APPROPRIATE MOBILE DEVICES FOR MEDICAL EDUCATION AT THE UNIVERSITY OF BOTSWANA'S FACULTY OF MEDICINE

Khutsafalo Kadimo, Masego B. Kebaetse, Alpheus Mogwe, Athulang Mutshewa
University of Botswana, Gaborone, Botswana

Abstract

The use of personal mobile devices for teaching and learning is gaining recognition in medical education and healthcare delivery. However, research on mobile device use and its implementation tends to focus on technical aspects, sometimes overlooking the sociotechnical aspects of mobile devices. This study used the actor–network theory (ANT) as a lens to explore what constitutes 'appropriate' mobile devices and their roles in the teaching and learning of medicine and healthcare delivery. This study adopted an interpretive approach and collected qualitative data from 27 purposively sampled key informants. Data were analysed using grounded theory techniques of open, axial and selective coding. The findings suggest that an appropriate mobile device should not only be portable, but also user-friendly, and that it should meet the national healthcare regulatory and communication technology infrastructure frameworks and support users to complete tasks related to the teaching and learning of medicine and healthcare delivery. The ANT approach to exploring appropriate mobile devices for the teaching and learning of medicine and healthcare delivery broadens our conceptualisation of appropriate mobile devices to combine the desired technical features with users' preferences and internal/external stakeholders' requirements. Thus, the use of socio-technical approaches such as ANT in researching technological implementation is recommended.

Keywords: Mobile learning, mLearning, mobile health, mHealth, mobile devices, medical education

Corresponding author

Mr Khutsafalo Kadimo
Department of Library Services
University of Botswana
Gaborone, Botswana
kadimok@ub.ac.bw

Introduction

The rapid increase in mobile devices is impacting all sectors of development. According to the Global System for Mobile Communications, there are currently more than 5 billion people in the world who own mobile devices (Mikulic, 2020). This number is projected to increase to 7.41 billion by 2024, indicating an unprecedented growth of mobile device ownership and use among the world populace. The health and medical industry has been ranked among the top three fields that accelerate the growth of mobile devices (Mikulic, 2020). There is also growing evidence of increased use of mobile devices in both medical education and healthcare delivery (Boruff & Storie, 2014; Chamberlain et al., 2015; Dunleavy et al., 2019; Moyer, 2013; Nestel et al., 2010; Tran et al., 2014; West et al., 2012). Various benefits are derived from the use of mobile devices in medical education and healthcare delivery, among which include convenience and ubiquitous access to medical information (Abolfotouh et al., 2019; Baheerathan & Selvaskandan, 2014; Chang et al., 2012; Yahya, 2019), real-time communication and collaboration (Chang et al., 2012; Nestel et al., 2010), delivery of flexible, just-in-time self-paced learning (Ally, 2013; Hardyman et al., 2013) and situating learning and performance support at the point of need (Rossett & Schafer, 2006; Wagner, 2008). In addition, because users generally carry their personally owned devices all the time and everywhere, they tend to be motivated, comfortable, efficient and competent in their use, and available to work anytime and from anywhere (Al Ayubi et al., 2016; Alharthy & Shawkat, 2013; Ansaldi, 2013).

The use of the mobile device, whether it is for teaching and learning (mobile learning - mLearning) (Bidin & Ziden, 2013; Winters, 2013), healthcare delivery (mobile health-mHealth) (Hernandez et al., 2001; Yan et al., 2010) or personal tasks (Johnson et al., 2015; O'Connor et al., 2014; Tran et al., 2014), is not without challenges. Available literature provides evidence of inappropriate use in some instances (Sim, 2019); examples of which include interrupting patient encounters and/or educational sessions (Johnson et al., 2015; O'Connor et al., 2014; Tran et al., 2014), using unregulated medical applications (Lewis & Wyatt, 2014) and using mobile devices without essential security, for example, password protection and encryption (Goldfarb et al., 2016; Johnson et al., 2015; O'Connor et al., 2014; Tran et al., 2014). In medical schools, this challenge could be exacerbated by the nature of medical training, where the learning environment is intricately embedded in practice.

To avert some of the challenges that may arise from using mobile devices in the teaching and learning of medicine and healthcare delivery, institutions are increasingly formalising their use (Al Ayubi et al., 2016; Disterer & Kleiner, 2013; Köffer et al., 2015; Weeger et al., 2016). For example, some medical schools and healthcare facilities are taking a policy approach called 'bring your own device' (BYOD) to regulate the use of mobile devices in the teaching and learning of medicine and healthcare delivery (Al Ayubi et al., 2016; Ealey, 2015; Ford et al., 2013; Kehoe, 2013; Meneghetti, 2013; Williams, 2014). The BYOD policy approach is preferred for creating an enabling environment that supports the use of personal devices for work. It is mainly perceived as

a cost-saving measure, sometimes eliminating the need for facility-sanctioned mobile devices (Al Ayubi et al., 2016; Ealey, 2015; Ford et al., 2013; Kehoe, 2013; Meneghetti, 2013; Williams, 2014).

Mobile devices are multipurpose tools, and their application depends on the context of use. For example, in medical education and healthcare (mLearning and mHealth), they are viewed as learning or practice tools, respectively. In contrast, in everyday life, they are viewed as core individual lifestyle tools (Wright & Parchoma, 2011). Another issue that adds to the complexity of understanding the use of mobile devices relates to the question of mobility. While the predominant view is that mobility is a feature of the device, authors such as Winters (Winters, 2013) take a rather radical view, arguing that it is the user that is the mobile entity. Therefore, our understanding of mobile device use needs to be informed by not only the technological factors but also non-technological factors such as those relating to the user (human entity) and the context in which it is used (Korpipää et al., 2003). Therefore, a mobile device will have different connotations depending on the context in which it is used. Both researchers and practitioners ought to determine the exact meaning of mobile devices and how they are used within a given context (Ducut & Fontelo, 2008).

Research and practice in the implementation of mobile device projects in both mLearning and mHealth have tended to use techno-centric theories and approaches (Njoku, 2016; Pimmer et al., 2012; Traxler, 2007; Winters, 2013). Theories and models such as the Technology Acceptance Model, the diffusion of innovation theory, the unified theory of acceptance and the Use of Technology Model (Im et al., 2011; Lyytinen & Damsgaard, 2001) have dominated research in the adoption and use of technologies and mainly focused on the capabilities of technology as a change agent. While such an approach is useful, it may lead to overlooking the intricate relationship between social and technical factors (Llewellyn et al., 2014) and the complexities surrounding the implementation and use of such technologies as mobile devices in work contexts (Winters, 2013; Wright & Parchoma, 2011). Furthermore, a focus on purely technological entities can only lead to a partial understanding of their use and capabilities. It is the predominance of such approaches that may have led to a lack of clarity on what is deemed an ‘appropriate’ mobile device for the teaching and learning of medicine and healthcare delivery.

This study adopted a sociotechnical approach, specifically the actor-network theory (ANT), to understanding mobile device applications in the context of the University of Botswana’s Faculty of Medicine (UB FoM). ANT was conceived in 1986 and developed by Callon (1986) and Latour (1987). ANT conceptualises technology as a sociotechnical artefact that emerges from the interaction of social and technical actors, also referred to as sociotechnical networks (Walsham, 1997) or hybrid entities (Bielenia-Grajewska, 1999). From the ANT perspective, nothing can be purely social or technical (Rhodes, 2009; Walsham, 1997). All the actors in a sociotechnical network equally share the impact and they should be analysed with the same tools (Rhodes, 2009).

The key claims from ANT are that the actors with a motive (enrollers) (Walsham, 1997) often persuade other targeted actors to embrace the idea that the solution to their problems lies with them (problematisation) (Underwood, 1999). Once actors are enrolled in the networks of association, such networks sometimes mature to a point of irreversibility, where actors can no longer consider alternatives (Walsham, 1997). The networks form inscriptions such as policies that bind them together, sometimes to a point where a network begins to be recognised as one actor, inaccessible to other actors (a black box) (Booth et al., 2016; Underwood, 1999; Walsham, 1997). For instance, although cell phones are viewed as sole objects, the reality is that they represent a group of actants such as cell phone applications, built-in cameras, radios, earphones, networks and service providers, among others. Moreover, the development of actor networks sometimes reaches an immutable mobile stage, becoming irreversible, such that they can transcend time and place, for example software standards (Walsham, 1997), specifications for procurement and business cases (Llewellyn et al., 2014). The interactions of the actants and the networks form potential black boxes (a network of actors that is often perceived as a single actor), which can only be understood through more in-depth analysis. Consequently, such ‘appropriate’ mobile devices and their role in the teaching and learning of medicine and healthcare delivery is one potential black box requiring in-depth analysis.

In this study, we used ANT as a lens to explore what constitutes ‘appropriate’ mobile devices and their roles in the teaching and learning of medicine and healthcare delivery at the UB FoM. Two questions guided the research process: (1) what is the appropriate mobile device for mLearning and mHealth at the University of Botswana’s Faculty of Medicine?, (2) what roles do these mobile devices play in mLearning and mHealth at the University of Botswana’s Faculty of Medicine? The assumption was that ANT would allow the researchers to explicate the characteristics of mobile devices that potentially make them ‘appropriate’ (see Booth et al., 2016; Rhodes, 2009; Wright & Parchoma, 2011).

Methodology

Our study adopted a qualitative interpretative case design approach (see Cohen & Manion, 1994; Creswell, 2003; Schwartz-Shea & Yanow, 2011). Data were collected through in-depth interviews, focus group discussions, direct observation, and document analysis, and analysed by employing the grounded theory methods of open, axial, and selective coding (for further information, see Corbin & Strauss, 2008). Ethical clearance was provided by the University of Botswana Institutional Review Board (UBR/RES/IRB/SOC/GRAD/134), the Botswana Government Ministry of Health and Wellness (HPDME: 13/18/1) and Princess Marina Hospital (PMH5/74 (479-1-2018)).

Case Description

The UB FoM is a relatively new medical school that offers eleven postgraduate programmes in addition to the undergraduate Bachelor of Medicine and Bachelor of Surgery (MBBS) programmes (Mokone et al., 2014). In both undergraduate and graduate programmes, students spend a significant portion of their time learning away from the main university campus at numerous teaching locations (hospitals and primary care facilities) spread across the nation (Kebaetse et al., 2016). To ensure that students and clinical staff have uninterrupted access to learning and clinical information during extended periods away from the main campus, the medical school implemented the mLearning Initiative in 2013. Besides the installation of internet infrastructure at the teaching sites, students in the clerkship years (years 3 – 5 of the MBBS programme), postgraduate students (residents) and teaching staff were allocated tablets to enable anytime, anywhere, self-paced access to information and collaborative learning tools (Kebaetse et al., 2014, 2016; Witt et al., 2016). The project was financed through the US government-funded Medical Education Partnership Initiative (MEPI) grant, received in 2010. The implementation of the mLearning Initiative was spearheaded by a multidisciplinary team from various university units, including the UB FoM, the UB Library, the Department of Information Technology and the Botswana UPenn Partnership (Kebaetse et al., 2016). In 2014, as the MEPI grant came to a close, the team explored BYOD as an alternative to institution-provided devices (Kadimo et al., 2018).

In 2013, the medical school implemented the mLearning Initiative to ensure that students and clinical staff have uninterrupted access to academic and clinical information during extended periods away from the main campus. Students in the clerkship years, postgraduate students (residents), and teaching staff were provided with tablets to facilitate anytime, anywhere, self-paced access to information and collaborative learning tools (Kebaetse et al., 2014, 2016; Witt et al., 2016). The initiative was funded by the 2010 US government US government's Medical Education Partnership Initiative (MEPI). A multidisciplinary team from various university entities, including the UB FoM, the UB Library, the Department of Information Technology, and the Botswana UPenn Partnership, led the implementation of the mLearning Initiative (Kebaetse et al., 2016). As the MEPI grant expired in 2014, the implementation team explored BYOD as an alternative to institution-provided devices (Kadimo et al., 2018).

Population, Sampling and Invitation to Study

We purposively selected a diverse group of key informants knowledgeable about the implementation of the mLearning Initiative at the UB School of Medicine. The sample comprised the mLearning Initiative implementation team, a group of third-year students and individuals with deep knowledge of the projects. As we analysed the data from the mLearning Initiative implementation team, we moved to theoretical sampling, identifying subsequent participants based on the themes identified. Participants were invited to participate in the study via email, telephone, or in-person contact.

Participant characteristics

There were 25 participants, 11 men and 14 women, of which 8 were students and 17 were staff members (Table 1). The mLearning Initiative implementation team (n=13) included staff from the MEPI project (n = 3), the Department of Information Technology (n = 1), medical librarians (n = 3), health informaticians from the Botswana UPenn Partnership (n=6) - three were supervisors, and the other three worked as operational employees. Along with the mLearning Initiative implementation team, other participants included eight third-year undergraduate medical students who were on clerkship at Princess Marina Hospital, one executive manager from the UB FoM, one manager from the Centre for Academic Development, two teaching clinicians, and another participant (n = 12). Additionally, two university documents—the Information Technology Policy from 2003 and the Learning and Teaching Policy from 2008—were examined per ANT guidelines.

Table 1: Summary of the study participants

UB or partner unit	Participating staff
UB Library	Medical librarians (n = 3); library managers (n = 2)
UB Department of Information Technology	IT specialist (n = 1)
UB FoM / MEPI project	Operational staff (n = 2); managerial staff (n = 1); teaching staff (n = 2)
Botswana-UPenn Partnership	Managerial staff (n = 3); operational staff (n = 3)
UB-wide staff	Managerial staff (n = 2)
Students	Third-year students (n = 8)

Source: (Kadimo et al., 2022)

Data Collection

Data collection started in the October 2018 – February 2019 academic year. Once developed, data collection instruments were piloted for validity and revised for clarity and simplicity. Data were collected using in-depth interviews and focus group discussions. Data were also gathered through non-participant observation to document the behaviour and activities of eight undergraduate medical students undergoing a clerkship at Princess Marina Hospital. Data were also gathered through document analysis of two sampled institutional documents (the information technology policy and the learning and teaching policy) to confirm and qualify assertions made during focus groups and interviews that these papers were mentioned.

Three focus group discussions and a total of 11 individual interviews were conducted. The focus groups lasted between 40 and 60 minutes, and the interviews lasted between 30 and 45 minutes. All focus group discussions and interviews were conducted by KK, who began each session by outlining the study's goals to ensure that everyone was on the same page (see Creswell, 2013). During focus group discussions, a trained data collection assistant was used to record notes and observe non-verbal communication. Individual interviews were conducted with members of the mLearning Initiative implementation team with supervisory or managerial responsibilities to prevent any negative power play that might have occurred if they had participated in a focus group with their supervisees. KK also observed two groups of third-year medical undergraduates, taking note of their mobile device-related behaviour and actions.

Participants were assured that their privacy and confidentiality would be respected and that the data collected would be used exclusively for research purposes. The participants were given time to read and fill out the informed consent form, which was then signed by both the subject and the researcher. The interviews and focus group discussions were captured on tape with the participants' consent. Participants were allowed to review their interview transcripts once the audio recordings were transcribed verbatim.

The University of Botswana's Learning and Teaching Policy from 2008 and the Information Technology Policy from 2003 were examined because participants in the focus groups and interviews mentioned them. KK analysed the documents and extracted the data relating to the use of personal mobile devices by UB constituents (staff and students) within the UB network and for various objectives, including personal, work, and learning-related activities.

Data Analysis

Data transcripts were de-anonymised by assigning to each transcript a special code made up of a date, a shortened instrument name (for example, as FG for focus groups and T for individual interviews), and a chronological transcript number. To create broad themes and sub-themes and establish relationships from the data, data were analysed hierarchically and recursively using grounded theory techniques of open, axial, and selective coding (see Creswell, 2013; Keddy, Sims, & Stern, 1996). The results of the data analysis were visualised using matrix tables and conceptual maps. Further analysis was influenced by the incoming data, which eliminated the impact of prior beliefs, notions, or hypotheses on the study's findings.

Findings

This study revealed that the critical characteristics and/or roles that the participants associated with ‘appropriate’ mobile devices included portability and user-friendliness, support for clinical teaching and healthcare delivery, integration with other learning technologies to support mLearning, supporting routine tasks and compliance with national healthcare regulatory frameworks and communication technology infrastructure.

Portability and User-Friendliness

The findings suggest that appropriate mobile devices for the teaching and learning of medicine and healthcare delivery should be small in size or “portable” (T11.22.10.18, T6.29.11.18), preferably those that can “fit into a pocket” (T11.22.10.18). For instance, one participant noted that the device “should be portable [so] that it can fit in the pocket the same way my Oxford handbook fitted in my pocket” (T11.22.10.18). Although participants identified cell phones, tablets and laptops as appropriate devices, some challenged the portability of tablets and laptops. For instance, one participant said, “I prefer something not big like tablets. For example, I used to have a tablet, but I can’t carry it everywhere because it’s cumbersome” (T6.29.11.18). Another participant noted that instead of a tablet, “it has to be something handy” (T6.29.11.18). This preference for a portable mobile device is consistent with the non-participant observations of third-year students; medical students tended to keep mobile devices in their pockets during their clinical rotations at Princess Marina Hospital (T15.O.04.12.18).

Even as participants suggested a preference for a portable device, they also highlighted the need for a balance between portability and a screen size that allows them to “read the text” (T11.22.10.18) without difficulty. Contrary to the end-user preference for pocket-size devices, information technology practitioners tended to suggest laptops as “ideal mobile devices” (T7.6.12.18) compared to tablets and cell phones. However, one participant also suggested that laptops are inappropriate, noting, “I think if you bring a laptop … it’s really inappropriate”, because it cannot easily be carried around (T11.22.10.18).

Support for Clinical Teaching and Healthcare Delivery

The findings suggest that the circumstances of the user influence what is considered an appropriate device. In the case of the UB FoM, participants tended to prefer mobile devices that can support clinical decision making, for example patient diagnosis and drug prescription (T11.22.10.18., T9.29.10.18) in addition to routine tasks; that is, devices that provide limitless access to information for trainees and faculty members, especially at the point of need (T8.15.11.18) such as at the “bedside” and “at home” (T11.22.10.18). One participant described appropriate mobile devices as follows:

> *I take it as a tool to facilitate both learning and research. It facilitates in the sense that it has the capacity to provide access readily, easily, anywhere, anyhow and it can be carried around and provide a service at the point of need.* (T8.15.11.18)

Appropriate mobile devices should have the ability to support telemedicine or remote healthcare service delivery. That is, devices should enable real-time communication between medical students at remote locations and their lecturers (T11.22.10.18), supporting "patient examination" (T1.FG.12.10.18), "calculating drug dosages" (T9.29.10.18) and other medical decisions. For instance, one participant stated the following:

> *If a resident [for] Dr X [is gone for] outreach [at] Mochudi, they should be able to, in real-time, [when] stuck … talk to Dr X and enable Dr X [to see] whatever pictures or whatever things [while talking] so that he can advise.* (T11.22.10.18)

That is, users should "see what I am seeing. If I am listening to the heart, there [should be] a way they can hear what I am hearing, [so] I am able to advise" (T11.22.10.18).

Integration with other Learning Technologies to Support Mlearning

The appropriate mobile devices should support mLearning in alignment with the University infrastructure. One participant stated that the University should "fully integrate the mobile devices into the education system to a point where all the learning really can be done from the mobile device" (T1.FG.12.10.18). First, appropriate mobile devices should support remote lectures, mentoring, tests and examination writing (T9.29.10.18, T11.22.10.18, T1.FG.12.10.18, T2.FG.21.11.18). For instance, lectures could be pre-recorded (e.g. through voice notes, video recording and video calls) and shared with students (T1.FG.12.10.18, T2.FG.21.11.18). Second, one participant suggested that appropriate mobile devices could support "virtual reality", especially for teaching and learning surgery (T9.29.10.18). Third, in addition to networking for academic scholarship, they can also support and facilitate "study groups, in other ways connecting you with people, and see who else has done similar projects" (T9.29.10.18). In addition, they should integrate or be compatible with other technologies such as the library information databases (T8.15.11.18) and the University's payment systems through innovations such as the "USSD" (Unstructured Supplementary Service Data) (T1.FG.12.10.18).

Supporting Routine Tasks

The findings suggest that for appropriate mobile devices to support tasks for the teaching and learning of medicine and healthcare delivery, they should be equipped with enough operational and storage memory (T11.22.10.18, T9.29.10.18) because they will be more of a personal library (T8.15.11.18). Therefore, space is required for running mobile device operations such as note taking, similar to “pen and paper” (T8.15.11.18), taking photos and “sharing” PDFs or any “documents” (T3.FG.11.12.18) through applications such as WhatsApp (T2.FG.21.11.18). Apart from running the operations, the mobile device should be able to store several applications and the data resulting from the tasks carried out.

Conformity with National Healthcare Regulatory Framework and Communication Technology Infrastructure

Participants suggested that appropriate mobile devices should conform to national policies, regulations and standards, such as supporting the “Ministry of Health strategy of using the mobile device … what they want to do and what they want to achieve” (T2.20.11.18). In addition, appropriate mobile devices should conform to the Botswana Communication Regulatory Authority’s “standards for communication” (T3.26.11.18). They should also conform to the “non-resolution of the universal standards for Botswana in terms of transiting from the analogue to digital” of the Botswana Ministry of Transport and Communications (T3.26.11.18).

Overall, the findings suggest that an ‘appropriate’ mobile device should be portable and user-friendly, meet the national healthcare regulatory and communication technology infrastructure frameworks and support users to complete tasks related to the teaching and learning of medicine and healthcare delivery. Mobile devices should support healthcare delivery by enabling access to information for clinical decision making, patient diagnosis and prescription. The devices should also enable mLearning by integrating other teaching technologies to allow for remote teaching, mentoring, study groups, assessment and administrative tasks such as online payment systems. In addition, mobile devices should be aligned with the Ministry of Health and Wellness’s mobile device implementation strategy and conform to national standards such as analogue to digital standards. To achieve portability and user-friendliness, mobile devices should have the capacity to support the operations and storage of the resulting data.

Discussion

Our findings expand the traditional understanding of an ‘appropriate’ mobile device for the teaching and learning of medicine and healthcare delivery beyond the conventional techno-centric approach of focusing on the capabilities of the device to include the needs of the user and internal/external stakeholders’ requirements. The study has found multiple actants that characterise an ‘appropriate’ mobile device. When using techno centric approaches, as opposed to sociotechnical approaches such as ANT, several actors or role players are sometimes overlooked or perceived as a single actor (black box), for example an ‘appropriate’ mobile device. Understanding these actors or actants and their networks of association requires sociotechnical approaches to analyse them in their roles in the healthcare and medical education context.

The market availability of mobile devices and the consideration of certain mobile devices as ‘appropriate’ for the teaching and learning of medicine and healthcare delivery are largely influenced by the internal/external stakeholders through ‘scripts’ such as legislation, standards, and strategies. For instance, our findings suggest that an ‘appropriate’ mobile device for the teaching and learning of medicine and healthcare delivery should conform to the Botswana national healthcare regulatory framework and communication technology infrastructure. Similarly, in the USA, the US Food and Drug Administration, the Health Insurance Portability and Accountability Act (HIPAA) and the University of California San Francisco School of Medicine and Scripps Research Institute regulate the use of mobile devices in healthcare (Gaglani & Topol, 2014; Williams, 2014). The HIPAA, in particular, has led to the production of HIPAA-compliant mobile devices (Williams, 2014). In Australia, the Medicines and Healthcare Products Regulatory Agency and the Therapeutic Goods Administration (Lewis & Wyatt, 2014) also regulate mobile device technologies and medical tools.

Consistent with existing literature, our findings highlight several functional characteristics that support tasks necessary for the teaching and learning of medicine and healthcare delivery. Appropriate mobile devices should enable easy access to medical information resources (Lasserre et al., 2010), sometimes through medical apps and websites (O’Connor et al., 2014). Also, they should enable healthcare providers to communicate through mobile device calls, emails, text and photo messaging (O’Connor et al., 2014; Ramesh et al., 2008). Features such as cameras are sometimes used to capture images of medical conditions, which are then shared with other providers to seek advice or a second opinion (O’Connor et al., 2014). Such communication is particularly helpful to junior doctors or medical interns seeking second opinions or assistance from senior doctors or specialists (Hardyman et al., 2013). In addition, our findings point to the importance of mobile devices being compatible with other technologies and can support remote lecturing, mentoring and healthcare provision.

Although not explicitly stated, the description of the ‘appropriate’ mobile device suggests internet connectivity as an essential aspect of such devices. Internet-connected mobile devices are a means of convenient access, retrieval, storage and sharing of information (Lasserre et al., 2010; Moyer, 2013; O’Connor et al., 2014), including point-of-care or point-of-need communication means such as calls, emails, text and photo messaging (O’Connor et al., 2014; Ramesh et al., 2008). Also, internet-connected mobile devices support tasks such as real-time communication between medical students at remote locations and their lecturers, as well as patient examination, calculating drug dosages and other clinical decisions. The preference for mobile internet connectivity is likely to continue growing, as demonstrated by recent trends of new mobile internet connectivity (Bahia & Suardi, 2019) and worldwide mobile connections (bankmycell, 2020). Such developments and growth will potentially continue to influence medical education and healthcare delivery, as evidenced in recent research on internet addiction among healthcare professionals (Buneviciene & Bunevicius, 2020).

Besides the above-mentioned functional characteristics, our findings suggest that portability is a critical component of what constitutes an appropriate mobile device. The portability of mobile devices gives them the ability to enable real-time communication, making them preferred instruments for the teaching and learning of medicine and healthcare delivery (Ansaldi, 2013; Disterer & Kleiner, 2013; Moyer, 2013; Olalere et al., 2015; Winters, 2013). Portability seems to be multifaceted and is associated with the user's pocket and hand, the patient and/or the patient's bedside. This association of portability with the hand is consistent with existing literature where mobile devices are sometimes referred to as pocket computers (Moyer, 2013), handheld technologies or handheld phones (Prgomet et al., 2009). End users' attire with pockets complements the hand by conveniently stowing away the mobile device (Masters et al., 2016) when not in the user's hand. In addition, the patient and/or patient bed is associated with the appropriate mobile device, because healthcare providers tend to use mobile devices to perform tasks such as accessing information and diagnosis during clinical rounds and consultations. Such use of mobile devices by healthcare providers to perform healthcare delivery tasks is commonly referred to as access at the point of care, access at the bedside or just-in-time access (Boruff & Bilodeau, 2012; Chang et al., 2012).

The association of an appropriate mobile device with the user's hand seems to exclude laptops and sometimes tablets as appropriate mobile devices for patient care, especially in a ward setting. Tablets and laptops are considered too big and cumbersome to be carried around, as they also cannot easily be stowed away in a pocket. A decade ago, tablets were preferred mobile devices because compared to laptops, they could easily be carried around and their screen size was more suitable for reading compared to the cell phone (Davies et al., 2012; Kebaetse et al., 2016; Masters et al., 2016; Witt et al., 2016). Continued advances in information and communication technologies might be influencing the current preference for smartphones as appropriate mobile devices, because cell phones increasingly have larger screens, while still fitting in the user's hand and pocket.

Mobile devices are also considered appropriate because of their ability to have 'multiple identities', where the same device is used for learning (mLearning), healthcare delivery (mHealth) as well as completing personal tasks (non-official use) (Chaiyachati et al., 2013; Kebaetse et al., 2016; Witt et al., 2016). These multiple identities of mobile devices suggest that mobile device use in medical schools is facilitated within a complex environment involving medical schools, healthcare facilities and personal spaces such as the home, restaurant and hotel. As such, the implementation of mobile device initiatives has to enable, accommodate and harmonise these multiple identities to ensure optimal learning and healthcare delivery, while safeguarding patient safety (Faulds et al., 2016; Jamu et al., 2016; O'Connor et al., 2014; Yetisen et al., 2014) and user preferences (Chaiyachati et al., 2013; Kebaetse et al., 2016; Witt et al., 2016). The failure to harmonise the multiple identities of mobile devices, coupled with their portability, may pose some challenges to the implementation of mobile device initiatives. For instance, because mobile devices can easily be carried around, the user's hands can become occupied with multiple devices, leading to 'digital overload' (Al Ayubi et al., 2016; Ealey, 2015; Williams, 2014). Also, the use of such mobile devices can create challenges such as distracted learning and doctoring (O'Connor et al., 2014; Tran et al., 2014) (e.g. the doctor taking non-emergency personal calls during consultations) and cross infection, where the device becomes an infection agent (Cobb & Lazar, 2020; Galazzi et al., 2019; O'Connor et al., 2014; Williams, 2014).

The challenges mentioned above potentially led to the development of computers on wheels (COWs) to support access to information during the clinical rounds. The COWs innovation involves laptop computers mounted to a mobile workstation that can be wheeled around (Jen et al., 2016; Murphy & Reddy, 2017). To some extent, COWs may address the challenges associated with the carrying and use of personal mobile devices by enabling the mobility of facility-owned devices. However, COWs may add to "digital overload, adding to the personal devices that the user is already carrying because COWs may not support other tasks that personal mobile devices ordinarily support. For example, COWs may not support tasks such as taking photographs and making telephone calls.

In summary, an appropriate mobile device for the teaching and learning of medicine and healthcare delivery seems to be one that balances the functional characteristics of the device with the needs of the user (medical teachers and students, and healthcare professionals) and those of internal/external stakeholders to support the teaching and learning of medicine and healthcare delivery (see Figure 1).

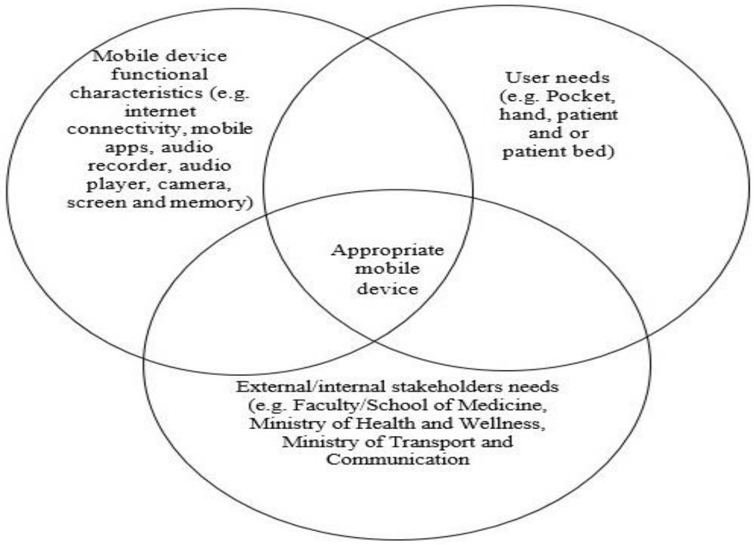

Figure 1: The relationship between the devices, their functional characteristics and user needs (patient and/or patient bedside, the user's pocket and the hand) and internal/external stakeholders' needs

Such a device meets the national healthcare regulatory framework and communication technology infrastructure, fits in the user's hand and pocket, and is easily used at the bedside, as shown in Figure 1. The needs of the users and internal/external stakeholders and the functional characteristics of mobile devices influence each other to constitute what the users suggest to be an 'appropriate' mobile device. For instance, in the USA mobile device manufacturers responded to the healthcare sector's need to protect the privacy and confidentiality of patients by developing HIPAA-compliant mobile devices (Williams, 2014). Also, with the increasing use of mobile devices for work and learning, the need for mobile devices with bigger screen sizes emerged, and mobile device manufacturers responded by developing portable cell phones with bigger screen sizes (Lewis & Vohra, 2014; Meneghetti, 2013; Williams, 2014).

Study limitations

Notwithstanding the potential benefits of the ANT approach in research, the theory is too descriptive, leading to an infinite list of actors/actants (Cresswell et al., 2010). Hence, it was not possible to follow all the players, because the study was confined to the setting (University of Botswana) as per the granted study permits.

What is already known on this topic?

- Mobile device users have a preference for a portable and user-friendly device.
- There is a preference for mobile devices that meet the national healthcare regulatory and communication technology infrastructure frameworks and support users to complete tasks related to the teaching and learning of medicine and healthcare delivery.

What this study adds?

- The Actor-Network Theory (ANT) approach to exploring appropriate mobile devices for the teaching and learning of medicine and healthcare delivery broadens our conceptualisation of appropriate mobile devices.
- Mobile devices are regarded appropriate for teaching, learning and healthcare delivery if their desired technical features conform to users' preferences and internal/external stakeholders' requirements.

Conclusions

The socio-technical approach, using ANT, to study the implementation of mobile device initiatives provides a deeper understanding of what constitutes an 'appropriate' mobile device. The findings suggest conceptualising 'appropriate' mobile devices by combining the desired technical features with user needs and/or preferences and internal/external stakeholders' requirements. It is instructive to study 'appropriate' mobile device players as a potential network (of actants) because it forms the basis for understanding them as individuals, their interests and their roles in the network, as well as the interests of the network. In that way, the choice and implementation of mobile devices could use a 'philosophy' that is sociotechnical to fairly represent the interests of the users and internal/external stakeholders.

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