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Going mobile: Each small change requires another

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Students are seeking flexible study opportunities. Smartphones have potential to support learning at times and places chosen by learners but their introduction presents challenges in negotiating the changes in the behaviour of learners and in the materials and activities provided by university courses. This project, funded by DEHub in two Queensland universities, explored how students used mobile devices with many characteristics of smartphones. This paper reports on the first phase that investigated the changes required to facilitate access to course materials and activities using the devices. Data have been viewed through the lens of activity theory. The results confirmed the need for developing skills and managing expectations of learners and academics and for adjustments to design of course materials and delivery systems to facilitate access.

Keywords: mlearning, activity theory, teacher education, smartphone, iPod Touch, distance education, online education

Introduction and background

Family and work commitments are prompting more students to choose distance or online modes of study for all or part of their degrees. Implicit in their decisions is a desire for flexibility that can be limited by the delivery of bulky printed materials or media that require computers for access. One challenge faced by universities is the provision of flexible study opportunities that match the needs of students.

We live in an age of *mobilism* and access by learners to personal mobile computing devices is becoming commonplace (Norris & Soloway, 2011). Devices small enough to be ‘always’ carried by the user could overcome many barriers that limit access to study material and support more flexible distance or online learning. Although developed primarily for business and entertainment, many current mobile devices are powerful computers capable of running educational applications.

Smartphones are significant because they merge telephone, Internet-connected computer, camera (still and video), audio recorder and player, and ebook reader. Of the 89% of Australian adults owning a mobile phone in April 2011, 37% had a smartphone and the number of users going online with their mobile phone had increased by 63% from 2.4 million to 3.9 million between June 2010 and June 2011 (ACMA, 2011). Smartphones, and similar devices, offer learners more options for ‘anywhere, anytime’ learning than do larger portable devices such as laptops. They can store learning materials for later access or support remote synchronous or asynchronous interaction with content, teaching staff, and peers. As more students have access to smartphones and a growing preference for flexible learning, it is important that universities investigate both the potential of smartphones for learning and the changes that may be necessary to facilitate their use.

Literature review

Australian undergraduates include many mature students seeking career change opportunities. In 2009, 24% of Australian undergraduates were aged 25 or older and 15% were older than 30 years (DEEWR, 2010). The proportion varies across universities and disciplines with a survey of final year teacher education students reporting 45% aged 25 or older and 10% aged 40 or older (DEST, 2006). Many of these students have family and employment commitments that affect their availability for on campus classes. In 2006 the typical Australian university student was undertaking substantial paid employment during the semester (James, Bexley, Devlin, & Marginson, 2007), with as many as 70% of full-time undergraduates working almost 15 hours per week on average, 15% working more than 20 hours per week, and almost 5% working full-time. It is not surprising that students seek flexible options to meet individual needs for balancing study, family and work commitments.

From 2001 to 2010 the proportion of Australian undergraduates studying part-time declined from 27% to 21% (DEEWR, 2011). Over the same period the proportion of undergraduates studying in internal (on campus) mode remained steady at 83% to 84%, while external enrolments decreased from 13% to 8% and multi-modal enrolments (study units taken partially internally and partially externally) rose from 4% to 8%. For USQ from 2006 to 2010 undergraduate enrolment density (ratio of head count enrolments to full-time equivalent load) decreased slightly from 1.99 to 1.86, indicating a slight increase in the proportion of full-time students. Over the same period internal and external enrolments reduced from 15% and 75% to 13% and 74% respectively while multi-modal enrolments rose from 10% to 13%. The number of web-based subjects offered rose from 119 to 198 and web-based student enrolments rose from 2676 to 12485, an increase of more than 400% (USQ, 2012). These trends are reflected in the observation that in 2012 up to 70% of Bachelor of Education students at USQ are studying at least some subjects online. Moreover students studying on campus are likely to access some of their study materials and activities from online sources. The evidence suggests that flexibility of study is increasingly important to students and that the mobility afforded by smartphones and similar devices will be part of the solution for meeting the need for flexible study options for students. Hence it is important to understand both the potential and the implications of adopting and adapting mobile technologies for learning and teaching.

Affordances and limitations of mobile devices

Cheung and Hew (2009) referred to "mobile handheld devices as any small machines that can be carried easily in one's palm and provide computing, as well as information storage and retrieval capabilities." Wireless Handheld Devices (WHDs) represent a subset of such devices with affordances that render them highly appropriate as learning tools in distance education (Soloway, Norris, Blumenfeld, & Fishman, 2001). Figure 1 represents the relationship between WHDs and related devices.

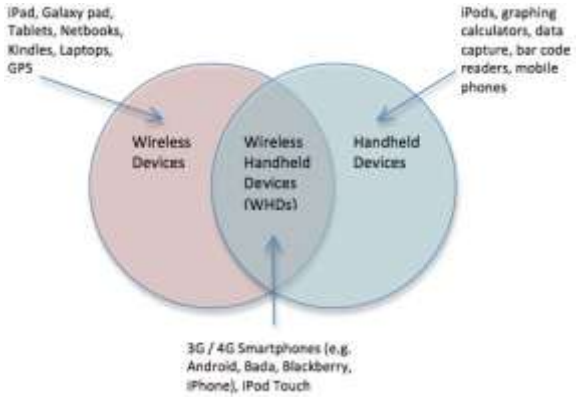

Figure 1: Categorization of computing devices as wireless, handheld or wireless handheld devices (WHD)

WHDs exhibit properties, including portability, potential for social interactivity, context sensitivity, connectivity, personal ownership, and ease of use, that can facilitate collaborative mobile learning (Naismith, Lonsdale, Vavoula, & Sharples, 2004). They are a comparatively inexpensive means for students to access multimedia content and communicate but are subject to constraints imposed by physical, logical and socio-cultural factors (Song, 2011). Physical constraints include screen size, slow processors, difficulty with text input and limited functionality. Logical constraints include availability and price of appropriate programs, difficulties in ending programs, and system instability. Socio-cultural factors include user expectations and preferences.

mLearning

Because this study investigated learning at a distance it is useful to review the praxis between distance education and mobility. Initially mLearning was viewed as a variant of distance education, which could occur at any place and time unlike conventional education that occurred at a set place and time (Keegan, 2005). The flexibility of distance education was curtailed by online learning because it required access to information from a desktop computer (Dye, Fagerberg, & Rekkedall, 2005). WHDs promise to restore flexibility to the distance learner.

Distance Education has been conceptually refined to encompass Contextual Life-long Learning (CoLL) which holds that learning is not confined to specified times and places and that traditional education cannot provide all the knowledge and skills people need to prosper throughout life (Sharples, 2000). Technologies to support CoLL need to be portable, individual, unobtrusive, available anywhere, adaptable to context of learning, and relevant to the learner's evolving skills and knowledge, persistent, useful, and easy to use (Jueming Chen, 2005). WHDs, as described above, meet these requirements.

Technologies, from posted print materials to synchronous online interaction, have always mediated the experience of distance education. As technologies change, so does pedagogy. Recent thinking recognises that new generations have not supplanted what has gone before but that layers have been added for a more complete experience embracing elements of behaviourism, constructivism, and connectivism (Anderson & Dron, 2011). Recent expansion of online learning raises questions about the nature of interaction in distance education. Moore (1993) suggested that distance in distance education is about psychological rather than geographical distance and introduced the concept of transactional distance. In an earlier paper he had clarified understanding of interaction in learning as being of the learner with content, instructor and other learners (Moore, 1989). WHDs have potential to make all three forms of interaction more conveniently available at diverse times and places, thereby enhancing learning by reducing transactional distance between learner and teacher and between learner and learner. However, for this to be achieved it is important to understand how the introduction of WHDs affects the interactions of university learners and teachers, which in turn has pedagogical implications.

Activity theory

The affordances of WHDs make them potentially useful for learning but determining their suitability requires understanding of the pedagogy appropriate to such devices. In this paper we will use Activity Theory as a lens for examining the effect of WHDs on the experiences of university learners and teachers. Activity Theory aims to understand human beings in their natural, daily circumstances through analysis of the genesis, structure, and processes of their activities. Activity is understood as a purposeful interaction of the subject with the world, a process in which mutual transformations between the poles of ‘subject–object’, via the use of tools, are accomplished (Kaptelinin & Nardi, 2006). Engeström (1987) reconceptualised Activity Theory from the initial subject-tools-object triangle into a six element model (Figure 2) which has become an analytical tool used in a wide range of educational research (Blin & Munro, 2008; Larkin & Finger, 2011; Lloyd & Albion, 2009).

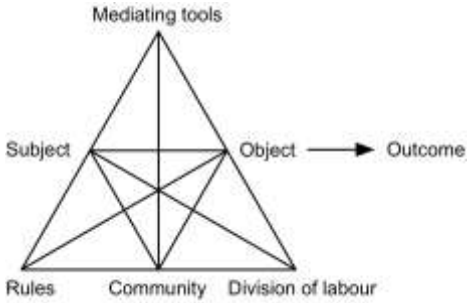

Figure 2. An Activity System (Engeström, 1987, p. 37)

Engeström's (1987) framework provides a tool for examining the various socio-cultural elements that affect the relationship between the subject and the community in attaining an outcome. Individuals and the community grow through the resolution of tensions and contradictions leading to transformations and expansions within the system. Contradictions exist when external influences change elements of activities causing imbalances between them, for example, the introduction of the iPod Touch in this study as a means of accessing course materials. Consequently, Activity Systems are almost always in flux as they work through contradictions that manifest themselves as problems, ruptures, breakdowns, or clashes (Scanlon & Issroff, 2005).

Appropriateness of Activity Theory to conceptualise use of WHDs

Activity Theory and its iteration as Activity Systems allow the researcher to critically examine the praxis between individual and society, and between object and subject, seeking to explain cognitive development through psychological processes driven by the individual but mediated by a variety of tools in a context (Larkin, 2010). It provides a coherent, theoretical framework to investigate multi-faceted sites to provide a broad and deep account of the actions of people as an activity unfolds over a period of time.

Activity Theory has been used by previous researchers in mobile learning and was used as the basis for a proposed "theory of learning for the mobile age" (Sharples, Taylor & Vavoula, 2010). Other researchers have identified limitations of Activity Theory as a basis for studies of mobile learning and suggested that an ecological approach would be more appropriate (Pachler, Bachmair & Cook, 2010). Nevertheless, Activity Theory was adopted for this study because of the prior experience of team members undertaking studies using Activity Theory (Lloyd & Albion, 2009; Larkin, 2010), and three features of Engeström's (1987) Activity Systems that render it appropriate to our research context. First the collective activity system is taken as a unit of analysis, giving context and meaning to seemingly random events; second, the activity system and its components are understood historically; and third, inner contradictions of the activity system are analysed as the source of the disruption, change and development of that system (Young, 2005). This research adds to the body of knowledge by using Activity Systems to reveal systemic contradictions and transformations stemming from the use of WHDs in a higher education and distance learning context.

Method

The research was conducted in two Queensland universities during 2011 and 2012 in the context of undergraduate Education and Nursing courses. Each university had 40 iPod Touch devices available for distribution to distance or online students in selected Nursing and Education subjects who responded to invitations to participate.

Data to enable rich descriptions of cases based on participating classes were collected using:
1. A pre-test & post-test survey based on previously validated instruments,
2. Reflections by students and facilitators logged in an online system,
3. Interviews conducted with student participants,
4. Online discussion forums involving students and facilitators, and
5. Software developed to record applications installed on returned iPods.

Although the primary focus of the research was on the use of the iPods for learning, the researchers were interested in any use of the iPods, including personal use (even that by other family members) because of the potential effects on the participants' learning activity systems. This paper reports data from participating Education students at one university in the first semester of the project. Other papers will report data from the broader group of participants across both semesters.

Participants and setting

Participants for whom data are reported in this paper comprised distance students completing an ICT and pedagogy course within a Bachelor of Education program at a regional university. The course explores the use of ICT for teaching and learning within school classrooms and included students from Early Childhood, Primary, Secondary, and Special Education specializations within the third year of a four year program. Participating students volunteered to use the iPod for course learning purposes and also during their professional experience where possible.

Twenty iPod touches were available for distribution and two students joined the project using their own iPhones. During the semester three students withdrew due to workload commitments, leaving 19 participants who completed the semester in the project. Each student completed a research consent form and an acceptable usage agreement form. The iPods, and iTunes gift cards ($30) to support the purchase of relevant software, were distributed to the volunteers by regular mail.

The course was offered online using the Moodle learning management system to provide recorded lectures, learning activities, additional readings, and facilitated online discussions related to the course content and assessment. Materials were not modified for mobile delivery in the first semester of this project. Students in the iPod project were supported within the Moodle space through a separate area that included information on how

to use iPods, online discussion areas for asynchronous discussion, synchronous discussion opportunities through Wimba, and links to project documentation such as consent forms and surveys. It also provided wikis for students to share ways of learning with WHDs, including their use in classrooms.

Data collection

Questionnaires
Questionnaires were administered online using LimeSurvey® (www.limesurvey.org) in the first and last weeks of semester. Data were transferred to SPSS 19 for analysis. They included multiple scales, each comprising several statements to which participants registered levels of agreement on a 5-point Likert scale from strongly disagree (1) to strongly agree (5), except for the frequency of use scale which used a 6-point scale (1=Not Used; 2=Once/twice a semester; 3=Once/twice a month; 4=Once/twice a week; 5=Once a day; 6=Several times a day**)**. The scales addressed interest in and attitude toward using ICT for learning (13 items), expected (actual in the post-test) ease of use of the iPod Touch for learning (6 items), expected (actual in the post-test) usefulness of the iPod Touch for learning (6 items), frequency of use of ICT (iPod Touch in the post-test) for various study activities (30 items), and desirability of a mobile device for study (13 items). Scores on the scales were calculated and reported as average ratings.

Qualitative data collection
Reflections were collected online, with the students and the facilitator completing the online form every two to three weeks. The reflections, online discussion archives and interview data were analyzed using the constant comparison method. The researchers searched for common themes and patterns within the data and inconsistencies were also noted. On receipt of the iPods returned by the participants software was used record the applications installed on the iPods.

Results

Survey data

From the 19 Education students who participated, 10 completed data sets matched for pre-test and post-test were extracted for analysis. The students were asked to record their access to various ICT hardware and services. All reported exclusive access to a computer, with nine having access to a laptop. While all of the students had home broadband Internet access, eight did not know the speed of their connection but agreed it was fast enough. Of the remaining two students, one had a connection speed of 8000kbps and the other had 1500kbps. Five of the students had a home monthly data limit of 10GB or more, one student had between 5 and 10GB and three students had between 1 and 5GB. Given these levels of Internet access, all would have been able to access study materials in the LMS. Most students reported limited or no access to portable devices such as MP3 players, eBook readers or tablet devices suggesting that addition of an iPod Touch would be a significant change in their access to ICT but also that lack of experience might result in some time being required for familiarization.

The pre- and post-test data for the 10 students were compared using paired samples *t*-tests for each of the five scales described above and these results are presented in Table 1. Mean differences were calculated as pre - post so that positive values represent a decrease in mean rating from pre- to post-test.

Table 1: Analysis of changes in ratings on the 5 key scales (N = 10)

	Paired Differences							
	Mean Diff	Std. Devn	Std Err Mean	95% Confidence Interval of the difference		*t*	df	Sig. (2-tailed)
				Lower	Upper			
Interest in & attitude to ICT for learning	-.046	.224	.071	-.206	.114	-.651	9	.531
Ease of Use of iPod Touch for learning	.350	.506	.160	-.012	.712	2.188	9	.056
Usefulness of iPod Touch for learning	.800	.987	.312	.094	1.506	2.563	9	.031
Frequency of Use in learning	1.803	.721	.228	1.288	2.319	7.915	9	.000
Desirability of iPod touch for learning	1.115	1.280	.405	.200	2.031	2.755	9	.022

As is evident in Table 1, interest in and attitude to use of ICT for learning increased slightly (pre-test mean = 4.38, post-test mean = 4.42), but not significantly, across the semester and expectations about ease of use of the iPod Touch decreased slightly (pre-test mean = 3.47, post-test mean = 3.12), but not significantly. Measures for usefulness of the iPod Touch for learning (pre-test = 3.30, post-test = 2.50), frequency of use (ICT on pre-test, iPod Touch on post-test) for learning (pre-test = 3.65, post-test = 1.85), and desirability of the iPod Touch for learning (pre-test = 3.82, post-test = 2.70) all recorded statistically significant ($p < .05$) decreases across the semester. Individual items from those measures were inspected for patterns that might explain the differences.

The six items on the usefulness scale had registered between 3.1 and 3.7 on the pre-test and decreased to 2.4 to 2.6 on the post-test suggesting that expectations about the iPod enabling quicker and easier access to course materials and enhancing communication were not realized. The decreases were reasonably consistent across the scale items with no evident pattern.

The frequency of use scale on the pre-test referred to use of ICT and included some tasks (e.g., create and present multimedia, upload files) that might not be possible using the iPod Touch and others (e.g., publish podcasts or other audio files, maintain a blog as part of course requirements) that were not required in the course. In that light it would be surprising if responses to post-test items phrased to ask about actual use of the iPod Touch had attracted agreement as strong as those recorded on equivalent pre-test items asking about potential use of generic ICT for the same purposes in the absence of sure knowledge of course requirements. Items that scored higher average responses related to looking up reference information on the web (3.0), accessing social networks (2.9), email (2.8), downloading course files (2.8) and accessing study material (2.7). These averages are on a scale where 3 indicated once or twice a month.

The scale referred to as "Desirability of iPod Touch for learning" sought agreement (or not) with 13 reasons for using WHDs for study purposes. The statistically significant decrease on that scale was driven by a decrease on all 13 items with the extent of change varying from 0.8 (easier and more frequent communication with peers) to 1.9 (better understanding of subject material). Items with smaller decreases (less than the mean decrease of 1.12) focused on ease and frequency of communication with peers or lecturers, better results, increased general ICT skills, and convenience for completing course work. Items with larger decreases were those related to having a wider range of tools for study, improved career prospects, and better understanding of the subject.

Qualitative data

Initial analysis of the text of student responses identified frequently occurring words (including 'access', 'lectures', 'information', 'people', and 'remote') that could be used as starting points for thematic analysis. Text was scanned to generate a key phrase list, which was used to tag responses from individual respondents to each of the questions that had been posed to them. This tagging of participants' responses against the key phrase list was used in Microsoft Excel to produce a frequency table and associated radar chart (Figure 3 below) showing the relative frequencies with which identified themes appeared in responses to three key questions.

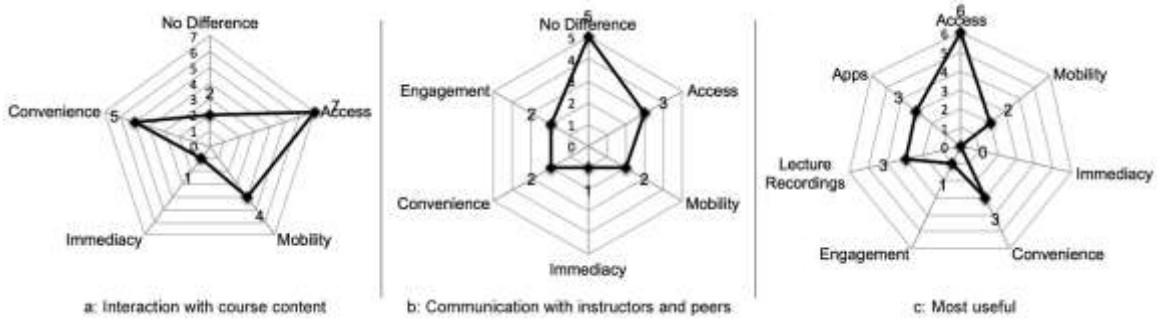

Figure 3: Radar plots of key themes from student interview data

The first question asked about differences that the iPod Touch may have made to interaction with course content (Figure 3a). Major themes in the responses were *access*, *convenience* and *mobility* with comments including being "able to listen to lectures while I walked my dogs" and "time management [becoming] less of an issue because I didn't have to rely on my home computer to access…readings and tools." One respondent mentioned *immediacy* of access "at the drop of a hat without having to set up my laptop and wait for it to load."

The second question asked about changes to patterns of communication with instructors and peers (Figure 3b). Most participants reported no difference but where changes occurred they mostly related to access, mobility, convenience, and engagement. Specific comments referred to more convenient access to email "instead of having to turn on my laptop", to access while away from home, and to being "able to record myself in the car and while taking part in normal day to day activities that I could then recall and send to my lecturers and peers."

The third question asked what participants found most useful about the iPod Touch (Figure 3c). The dominant theme was *access*, represented by comments about use away from home, mobility facilitated by the small size, and being able to watch or listen to recorded lectures "while I walked my dogs."

Across the three questions the most common themes were *access* (16 instances), *convenience* (10), and *mobility* (8) but these three and other concepts were often linked in a single statement, for example, the student who reported using the iPod to "listen to lectures while I walked my dogs." Most participants reported no change to communication resulting from the iPod; changes to interaction with course content were more numerous; and the responses for *access* in the question concerning the most useful aspects were predominantly about accessing recorded lectures or other course material.

Discussion

As noted in the literature review, Activity Theory provides a useful framework for conceptualizing the interactions of human beings with the various components of systems with which they interact in order to accomplish desired outcomes. Figure 2 represented the relationships among components in a generalized activity system. Figure 4 presents possible representations of the salient components of the activity systems experienced by students and academics participating in this study. In each case the generalized labels have been substituted with labels particular to the systems under consideration in this study. The activity systems experienced by students and academics will interact and have common components, some of which are apparent in the labels. Although the real activity systems will be more complex and will vary for individuals the representations include what we believe to be the most significant elements from this study.

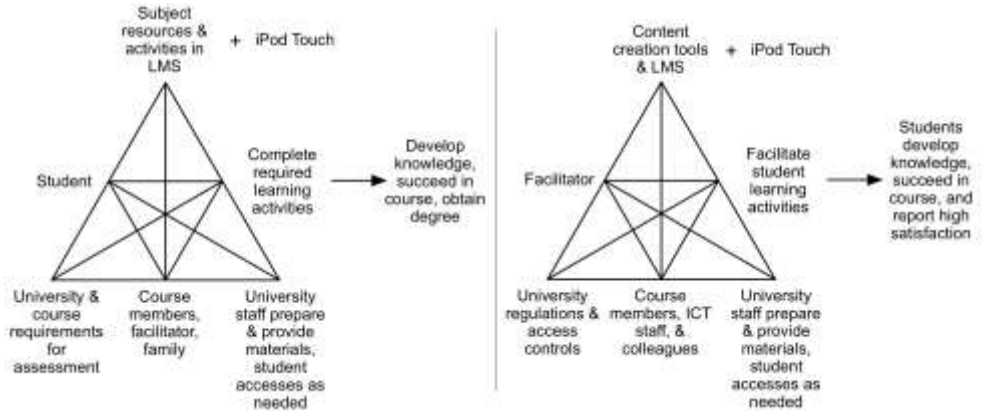

Figure 4: Activity systems experienced by students and academic facilitators

Students are represented as directing their activity toward successful completion of required learning activities as the object in their activity system with their outcome being to pass the subject and ultimately their degree. The object and outcome for the academic facilitators are related to those for the students but with a difference in emphasis on facilitating student completion resulting in passes and satisfaction with the course. Other parts of the systems are similarly parallel with variations in perspective according to the different roles being played in the systems. In each case the addition of the iPod Touch to the available tools represents a potential contradiction to the system that will affect, and be affected by, other elements of the system.

The results presented in the previous section offer some insights into how the introduction of an iPod Touch might have affected the activity systems being experienced by these student participants. Students reported positive attitudes toward the use of ICT for learning, together with levels of availability of computers and Internet connectivity that would have enabled them to conveniently access course materials and interactions through the LMS when at home or in similarly equipped locations. Most students reported limited or no access to mobile devices suggesting that access to an iPod Touch would increase the variety of locations in which they might be able to access suitably packaged course content and learning interactions.

These expectations were reflected in their responses to the questionnaire at the beginning of the semester. On the 'ease of use' scale they expected that it would be easy to learn how to use the iPod (mean = 3.8) and to get it to do what they wanted in the course (3.6), which appeared to focus more on communication with staff (3.6) and peers (3.4) rather than on access to materials (3.2) or completion of assessment (3.2). Expectations about 'usefulness' focused on increased interaction with course materials (3.7), increased communication with staff and peers (3.4), easier completion of the course (3.4) and improvements in results (3.1) through being able to work more quickly (3.1) and easily (3.1). Among these expectations the only one that was realized was the ease of learning to use the iPod, which registered an increase in mean rating from 3.8 (pre) to 4.3 (post). Every other item on the scales for 'ease of use' and 'usefulness' recorded a decrease from pre-test to post-test. Items with larger (greater than average) decreases in mean scores from pre-test to post-test included those that focused on communication, ease of completing assessment and the course, and increased interaction with course materials. The latter recorded the largest change of all items from 3.7 (pre) to 2.5 (post) which is somewhat surprising in light of the qualitative data in which accessing course materials, especially recordings, emerged as a major theme. The explanation may lie in the change being in the mode and location of access to materials rather than an increase in *amount* of access. Another explanation may be that the type or format of the materials limited the affordances of mobility because some are less than satisfactory on current WHDs. For example, PDF files may not zoom or, if they do, require inconvenient horizontal scrolling to read.

From the perspective of the activity system, students clearly anticipated the introduction of the iPod Touch as an additional tool to bring changes that would facilitate their achievement of the object and outcome. However, the effects in most areas were less than anticipated. At least part of this may be attributable to the short time over which the project ran. Allowing for time taken to recruit students for the project, distribute the iPods and return them at end of semester, and for the 3 weeks during which students were on professional experience, the participants had approximately 9 to 10 weeks of regular class time during which to experience working with the iPod Touch. Expectations about it being easy to learn to use were fulfilled but students may have needed some time to learn its use and may not have discovered all the functionality either inherent in the device and its OS or available through installable apps. Moreover, the short timeframe limited the time available for course leaders to identify, from student feedback, the resources that were problematic and provide alternatives. If course resources are to be device-independent and WHD-friendly, course leaders will need time to experiment with a range of devices to ensure maximum accessibility for students using these devices.

The course materials in this course were not modified specifically to support access using the iPod but the file formats provided in the course (.htm, .doc, .ppt, .pdf, .mp4, .mp3) were capable of being accessed using the iPod touch. Some files could be downloaded and stored for later access on the iPod Touch without access to a computer, some could be streamed while connected to the Internet, but some could be downloaded only on a computer and then transferred to the iPod, limiting the potential of the device to be the 'total' access solution. However, access to audio content, supported by the mobile devices would not have been possible otherwise for some students. Although it appears that the total amount of interaction with materials did not increase as a result, students reported greater mobility of use, for example, while mowing or walking the dog. The iPod has therefore had a perceptible effect on the activity system with regard to access to and use of course materials.

Introduction of the iPods brought fewer benefits for communication than students had anticipated. In part, this may have resulted from restricted network connectivity (WiFi only where available) of the iPod compared to a smartphone, but part will have resulted from interaction between the iPod and other tools in the activity system. Synchronous communication in the course used Wimba, which requires Java and as a consequence does not work on the iPod. Asynchronous communication using the discussion forums in the LMS (Moodle) is possible but sometimes awkward because the default configuration of the LMS is not well tuned for use on the smaller screens of mobile devices. Some students mentioned using the iPod successfully for email but other modes of communication characteristic of small mobile devices (SMS, Twitter, Facebook) are not officially supported by the university and may or may not have been in use by members of the course community in the activity system. Thus the iPod had only a limited effect on communication within the course activity system because of technical limitations in the device and historical factors in the existing tools, rules and community of the activity system.

In seeking to understand the effect of introducing the iPod Touch on the course activity system it is also important to consider the system also from the alternative perspective of the facilitator responsible for the course. As described in the section about participants and setting, although there was a specific section of the LMS space developed to facilitate students participating in the iPod project the first semester of iPod Touch use in the course involved no significant modification of course materials to support the new device. The division of labour is a key node in this activity system, with the facilitator providing links and creating the spaces for interaction and students using the links and contributing experiences in the forum. Like the students, the

facilitator was constrained by the existing tools in the system that had variable levels of usability with the iPods. Resources on the web were generally accessible from the iPod by following the links provided; discussion forums were workable with effort; Wimba could not be used; and the format, and ease of downloading for offline use, of recorded materials was determined by the standard tools (Camtasia Relay) available as part of the university learning and teaching systems. Rules in the activity system, in the form of university regulations and controls on access to systems, effectively constrained the use of the iPods to substituting for a computer to access existing types of materials and interactions. Provision of materials in different formats; the inclusion of Web-based activities; and assessments that used the capabilities of the iPod to capture, create, and submit student-generated content, were restricted by existing system capabilities or university regulations that would have required more time than was available to negotiate adjustments to the course. These limitations by rules and access to technical support within the community element of the activity system may have caused contradictions between student and object that resulted in students' expectations for access to material, communications and assessment not being realized.

Conclusion

This study has limitations associated with its small size (19 student participants), restricted context (a single Education course) and limited timeline (a single semester with limited preparation). However, despite those limitations it has demonstrated the potential for WHDs to disrupt existing activity systems by facilitating access to study materials at a wider variety of times and locations. It has also identified elements of the learning activity system that may need modification in order to facilitate greater use of WHDs and suggests areas in which attention to course design might enable more of the potential of WHDs for learning to be realized.

Although students were able to access most course content using the iPod Touch, there are changes that could usefully be made to improve readability on the small screen and to make it more convenient to download files from the LMS for storage and offline use on the device. These considerations apply to all WHDs even smartphones, which are likely to be more frequently connected to the network than the WiFi-only iPod touch but can still benefit from offline access for savings of time and data costs. Communication within the constraints of existing university systems presented more challenges. The LMS and associated systems need to be reviewed for compatibility with smaller screens and there are likely benefits in considering options for shorter form communications characteristic of mobile users. SMS, Twitter and Facebook exemplify messaging that works well on mobile devices and similar functionality could be incorporated within the LMS or associated systems.

Both students and facilitators require time to become familiar with the core and extended functionality of WHDs before their true potential for learning and teaching can be realized. As the capabilities of such devices evolve it will be important for university regulations and systems, the 'rules' and 'division of labour' of activity systems, to provide for creative exploration of the possibilities for delivery of content to learners, communication within the learning environment, and the collection, possibly for assessment, of content captured or generated by students using WHDs. Shared exploration by learners and teachers will be important in enabling universities to address the challenges of providing students with the flexible learning opportunities they are seeking.

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