to host their apps in the main app stores.

A few example scenarios

Although we have referred to several practical examples in this Guide, it will be useful to round off these suggestions with a few scenarios in a little more depth, so that the reader can have some more insight into mobile technology usage in different medical education scenarios.

Scenario 1: Lower Limb assessment and treatment evaluation

The objective range of motion measurement is crucial for lower limb assessment and treatment evaluation. The digital inclinometer is useful, but expensive. iHandy Level is a simple free app (iOS and Android) to measure the range of ankle motion for lower limb assessment and treatment evaluation. A recent study (Vohralik et al. 2015) demonstrated the iHandy's accuracy. (This study is also a good example of testing of an app against known instruments).

Scenario 2: Transitioning to the Workplace

For learners, the transition from medical school to the workplace is difficult. One particular difficulty for newly-qualified doctors is ready access to medical and other information. A recent study (Bullock et al. 2015) has shown how the use of the Dr Companion app can assist in this transition.

Scenario 3: Interpreting Laboratory Results

The interpretations of laboratory results to arrive at a diagnosis can be daunting. MedLab Tutor is a simple free app (iOS and Android) that teaches the basics of lab result interpretations, and then presents a series of lab results requiring students to select an answer. A good way to use this app is to show the scenarios to the class, have them indicate their choices (similar to using TBL), and then argue the case before displaying the correct answer. Students can then download the app and use it for their own learning and revision.
For more information on MedLab Tutor, see:
http://www.imedicalapps.com/2012/08/medlab-tutor-app-pocket/.

Scenario 4: Teaching Diagnostic and Management Skills

Teaching diagnostic skills, particularly developing realistic cases, is time-consuming and difficult. In addition, students tend to want to guess the diagnosis before they have evaluated all the evidence properly. Finally, if one disagrees with a diagnosis, part of the learning experience is to determine why the differences occur, and the evidence supporting a particular diagnosis and management process. Prognosis: Your Diagnosis is a free (Android and iOS) app that presents hundreds of cases to students. Users are given the history and results of an examination, then have to select the investigation (e.g. ECG or MRI), and are presented with the results of those investigations, and then have to decide on the best course of management. The app gives a detailed analysis of the student's performance and the evidence supporting the information in the app. New cases are added almost weekly. This app can be used for student self-study, or part of larger classes, similar to that outlined in the MedLab Tutor scenario above.

Scenario 5: Teaching Benign Vertigo

An innovative and useful app in CPD training is DizzyFIX (http://www.dizzyfix.com/). This iOS app utilizes the iPhone accelerometers to detect position and angles. A common challenge in CPD workshops on benign positional vertigo (BPV) is describing the odd angles and trajectories that must be inflicted on your patient's head in the Dix-Hallpike and similar manoeuvres. Beyond this, most clinicians tend to rush the process, not waiting for the otoliths to settle into position. The app's timer and audible countdowns increase success by proper pacing, while the simple diagrams guide one to place the patient into the correct positions in a very intuitive manner. Currently, the app is unavailable "due to iOS changes," but the company is hoping to make it available soon. For details of the app, and a more detailed review, see http://thischangedmypractice.com/dizzyfix-app/.

What's next?

This Guide has so far examined the current situation, and has provided a framework for working within that situation. However, we have also observed that things are in constant change, and we conclude this Guide by considering some technologies that will impact on medical education in the future.

An area of current development is the "Internet of Things" (IoT), in which Internet-aware systems are incorporated into everyday consumer products, allowing them to communicate with users and other devices across the Internet. Much of this communication will be without human intervention, and will be machine-to-machine (M2M). The broad impact of these systems and their architecture on society and education is yet to be determined, and the subtle pervasiveness of connectivity will usher in new possibilities (including machine-learning) and possible problems. A particular instance of the IoT is wearables, discussed in the next paragraphs.

"Wearable computers, or "wearables," are mobile devices that are worn by consumers. Although we may think primarily of watches, glasses and rings, there is hardly a part of the body, external or internal, that cannot be used to carry a mobile computing device."

Wearable computers, or "wearables," are mobile devices that are worn by consumers. Although we may think primarily of watches, glasses and rings, there is hardly a part of the body, external or internal, that cannot be used to carry a mobile computing device. This ranges from "smart" clothes, weaving technology into our garments, such as proposed by Project Jacquard (https://www.youtube.com/watch?v=qObSFfdfe7I) to Google's "smart contact lens" (https://googleblog.blogspot.com/2014/01/introducing-our-smart-contact-lens.html) to nano-computing devices inside the body (Lee et al. 2015; Michael et al. 2015).

The impact of wearables on the concept of the human individual in society should not be under-estimated. While they are currently a novelty, there is every indication that they will follow Rogers' path of rapid adoption. Within five to seven years, they will be the norm, and it will not be strange for any person to be wearing two or three computers connecting to the Internet. We are entering an age in which the human individual has effectively become a carrier of several nodes on the Internet, and has actually become a functioning super node, a homo nodus (Masters 2015c) of the Internet. The potential disruption to education goes far beyond current concerns of cheating in exams (although this must certainly be addressed), and presents opportunities for principles of collaboration and teamwork, currently used in teaching methods such as Problem-Based Learning (PBL) and Team-Based Learning (TBL), to be expanded. For example, educators can look to applying Connectivist principles (Downes 2008) in teaching and assessment, "big data" analysis, and other approaches enabling a move away from fact recall testing to open-book exams and problem-solving. Educators, moreover, do not have to wait for the future, as, some 10% of all health apps already connect to sensors, and large numbers connect to social media (Aitken and Lyle 2015).

This level of connectivity increases privacy concerns, and the term "Überveillance" has emerged (Michael et al. 2015). Wearables like Autographer (http://www.autographer.com/) and Narrative Clip (http://getnarrative.com/)

are small wearable cameras designed to record one's life, but using these in the classroom or clinical setting could prove disastrous. From the institution, there will be further ethical concerns regarding using the devices to track learners – either by app or device providers or by institutions. It is one thing to track learners' use of an LMS; it is quite another to track their use of their personal devices. Facial recognition software built into glasses may provide teachers and practitioners instant access to learners and patient information (beginning with their names!). This will allow for much easier access to just-in-time information. Again, however, confidentiality may be compromised. For now, whether we will need an AMEE Guide on Wearable technologies in medical education in the coming years is still unclear.

Virtual reality can also be built into wearables, and examples of applications include devices that allow a physician to examine a patient virtually with the patient's data (rather than generic data), guide learners around a campus, patients around a hospital, and disabled persons to special-purposes facilities such as parking bays and elevators. Google Glass was an early indicator of combining virtual reality and wearables, while devices like Microsoft's HoloLens® (https://www.microsoft.com/microsoft-hololens/en-us) also hold great promise.

“Virtual reality can also be built into wearables, and examples of applications include devices that allow a physician to examine a patient virtually with the patient's data (rather than generic data), guide learners around a campus, patients around a hospital, and disabled persons to special-purposes facilities such as parking bays and elevators.”

With all of this future development, however, a guiding principle remains: the potential offered can only be utilised if educators are prepared to make changes to their educational practices, rather than merely use these technologies to reinforce current teaching practices.

Conclusion

We started this Guide by discussing the theories that inform the use of mobile devices in medical education. That is because, if medical teachers wish to properly utilise the power of mobile devices, they will have to be ever-cognisant of both the personal nature of the device and the extent to which it has the ability to disrupt educational relationship and dynamics in the classroom, at the bedside, and beyond.

Mobile technology has developed rapidly, and there is every reason to expect that it will continue to do so. For instance, Apple's iOS and Google's Android currently dominate the mobile device environment. Although educators wish to concentrate on education, they will need to keep an eye on other operating systems and technological developments, as sudden changes may cause a shift in their learners' preferences. While these advances do not supply panaceas, they do afford many possibilities to both medical learners and their teachers. If educators wish to remain in safe zones, hoping to merely use mobile technologies to do what they have always done, then these possibilities will be wasted, and may even prove harmful. To properly utilise mobile technologies, medical educators need to grasp the underlying principles governing their social and pedagogical uses, and then to create an environment in which these technologies can be effectively utilised. In so doing medical educators can better utilise the advantages of using mobile technologies and they can better prepare their learners for practice in a world in which mobile technology use is pervasive and transformative.

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References

Aitken M, Lyle J. 2015. Patient Adoption of mHealth: Use, Evidence and Remaining Barriers to Mainstream Acceptance. Parsippany (NJ): IMS Institute for Healthcare Informatics. [Accessed 10 October 2015] Available from http://static.correofarmaceutico.com/docs/2015/09/21/iihi_patient_adoption_of_mhealth.pdf.

Archibald D, MacDonald, CJ, Plante J, Hogue RJ, Fiallos J. 2014. Residents' and preceptors' perceptions of the use of the iPad for clinical teaching in a family medicine residency program. BMC Medical Education. 14:174. [Accessed 23 September 2015] Available from http://www.biomedcentral.com/1472-6920/14/174.

Berkowitz SJ, Kung JW, Eisenberg RL, Donohoe K, Tsai LL, Slanetz PJ. 2014. Resident iPad Use: Has It Really Changed the Game? JACR Journal of the American College of Radiology 11(2):180-184.

Blint F, Munro M. 2008. Why hasn't technology disrupted academics' teaching practices? Understanding resistance to change through the lens of activity theory. Computers & Education 50:475–490.

BSI and Innovate UK. 2015. PAS 277: 2015: Health and wellness apps – Quality criteria across the life cycle – Code of practice. [Accessed 23 September 2015] Available (on supplying contact details) from http://shop.bsigroup.com/forms/PASs/PAS-2772015/.

Bullock Alison, Dimond Rebecca, Webb Katie, Lovatt Joseph, Hardyman Wendy, Stacey Mark. 2015. How a mobile app supports the learning and practice of newly qualified doctors in the UK: an intervention study. BMC Medical Education 15(71) [Accessed 24 October 2015] Available from http://www.biomedcentral.com/content/pdf/s12909-015-0356-8.pdf.

Chamessian A. 2011. How a medical student uses an iPad for patient care and education. [Accessed 23 September 2015] Available from htttp://www.kevinmd.com/blog/2011/10/medical-student-ipad-patient-care-education.html.

Christensen CM, Armstrong EG. 1998. Disruptive Technologies: A Credible Threat to Leading Programs in Continuing Medical Education? The Journal of Continuing Education in the Health Professions,18:69-80.

Comstock J. 2013. iPad-equipped medical school class scores 23 percent higher on exams. [Accessed 23 September 2015] Available from http://mobihealthnews.com/20311/ipad-equipped-medical-school-class-scores-23-percent-higher-on-exams/.

Conole G, de Laat M, Dillon T, Darby J. 2008. 'Disruptive technologies', 'pedagogical innovation': What's new? Findings from an in-depth study of students' use and perception of technology. Computers & Education 50: 511–524.

Dahlstrom E, diFilipo S. 2013. The Consumerization of Technology and the Bring-Your-Own-Everything (BYOE) Era of Higher Education. EDUCAUSE Center for Applied Research, Washington DC, USA. [Accessed 23 September 2015] Available from http://net.educause.edu/ir/library/pdf/ERS1301/ers1301.pdf.

Davies BS, Rafique J, Vincent TR, Fairclough J, Packer MH, Vincent R, Haq I. 2012. Mobile Medical Education (MoMEd) - How mobile information resources contribute to learning for undergraduate clinical students - A mixed methods study. BMC Medical Education, 12(1):1 [Accessed 23 September 2015] Available from http://www.biomedcentral.com/1472-6920/12/1.

Dolan B. 2011. Nine medical schools that support mobile learning. [Accessed 23 September 2015] Available from http://mobihealthnews.com/12346/nine-medical-schools-that-support-mobile-learning/.

Downes S. 2008. Places to Go: Connectivism & Connective Knowledge. Innovate 5(1). [Accessed 23 September 2015] Available from http://nsuworks.nova.edu/cgi/viewcontent.cgi?article=1037&context=innovate.

Ellaway RH. 2011. Apps. Med Teach, 33(3):258–60.

Ellaway RH. 2014. The informal and hidden curricula of mobile device use in medical education. Med Teach, 36(1):89-91.

Ellaway RH, Coral J, Topps D, Topps MH. 2015.
Exploring digital professionalism. Med Teach, 37(9):844-9.

Ellaway RH, Fink P, Campbell A, Graves L. 2013. Left to their own devices: medical learners' use of mobile technologies. Med Teach, 36(2):130–8.

Ellaway RH, Hayward R, Ho K, Hurley K, Littleford J. 2014. eHealth Competencies for Undergraduate Medical Education. AFMC, Ottawa, ON. [Accessed 23 September 2015] Available from https://chec-cesc.afmc.ca/sites/all/files/resource_files/eHealth%20Competencies%20for%20UME.pdf

Ellaway R, Masters K. 2008. AMEE Guide 32: e-Learning in medical education Part 1: Learning, teaching and assessment. Medical Teacher 30(5):455-73.

Engeström Y. Developmental studies of work as a testbench of activity theory: the case of primary care medical practice. In: Chaiklin S, Lavew J, editors. Understanding practice: perspectives on activity in context. Cambridge: Cambridge University Press, 1993.

Engeström Y. 2001. Expansive Learning at work: toward an activity theoretical reconceptualization. Journal of Education and Work 14(1):133-56.

FDA. 2015. Mobile Medical Applications: Guidance for Industry and Food and Drug Administration Staff. [Accessed 23 September 2015] Available from http://www.fda.gov/downloads/MedicalDevices/.../UCM263366.pdf.

Ferguson T, Dreiss M, Fox S, Frydman G, Graedon J, Graedon T, Greene A, Greene C, Grohol J, Hoch D, Smith C, Smith C. 2007. E-Patients: How They Can Help Us Help Health Care. [White Paper]. [Accessed 23 September 2015]
Available from http://e-patients.net/e-Patients_White_Paper.pdf.

Forkner-Dunn J. 2003. Internet-based patient self-care: The next generation of health care delivery. J Med Internet Res 5:e8.

George P, Dumenco L, Doyle R, Dollase R. 2013. Incorporating iPads into a preclinical curriculum: A pilot study. Med Teach, 35(3):226-30.

Gidda M. 2014. Students: bring your own technology to uni: asking students to use their own tech in lectures could save money, but will it damage attention spans? The Guardian, 11 April 2014. [Accessed 23 September 2015]
Available from http://www.theguardian.com/education/2014/apr/11/students-bring-tech-device-uni.

Hogue RJ, Mercer J, Montpetit M. 2014. iPadagogy: Employing the iPad as a Clinical Teaching Tool. iBooks. [Accessed 23 September 2015]
Available from https://itunes.apple.com/ca/book/ipadagogy-employing-ipad-as/id890329687?mt=11.

Johnson L, Adams Becker S, Estrada V, Freeman A. 2014. NMC Horizon Report: 2014 Higher Education Edition. Austin, Texas: The New Media Consortium.
[Accessed 23 September 2015] Available from http://www.nmc.org/publication/nmc-horizon-report-2014-higher-education-edition/.

Johnson L, Adams Becker S, Estrada V, Freeman A. 2015. NMC Horizon Report: 2015 Higher Education Edition. Austin, Texas: The New Media Consortium.
[Accessed 23 September 2015] Available from http://www.nmc.org/publication/nmc-horizon-report-2015-higher-education-edition/.

Kay D, McGonigle B, Patterson W, Tabbiner B. 2008. Next Generation User Skills: Working, Learning & Living Online in 2013. Sero Consulting Ltd (for Digital 2010 & the Scottish Qualifications Authority. [Accessed 23 September 2015]
Available from http://www.sqa.org.uk/files_ccc/HNComputing_NGUSReport_NextGenerationUserSkills.pdf.

Korbage AC, Bedi HS. 2012. Mobile technology in radiology resident education. JACR Journal of the American College of Radiology, 9(6):426-9.

Koutropoulos A. 2011. Digital Natives: Ten Years After. MERLOT Journal of Online Learning and Teaching, 7(4). [Accessed 23 September 2015] Available from http://jolt.merlot.org/vol7no4/koutropoulos_1211.htm.

Kuss DJ, Griffiths MD. 2011. Online Social Networking and Addiction: A Review of the Psychological Literature. International Journal of Environmental Research and Public Health 8(9):3528-3552.

Lee SH, Jeong CK, Hwang GT, Lee KJ. 2015. Self-powered flexible inorganic electronic system. Nano energy. 14:111-125.

León SA, Fontelo P, Green L, Ackerman M, Liu F. 2007. Evidence-based medicine among internal medicine residents in a community hospital program using smart phones. BMC Medical Informatics and Decision Making, 7, 5. [Accessed 23 September 2015] Available from http://link.springer.com/article/10.1186%2F1472-6947-7-5.

Leung GM, Johnston JM, Tin KY, Wong IO, Ho LM, Lam WW, Lam TH. 2003. Randomised controlled trial of clinical decision support tools to improve learning of evidence based medicine in medical students. BMJ, 327(7423): 1090.

MacKellar B, Leibfried M. 2013. Designing and Building Mobile Pharmacy Apps in a Healthcare IT Course. In Proceedings of the 14th annual ACM SIGITE conference on Information technology education (SIGITE '13), pp. 188–197. ACM.

Michael MG, Michael K, Perakslis C. 2015. Überveillance, the Web of Things, and People. IEEE Consumer Electronics Magazine. 4(2):107-113.

Manning ML, Davis J, Sparnon E, Ballard RM. 2013. IPads, droids, and bugs: Infection prevention for mobile handheld devices at the point of care. American Journal of Infection Control, 41 (11): 1073-1076.

Masters K. 2005. Low-key m-learning: a realistic introduction of m-learning to developing countries. Seeing, Understanding, Learning in the Mobile Age, Budapest, Hungary, April. doi: 10.13140/RG.2.1.1032.4962.

Masters K. 2008. M-learning: how much of what has been diffused? A systematic literature review. Proceedings of the World Conference on Educational Multimedia, Hypermedia & Telecommunications (EdMedia 2008), Vienna, Austria, June 30-July 4. Eds. Joseph Luca and Edgar R. Weippl, pp. 5790-5795.

Masters K. 2014. Health Professionals as mobile content creators: teaching medical students to develop mHealth apps. Medical Teacher, 36(10):883-880.

Masters K. 2015a. Social Networking Addiction among Health Sciences Students in Oman. SQMJ. 15(3):327-333.

Masters K. 2015b. The e-patient and medical students. Medical Teacher. [In press].

Masters K. 2015c. Homo Nodus: preparing for the next stage of the Internet of Things in Medical Education. Internet Journal of Medical Education 5(1) [Accessed 23 September 2015] Available from http://ispub.com/IJME/5/1/32411.

Masters K, Al-Rawahi Z. 2012. The use of mobile learning by 6th-year medical students in a minimally-supported environment. International Journal of Medical Education, 2(3):92-97.

Masters K, Ellaway R. 2008. AMEE Guide 32: e-Learning in medical education Part 2: Technology, management and design. Medical Teacher 30(5):474-89.

Masters K, Ng'ambi D. 2007. After the broadcast: disrupting health sciences 'students' lives with SMS. Proceedings of IADIS International Conference Mobile Learning, Lisbon, Portugal, August. Ed. Inmaculada Sanchez, 171-175.

Masters K, Ng'ambi D, Todd G. 2010. "I found it on the Internet": preparing for the e-patient in Oman. SQMJ, 10(2):169-179.

Maslow AH. 1943. A theory of human motivation. Psychological Review, 50(4):370–96.

Mosa ASM, Yoo I, Sheets L. 2012. A systematic review of healthcare applications for smartphones. BMC Medical Informatics and Decision Making, 12(1):67. [Accessed 23 September 2015] Available from http://www.biomedcentral.com/1472-6947/12/67.

OfCom. 2013. Children and parents: Media use and attitudes report. London: OfCom. [Accessed 23 September 2015] Available from http://stakeholders.ofcom.org.uk/binaries/research/media-literacy/media-use-attitudes-14/Childrens_2014_Report.pdf.

Patel BK, Chapman CG, Luo N, Woodruff JN, Arora VM. 2012. Impact of mobile tablet computers on internal medicine resident efficiency. Archives of Internal Medicine, 172(5):436-8.

PatientView. 2012. European Directory of Health Apps 2012-2013.
[Accessed 23 September 2015]
Available from http://g3ict.com/download/p/fileId_955/productId_265.

Pew Research Center, April, 2015, "The Smartphone Difference"
[Accessed 23 September 2015] Available from
http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/.

Pimmer C, Linxen S, Gröhbiel U. 2012. Facebook as a learning tool? A case study on the appropriation of social network sites from mobile phones in developing countries. BJET, 43(5):726-738.

Pimmer C, Linxen S, Gröhbiel U, Jha AK, Burg G. 2013. Mobile learning in resource-constrained environments: A case study of medical education.
Med Teach, 35(5):e1157-65.

Prensky M. 2001. Digital Natives, Digital Immigrants. On the Horizon, 9(5):1-6.
research2guidance. 2014. mHealth App Developer Economics, 2104.
[Accessed 23 September 2015] Available from http://research2guidance.com/r2g/research2guidance-mHealth-App-Developer-Economics-2014.pdf.

Robin BR, McNeil SG, Cook DA, Agarwal KL; Singhal GR. 2011. Preparing for the Changing Role of Instructional Technologies in Medical Education.
Acad Med 86(4):435-439.

Rogers E. 1983. Diffusion of Innovations (5th Edition). New York, NY: Free Press.

Rosser BA, Eccleston C. 2011. Smartphone applications for pain management.
J Telemed Telecare. 17(6):308-12.

Royal College of Physicians. 2015. Using apps in clinical practice: Important things that you need to know about apps and CE marking. [Accessed 23 September 2015] Available from https://www.rcplondon.ac.uk/sites/default/files/apps_guidance_factsheet.pdf.

Sclafani J, Tirrell TF, Franko OI. 2013. Mobile tablet use among academic physicians and trainees. Journal of Medical Systems 37(1):9903.

Scher DL. 2012. The Medical App is a Patient Advocacy Tool. The Digital Health Corner Blog. [Accessed October 20 2015] Available from http://davidleescher.com/2012/05/08/the-medical-app-is-a-patient-advocacy-tool/.

Simonson Shawn R. 2014. Making students do the thinking: team-based learning in a laboratory course. Adv Physiol Educ 38: 49–55.

Tanaka PP, Hawrylyshyn KA, Macario A. 2012. Use of Tablet (iPad®) as a Tool for Teaching Anesthesiology in an Orthopedic Rotation [Uso de Tablet (iPad®) como Ferramenta para Ensino da Anestesiologia em Estágio de Ortopedia].
Revista Brasileira de Anestesiologia 62(2):214-22.

Tapscott D. 1997. Growing up digital:
The rise of the net generation. New York, NY: McGraw-Hill.

Tempelhof MW. 2009. Personal digital assistants: a review of current and potential utilization among medical residents. Teach Learn Med 21(2):100-104.

Thompson BM. 2013. FDA Regulation of Mobile Health (2nd Ed.)
N.p.: Chester Street Publishing.

Topps D, Ellaway R, Helmer J. 2012. YouTube as a Platform for Publishing Clinical Skills Videos. Acad Med, 88(2):192-97.

Topps D, Thomas R, Crutcher R. 2003. Introducing personal digital assistants to family physician teachers. Fam Med 35(1):55–9.

Vohralik SL, Bowen AR, Burns J, Hiller CE, Nightingale EJ. 2015. Reliability and Validity of a Smartphone App to Measure Joint Range.
Am J Phys Med Rehabil 94(4): 325-330.

Wallace LS, Dhingra LK. 2014. A systematic review of smartphone applications for chronic pain available for download in the United States. J Opioid Manag 10(1):63-68.

White DS, Le Cornu A. 2011. Visitors and Residents: A New Typology for Online Engagement. First Monday 16(9) [Accessed 23 September 2015]
Available from http://firstmonday.org/ojs/index.php/fm/article/view/3171.

Wolber D, Abelson H, Friedman M. 2014.
Democritizing Computing with App inventor. Get Mobile 18(4):53-58.

Woolgar S (Ed.) 2002. Virtual society? Technology, cyberbole, reality.
Oxford, UK: Oxford University Press.

Young KS. 1996. Internet Addiction: The Emergence of a New Clinical Disorder.
104th Annual Meeting of the American Psychological Association. Toronto, Canada, 15 August, 1996.

Zhang Chi. 2014. Healthcare Mobile App Development with App Inventor in a Health IT Course. In Proceedings of the Southern Association for Information Systems Conference, Macon, GA, USA March 21st – 22nd 2014: 1-6.

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