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ADDRESSING DESIGN ISSUES IN MOBILE APPLICATIONS SUPPORTING UBIQUITOUS LEARNING

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The utilisation of mobile technology provides an opportunity to reflect on the milieu in which today's courses are delivered and how mobile technology can be leveraged to enable transformative classroom instruction by focusing on higher-level thinking skills and creativity. Numerous studies have suggested that there is improved learning when students have the means to physically move their own learning environment with them. However, the use of mobile applications does not, in itself, change the essential aspects of how students learn. Despite the ubiquity and flexibility offered using mobile applications, their design and integration with the course in which they are used needs to be carefully considered in order to transform the current learning environments into more productive and user-centred spaces. This paper addresses the design issues of different mobile applications, their effectiveness and potential impact on the current educational landscape.

Keywords: *Mobile, apps, ubiquitous, u-learning, pedagogy, instructional design*

INTRODUCTION

Today's students experience digital environments in very tactile and personal ways, and through a broad range of mobile devices. The use of these mobile devices provides students with more flexibility with respect to how, when, and where learning can take place. This then impacts educational systems, introducing new demands on information technology and how educators need to adapt their teaching approaches in ways that allow for more ubiquitous learning environments. Capitalising on the possibilities created when students access teaching materials at all times brings about new opportunities for learning. Students can now have, in the palm of their hand, an array of tools that can vastly expand their knowledge. Ching, Shuler, Lewis, and Levine (2009) noted, "the anytime, anywhere availability of mobile devices also has potential to promote a seamless 360-degree learning experience that breaks down the barriers between formal and informal educational environments" (p. 28). This ubiquitous learning (u-learning) environment combines the advantages of an adaptive environment with the benefits of ubiquitous computing.

Having the possibility and capability to learn whatever content one wants to outside of a classroom is a unique feature of the mobile learning movement. The best designed apps provide opportunities for exploration and involvement in the learning process. These apps offer learners active control of their learning in the palm of their hands. Due to the ubiquity of mobile phones, the familiarity of learners with mobile technology has helped to reduce the technological

barriers often associated with deploying learning technologies (Parsons & Ryu, 2006). Moreover, proponents of u-learning perceive individual access to technology as an essential element for exploiting the potential of technology to transform teaching and learning (Hill & Roldan, 2005; Peng, Su, Chou & Tsai, 2009).

The development of mobile learning and the expanding range of opportunities to develop educational processes anytime and anywhere has ultimately led to the new learning paradigm: u-learning (Peng et al., 2009). U-learning encompasses learning in an environment where "all students have access to a variety of mobile computing devices, whenever and wherever they need them" (van't Hooft, Swan, Cook & Lin, 2007, p. 6). Smartphones, in particular, have the possibility to augment and help realise ubiquitous mobile computing environments. According to Wesier (1993), in a ubiquitous computing environment, users can learn to use the available technology so well and do use it so frequently that they are not even consciously mindful of its presence. Students are recognising the impact that mobile learning has on helping to fulfil their learning needs (Spikol, 2010).

In the context of today's classroom environment, which leverages technology and emphasises creativity and innovation, it is essential that instructional designers continue to reassess mobile learning design and development (Elias, 2011). Hence, the purpose of this paper is to address design issues in the creation of mobile applications to support u-learning.

Mobile Apps

A mobile application, most commonly referred to as an "app", is a type of application software designed to run on a mobile device, such as a smartphone or a tablet computer. Apps can take different forms, such as an e-book, a game, flash cards, guided media, or an interactive animation (Geist, 2011). Apps designed to reinforce concepts from learning content can be very effective. Additionally, the affordability and ubiquity of mobile apps has contributed to the increasing attention given to learning (Garcia-Cabot, de-Marcos & Garcia-Lopez, 2015). However, mobile apps for education present a number of design challenges that must addressed in order to produce successful learning experiences (Tu & Sujo-Montes, 2015; Wright, 2015). Educational practitioners and designers need to develop strategies and practices that take advantage of how students use mobile apps, and that fulfil the potential of ubiquitous and personalised learning in the context of a specific course (Nicholas & Ng, 2015).

Unfortunately, there is, to date, relatively little information on exactly what types of apps can best enhance and promote student learning in various disciplines. This then presents a challenge for instructional designers and app creators to design appropriate interactive mobile features, and to subsequently assess what feature is most effective for delivering the content to learners. Moreover, for mobile apps to be pedagogically significant, they need to satisfy several conditions: (1) the apps should focus on specific pedagogical problems that are demonstrably difficult to address in the classroom; (2) their overall design must be transparent and fun to use, and aesthetically pleasing in order for them to compete in the mobile ecosystem of other apps, all vying for users' attention; and (3) why the app's content is important and how it will be used and/or assessed in the course must be crystal clear to the student. Failure of any of these essential elements may, unfortunately, render the production of the app an expressive waste of time and resources.

The creation of educational apps aligned with recent instructional design which can be seen as a shift toward a user-centric perspective due to the learners' access to readily available forms of content. This makes it important for designers to be aware of emerging learning environments influenced by technological changes. According to Irlbeck (2011), the time has arrived for instructional models that provide greater flexibility for time, location, content, and the facilitation of a variety of learning support strategies both for guided and self-directed learning. Hence, designing mobile technology for guided and self-directed learning has become a rapidly emerging area of educational research. It is necessary to investigate mobile learning design strategies and explore how these strategies are being carried out to engage students in the learning process.

CURRENT MOBILE APPS DESIGN

A number of case studies have demonstrated the successful use of mobile devices to enhance and support student learning, especially in the area of social interaction and communication (Jones, Scanlon, & Clough, 2013; Sharples, Arnedillo-Sánchez, Milrad & Vavoula, 2009). Dundon et al. (2013) examined two particular apps to support communication among learners and established that combining reinforcement techniques with apps, which are specifically aimed to enable communication, significantly improved the learners' communication skills. More importantly, the use of mobile apps allow instructors and students to have instant access to information at all times (Beutner & Pechuel, 2014). This potentially enhances the instructor's ability to be effective by giving the instructor the liberty to engage in tasks like monitoring the students' learning progress, supervising their participation in class activities and tasks, implementing various learning exercises, and monitoring whether students are deviating from an idea, task, or lesson (Liu et al., 2003). Ultimately, however, it is the instructor's responsibility to understand the benefits and limitations of mobile technology, which are not necessarily transparent, for instructional purposes inside and outside of the classroom.

The question of how learners interact with mobile apps is complex (Christensen & Prax, 2012). In addition to the content that the mobile device can deliver, the technology itself poses intriguing design issues. Two of the most important of these are: (1) what functionalities of an app *can* be incorporated; and (2) what functionalities that can be incorporated *should* be incorporated, or what are more efficiently delivered on other platforms or via direct interaction with students.

As the use of mobile technology becomes more common in education, researchers and educators are beginning to pay closer attention to designing apps that supplement classroom instruction (Park, 2011). Despite the fact that there are educational apps specifically intended to support and enable learning, educators and researchers continue to discover that the educational benefits of these technological devices may not necessarily stem from the devices themselves, but instead from the choices of how instructors integrate them into their teaching approach. Given the optimal situation where instructors can have apps made specifically for their classes and students, it is up to the instructors to guide the development of the apps that they consider useful, and then strategically integrate them into the appropriate curriculum. Goodwin and Highfield (2013) conceptualised a model to understand educational apps for the type of task embedded into the app. In this particular framework, apps were categorised based on their instructional design, depending on any of three instructional roles addressed (explorative, productive, and instructive roles). Goodwin and Highfield further proposed another three broad categorisations of educational apps which we will examine. Their

categorisations included instructive, manipulable, and constructive, and two hybrid categorisations that include constructive/manipulable and manipulable/instructive.

Instructive Apps

Instructive apps promote rote memorisation of content through recall and drill-and-practice activities. A flashcard interface can be effectively utilised for many such apps. Despite their lower categorisation in Bloom's Taxonomy (Bloom, 1956), such learning activities are often essential to develop the vocabulary necessary for meaningful discussion and higher forms of learning activities. Hence, most of the problems provided on these apps are somewhat similar and repetitive in nature as they are meant to expand students' knowledge in a specific subject area (Handal, Campbell, Cavanagh & Dave, 2014). The *Music Technology Glossary* app (Figure 1), developed by the Resource Centre for Ubiquitous Learning & Integrated Pedagogy (ULIP) at Hong Kong Baptist University, is an example of an instructive app type using flashcard strategies to help students learn basic terminology and cable identification essential for music technology literacy.

Figure 1. Instructive app example – Music Technology Glossary.

Unlike an examination or quiz, the feedback these apps provide is instant. Although low on rigour, the significance of these apps ranks high because students are able to apply the subject area knowledge these apps develop as they engage in more challenging learning tasks (Yarmey, 2011). These apps can be made more interactive when given the possibility of students making their own entries or by requiring the students to make all entries using their own recently learnt conceptual understandings.

The design of this app was informed by the requirements we considered the most pedagogically significant, as detailed above. Firstly, it focuses on recall and drill-and-practice type activities that are less efficient and less effective in a classroom. Secondly, beta-testers confirmed its design was easy to use and aesthetically pleasing. Lastly, it incorporates a "why this app?" page to convey, in simple terms, why its content is important and how it will be used/assessed in the course. This is presented in a pop-up screen the first time the app is used, prompting the student

to tick "I understand" before continuing to the next screen, and is also accessible via a high-profile button on the home screen.

Its pedagogical use in the classroom lies in several tiers. The most basic are periodic quizzes and exams on the content. Above this, tier classroom time is more focused on placing the content in a larger context of their use. And finally students in the class are presented with common recording and technology problems to solve that rely on their comprehension of the terms studied.

Manipulable Apps

Manipulable apps offer students digital manipulatives for guided discovery and by virtue of which they are able to demonstrate this learning using a pre-constructed context, template, or structure (Cherner, Dix & Lee, 2014). An example is the *20th Century Music Study Guide* app, developed by the ULIP, facilitates the studying music of the 20th century, learning both repertoire and compositional techniques of various musical compositions. This is accomplished by playing excerpts of a repertoire, reading texts/notes about them, displaying pertinent images based on historical context or analysis, and showing videos related to specific topics. Common to most of our apps, the design of the *20th Century Music Study Guide* includes a game engine which simultaneously makes learning more fun for many students and allows for them to track their progress.

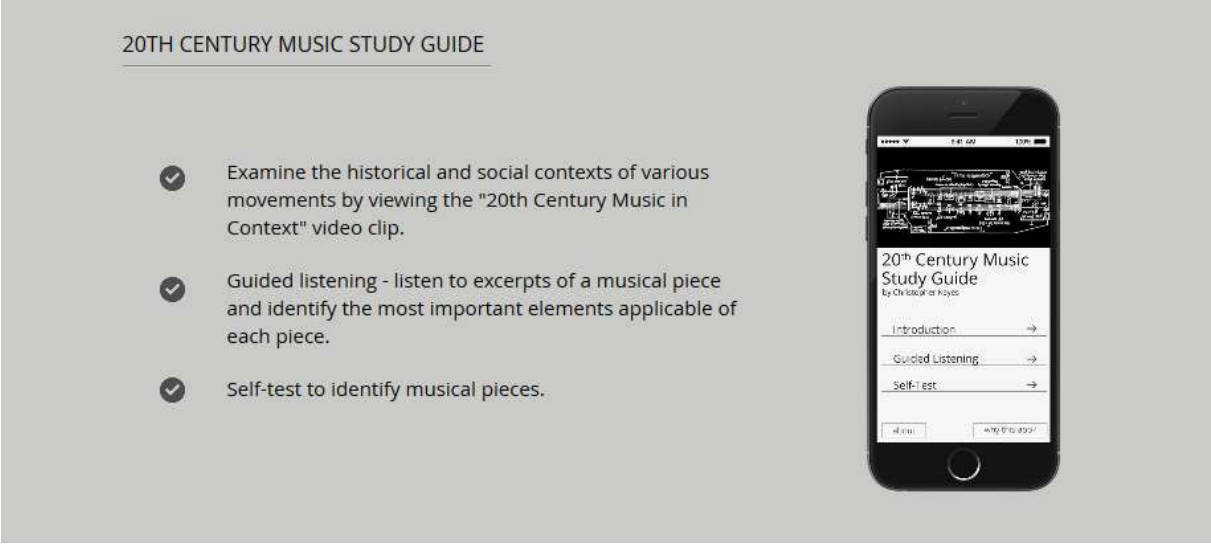

Figure 2. Manipulable app example – 20th Century Music Study Guide.

Its pedagogical use in the classroom lies (again) partly with exams to test their mastery of the repertoire. Beyond this, the pieces are placed in historical context along with similar pieces. This leads to exercises in the identification of techniques used in new pieces presented in class. Finally, students are required to compose similar pieces using the techniques studied.

As digital manipulatives, the tasks fall within pre-determined and scripted parameters, but still provide students some degree of freedom to explore (Hirsh-Pasek et al., 2015). A common characteristic of manipulable apps is that they do not assess students or require them to complete a learning activity or task (Goodwin & Highfield, 2013).

Manipulable: Subject-area Apps

Subject-area apps comprise pre-programed content intended to deepen students' understanding of a particular academic content area (e.g., music, art, math, science). These apps are considered "top–down" because the content students immerse themselves in is already programed into the app, thereby limiting students to nothing beyond the pre-programed content (Cherner et al., 2014).

Manipulable: Reference Apps

Reference apps enable students to access, search, examine, and explore an extensive variety of topics. These apps are typically regarded as "bottom–up" (Van Der Vet & Mars, 1998) because they allow students to perform their own searches for content in order to develop their understanding of a topic. For example, the *Medicinal Plants Database* app, developed by the ULIP, helps students from the School of Chinese Medicine to identify over 1200 medicinal plants through a user friendly and powerful search platform.

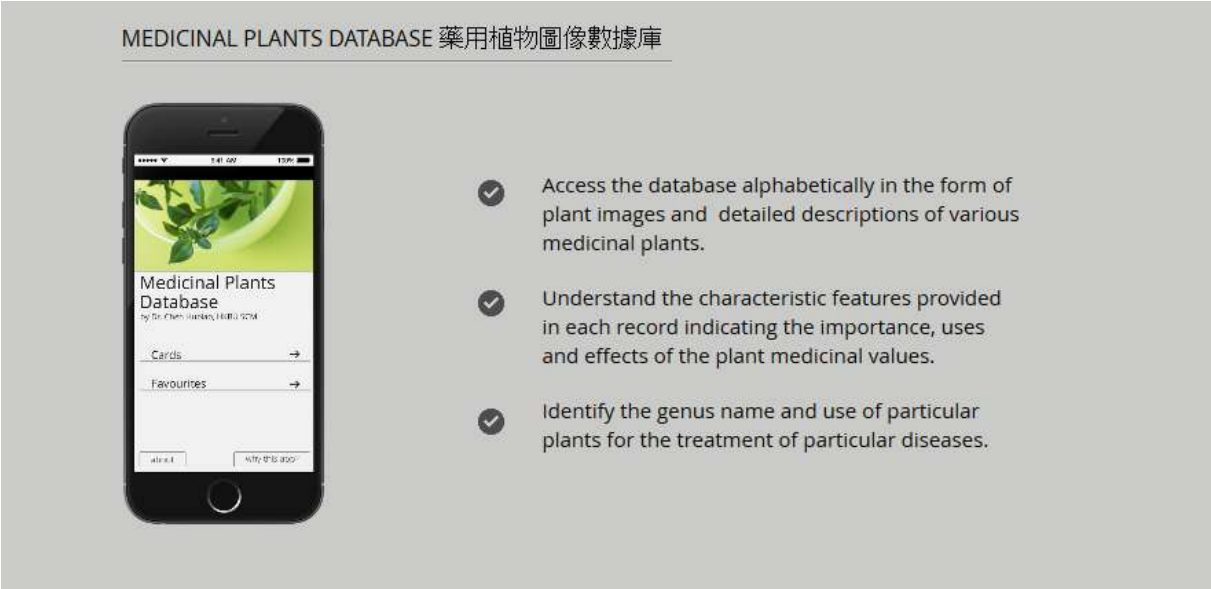

Figure 3. Reference app example – Medicinal Plants Database.

Constructive Apps

As with the requirement of students to compose pieces based on works they have studies in our previous apps, constructive apps assist students in transforming learnt information into usable forms, presenting students with templates, open-ended contexts, or structures, subsequently enabling them to create learning artefacts (e.g., videos, text or images; Cherner et al., 2014; Goodwin & Highfield, 2013). Moreover, constructive apps do not emphasise assessments nor do they comprise academic content. Students often utilise these apps to create learning artefacts, which may include multimedia presentations, visual representations, or textual descriptions of their learning (Beutner & Pechuel, 2014). In this way, constructive-based apps use the literacy

and numeracy skills students learnt from instructive apps to display the knowledge they had learnt from manipulable apps (Zosh et al., 2013).

Design Issues

It is with these type of apps that the efficacy of using mobile technology to enable students to create learning artefacts, as opposed to in-class or individual contact, becomes less clear. These are learning activities that will likely generate the most questions, which may be difficult to anticipate and address sufficiently in an app. They may also generate a need for aesthetic judgments and guidance, which would be difficult to address in an app. This type of app may be more useful for distance learning, but more study is needed to clarify the value-added qualities of the app in a blended learning environment. Such a study may also demand a closer look at qualities beyond content and functionality.

Certainly, one would agree that content and functionality are important when it comes to educational apps, and they are often the focus of app creation. However, exactly what and how much content and functionality is pedagogically efficient and most useful to students is an added complex question to answer, which requires greater attention to app *design*. A design with too much content in an app, for example, may lead students to feel overwhelmed and less likely to engage with it, similar to a 1200-word manual on software usage. Often a better design may break content into smaller units for multiple apps. These smaller, more individual apps can, however, be programmed to link and open content in other apps, creating a suite of apps on a common theme but with different foci. Thus, content may be designed to accomplish different goals with specific pedagogies or design frameworks.

Other important design issues lie in the transparency of the app's content and navigation: is it obvious to the student how much content and functionality the app contains, and how easy is it for the student to navigate to them. Also of paramount importance is the amount of student interactivity and engagement with the app: is the app static or does it change in some way as a result of student's input?

Perhaps most important is the app's behaviour. An app that does not behave as students expect or has significant design flaws may be ignored much as a poorly designed website would be. Once frustrated by a poor website's behaviour and navigation or a programming error which freezes their browser, students will most likely never navigate back to it and any potential education value would be lost entirely. This may also negatively affect the student's interest and appreciation of the subject, which would render the app counterproductive.

Amershi et al. (2005) identified usability requirements they considered as crucial for educational apps. They identified such apps as usable if they are simple to learn, understand, and use. An educational app that students find difficult to use may prevent them from learning anything with it. To be effective, it needs to be stimulating, attractive, and exciting for students.

POTENTIAL IMPACT OF MOBILE APPS ON TEACHING AND LEARNING

Despite these potential problems, findings from past research advocate a positive potential impact of mobile applications on teaching and learning in higher education (Godwin-Jones, 2011; Khaddage & Knezek, 2011; Khaddage & Lattenman, 2013). Additional findings support

the overall pedagogical potential of mobile apps. The questions they addressed were: (1) "How do mobile apps support learning?" and (2) "What does this mean for what learners actually do?" The findings identified a wide range of learning activities that could be supported with mobile apps (Kress & Pachler, 2007).

This view is supported by prior research suggesting that attitudes toward educational mobile apps are an important factor in their adoption (Haag, 2011; Koehler, Yao, Vujovic & McMenamin, 2012). Liaw, Hatala, and Huang (2010) studied student attitudes toward mobile learning and concluded that students displayed positive attitudes toward the use of mobile apps in the educational environment. This is especially true when the curriculum is designed for autonomy, and designed to facilitate and support self-managed learning, which is highly interactive (Williams, Karousou & Mackness, 2011).

CONCLUSION

Mobile learning with ubiquitous devices allows access to numerous novel learning opportunities (Shippee & Keengwe, 2014). Mobile learning provides users with learning mobility and ubiquity through digital tools with a wireless connection or, preferably, without. The ultimate vision of ubiquitous knowledge construction will encompass mobile learning, constructivism, and lifelong learning theories (Peng et al., 2009). They can provide learning support for students by utilising their skills and competencies, which involves the enabling of rapid content delivery, a higher level of student engagement in learning-related activities, a myriad of diverse physical locations, and the greater accessibility and availability of information (Clough, Jones, McAndrew & Scanlon, 2008). Today's learning environments have the technological means to support interaction styles that are fundamentally different from those encountered in the instructor-centred paradigm.

Mobile apps offer many opportunities for educational reform; however, instructors and app creators need to pay special attention to design, along with content and functionality, to enable its full potential. This includes an often-overlooked aspect of integration into the greater learning environment. In the context of today's educational milieu, mobile apps may be a key component of how knowledge and its pedagogic discourse transform learning may be instrumental for generating new methods of accessing and sharing knowledge and information (Wong, 2012), and integrated into blended learning environments.

Authors

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