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THE INNOVATIVE USE OF PERSONAL SMART DEVICES BY STUDENTS TO SUPPORT THEIR LEARNING

Anne Nortcliffe and Andrew Middleton

ABSTRACT

Research into the autonomous use of MP3 audio recorders by students in UK Higher Education demonstrated that students were innovative in their autonomous use of the devices. They used them to capture learning conversations from formal and informal situations to personalise and enhance their learning. However, today smartphones and other smart devices have replaced the necessity for students to carry multiply mobile devices including MP3 recorders. This chapter builds upon the earlier work and presents a small qualitative study into how students are autonomously using their smart devices to support their learning. The research explores the hypothesis that students are being innovative in the ways in which they use their smart devices to support their formal and informal learning. The study involved five students who own smart devices who were invited to discuss their ownership of smartphone and tablet technologies and the ways they used them in their studies. The students first completed a short questionnaire and were then interviewed in small groups. The results agree with previous research into the student use of smart devices and describe autonomous engagement facilitated by personally owned smart technologies. The study identifies continuous patterns of pervasive engagement by students and concludes that more thought should be given to disruptive innovation, digital literacy and employability.

INTRODUCTION

Earlier work conducted by the authors investigated the autonomous use of MP3 audio recorders by students in UK higher education to enhance their learning. It showed that students used the recorders they had been given in many ways, but it was the disruptive, innovative and autonomous use of the recorders to support their peripheral engagement with the formal curriculum that was most significant.

Two years after the MP3 recorder research, this chapter reports on a small qualitative study into the autonomous use of personally owned smart devices by students and considers how these devices are changing the way students engage with their studies. The issue of student ownership of technology has changed: not only do the smart technologies that many students bring to university have recording functionality, but they can also run diverse free or cheap applications ('apps') which are potentially useful to student productivity.

The chapter begins by introducing key ideas that situate the research and by describing the inherent potential of smart devices and the barriers to innovation. This is followed by a review of literature and findings from our earlier study into the use of MP3 recorders by students.

In moving our attention to smartphones and tablet PCs we were not expecting to find evidence of widespread autonomous innovation. Instead we expected to discover diverse and rich accounts of personal innovation addressing priorities determined by individual students. As a study of emerging innovation, the scale of ownership at this stage was not important. The main drivers for us were student interest, imagination and the attitudes towards using personal technology for academic work

as indicators of a shift towards learner independence in the use of learning technology, even where the devices and applications were not primarily bought for academic purposes. The research therefore adopted a qualitative approach capable of drawing out student attitudes as well as examples of what students have done.

BACKGROUND

Bring Your Own Device (BYOD)

Investment in smart devices is significant for most students, especially at a UK "post '92" university like Sheffield Hallam where the majority of students do not come from affluent backgrounds (Bowers-Brown, 2006). While all students these days might be expected to bring their own mobile device to university, the decision to purchase multifunctional, smart technology is of a different order. The rapid growth in the range of alternative multifunctional connected technologies means our students and their families have to make a difficult purchasing decision: Mobile phone? Smartphone? Tablet PC? Laptop? Notepad? PDA (Personal Digital Assistant)? Desktop PC? How do students decide and what advice is available to them?

At the same time universities are finding their investment decisions are changing too, with planners recognising student expectations for widespread digital connectivity whether on or off campus (JISC, 2006; Oblinger, 2006). University investment in physical formal and informal learning spaces needs to reflect different expectations and behaviours, especially where technology is concerned and as the JISC study into designing effective learning spaces highlights "spaces are themselves agents for change" (JISC, 2006, p.30).

Disruption, autonomy and innovation

Development and research into learning technology is often concerned with how it can bolster existing formal pedagogic philosophies and methods, rather than in how technology becomes a 'game changer', positively disrupting the existing paradigms. However, pedagogy has largely been determined by historic constraints. The lecture theatre, for example, was invented in medieval times as a technical solution in response to the difficulties scholars had in communicating their knowledge. Bligh (2000) and others have highlighted how ingrained some ideas about teaching and teaching environments are, even after constraints have been removed. If technology, and specifically personally owned smart technology, removes many constraints relating to communications, educators need to reassess learner engagement, access to and expectations of formal and informal learning spaces and resources, and independent and social learner productivity.

It is suggested that the learner's ready access to intuitive, familiar and highly usable smart device technologies exemplified by Apple's iPad, but found in myriad smartphones and tablet PCs, will result in the phenomenon of what Bower and Christensen (1995) initially termed *disruptive technologies* and what Christensen subsequently reconceptualised as *disruptive innovation* (1997). It is the behaviour associated with such technology, rather than the technology intrinsically, that is significant.

The idea of disruptive innovation is useful in the context of Education where the changing relationship between the teacher and the learner has been central to ongoing research; a debate heightened by the widespread adoption of digital technologies (Mayes, Morrison, Mellar, Bullen & Oliver, 2009).

Traxler (2010, p.156) discusses the notion of the "strong" disruption which results from the advent of ubiquitous, personally owned mobile technologies and how the "long-term consequences must be to challenge the authority of the curriculum" and dominant thinking about the nature of formal learning. Kukulsha-Hulme & Traxler (2005) and many others have developed the concept of mobile learning. This has been framed variously, however Kukulsha-Hulme & Traxler (2005, p.42) set out the attributes of mobile learning as being "spontaneous, portable, personal, situated; it can be informal, unobtrusive, ubiquitous and disruptive."

Amongst those who plan and deliver teaching at scale, it is a lack of ubiquitous technical interoperability that has held back the widespread reappraisal of the learning environment, although specialist and exceptional mobile learning interventions have been numerous. Technological ubiquity supposes that a technology is familiar, commonplace and widely accessible; characteristics evident in smart devices. Growth in the personal ownership of smart devices suggests education should prepare itself for changes to student behaviour and their expectations for the use of engaging technologies.

Creativity, autonomy and self-regulation

Learner creativity and critical thinking coupled with confident, self-regulated autonomy may be the prerequisite learner attributes to the widespread adoption of disruptive technologies. However, a lack of digital literacy may create a barrier to innovation in this emerging area of using smart devices for learning. Theory about the ways groups think (Janis, 1972) explains why creative, independent thinking may be quashed and become a barrier to disruptive innovation. Groupthink theory suggests that group members display a tendency to value cohesive behaviour and group unanimity above their individual motivation to pursue even realistically appraised courses of action.

The importance of self-regulation and self-directed learning to independent academic innovation is discussed by Song and Hill (2007). They conclude that the learning context, especially where this involves technology, influences the level of learner autonomy, the efficacy of learner strategies and their use of resources.

Autonomy and self-regulation can be framed in ways that suppose a formal and conscious path is being strategically followed by the learner; however, it is useful to consider a less formulated idea of autonomy and self-regulation in understanding the relationship of disruptive innovation to the student use of smart devices. The idea of pervasion is also relevant in considering this (Kukulka-Hulme and Traxler, 2005). In reflecting on the diverse ways that students had used audio recorders in our study of MP3 recorders (Middleton and Nortcliffe, 2011), the richest experiences happened in a space between students' formal engagement with the delivered curriculum and their informal engagement as students; the degree of intention being another way of expressing this. It is often the impromptu or spontaneous moment that offers the richest engagement.

While a weakness of smart devices is their inability to technically perform multi-tasking operations, one of their apparent strengths is that they enable and promote multi-tasking user behaviour by being pervasive and available to use in diverse contexts. Multi-tasking behaviour has been identified as a feature of the NetGen learner, whereby students optimise the use of their time and take from each learning situation what they need (Lohnes and Kinzer, 2007). In informal situations, as our ongoing work is suggesting, the relationship of being at university to family life alters when a student plays a piece of audio feedback on an assignment to a sibling or parent, for example. Delineation between study, life and work is fading and the pervasive, persistent nature of smart technology is part of that change.

The multiple technologies used by the NetGen learner are not the cause of a "multi-processing" phenomenon (Brown, 2000); previous generations have always attempted to do more than one thing at a time. However, smart devices do create opportunities for students to respond to ideas immediately and engage in discourse differently because of the new access they provide for recording and distributing data. While there are questions about the quality of discourse and level of learning in multi-tasking situations are involved (Ophir, Nass & Wagner, 2009; Fischer, Morris & Joslyn., 2003; Hembrooke & Gay, 2003; Edwards & Gronlund, 1998). Therefore we need to know more about student interest and behaviour before deciding about the prudence of smart technologies and multi-tasking.

Connectivity

Unlike our previous interest in the disruptive possibilities of portable audio recorders and the ways in which the recorded voice can enhance educational discourse, the smart devices under consideration here now incorporate connectivity. If change in access to learning environments is an important factor in understanding disruption and innovation, then the connectivity of devices introduces an important consideration.

The value of a formal, higher education is very much about interactivity and social engagement. The benefits of a university education would be considerably less if education was only concerned with the process of accessing and absorbing knowledge and skills: it is how we assimilate knowledge together and how this develops understanding that is important. Pursuing the application and further development of knowledge is fundamentally a socially mediated activity. A challenge in our initial audio work, therefore, was the lack of technical connectivity between the MP3 recorder and the situation in which the recording was to be used. Although it is a minor inconvenience to download content from a portable device in order to make it available on a network, it is an important inconvenience nevertheless. It requires technical skills and confidence that many academic users do not have.

Device connectivity enabling integrated user behaviour, a characteristic of smart devices, supports the immediacy and fluency that is so important to socially mediated learning.

MOBILE LEARNING

Mobile learning pedagogy

Smart mobile devices establish a potential for ubiquitous learner engagement that is often referred to as 'learn anything at anytime and anywhere' (Sakamura & Koshizuka, 2005). This is complemented by the notion of 'learn any how' in our work. Anytime and anywhere learning suggests the potential for developing learner autonomy, but autonomy is epitomised by the learner's own decision about *how* they will engage so that it meets their needs and addresses their situation optimally. This highlights the importance of conceptualising behaviour in terms of disruptive innovation and personalisation when considering the potential of smart technologies for learning.

Mobile learning affects traditional student learning strategies, both in and out of the classroom, by extending the environment and the opportunity for engagement (Jeng, Wu, Huang, Tan & Yang, 2010); learning opportunities that can be autonomously driven by curiosity using smart devices (Camargo, Barry, Boly, Rees & Smith, 2011).

Sharples, Taylor & Vavoula (2007) highlight mobility as an important factor in understanding the disruptive significance of mobile learning. While the use of different locations for learning is of interest, they identify the act of moving through and between spaces, people and contexts as one which creates new opportunities. The portability of devices offers new opportunities as to who, when, where, what and how students and academics engage with one another for learning purposes (Traxler, 2009; Sharples, Arnedillo-Sanchez, Milrad & Vavoula, 2009). Therefore, for the educational provider, smartphones and smart devices can be used to create new personalised learning experiences incorporating methods that have not been previously conceived.

Disruptive innovation is best viewed in terms of changes to engagement rather than changes to technology *per se*. Ruth (2012) refers to this using the metaphor of the screenface: it is more useful to think about the act of learners engaging than the specific tools that facilitate their learning. However, mobile learning presents a complex shift in socially mediated learning and is ethically, technologically, and socially problematic (Vavoula & Sharples, 2008).

While its potential is palpable, the reality is that interoperable mobile technology is not yet universally available across the student population. For those who do have access, there are indications of widespread adoption by students (Jones, Ramanau, Cross & Healing, 2010) and where academics and students already use mobile technology extensively for personal and work

purposes, they are more likely to use it in their academic practice (Corbeil & Valdez-Corbeil, 2007).

Existing studies clearly indicate that ubiquitous learning can be powerful in facilitating meaningful learner immersion; learning that is likely to be enhanced by active, authentic, constructive, cooperative and personalised engagement (Huang, Chiu, Liu & Chen, 2011). Nevertheless, some of the many areas that need further investigation at institutional level include the benefits of mobile learning to all and how this will impact investment plans, useful and acceptable behaviours and attitudes, managing consistent and widespread adoption, and encouraging learning autonomy in using personal devices.

The potential of mobile technology for learning

The potential of mobile technology for learning can only be realised by users adopting the technology. Hwang, Chen, Chu & Cheng (2012) propose the TAM framework to explain how the adoption of technology is influenced by several factors: perceived ease of use (PEU), perceived usefulness (PU), attitudes towards technology usage (ATT) and behavioural intentions (BI) towards the new technology.

Chen, Park & Putzer (2010) also note how the perceived usefulness and ease of use were key factors in the adoption of smart devices by medical professionals. Shin, Shin, Choo & Beom (2011) also identified the importance of usability to user adoption, specifically high quality screen resolution, interoperability, and network accessibility, reliability and security.

Converging phone technologies

Mobile phone design has changed markedly since they were first introduced. Integrated cameras, audio recorders, and PDA functionality are now commonplace. However, there is little known about consumer preferences or about how they actually use the functionality available to them (Hans et al., 2009).

There are many small scale studies of how mobile phones with converged functionality have been used to support pedagogic innovation. However, much of the literature has talked about the potential for this converged technology to be widely adopted, rather than actual general changes in user behaviour (Lee, 2006; Oliver & Goerke, 2007). Tucker & Winchester (2009) also consider potential in their examination of converged phone and video technology to support the just-in-time learning needs of professionals, an area also investigated by Vozenilek, Huff, Reznek & Gordon (2004) who considered the transfer of medical learning pedagogy ("see one, do one and teach one") to the mobile realm and found the technology difficult to apply and inappropriate.

Wu, Yang, Hwang & Chu (2008) used mobile phones to guide their learners and to increase their contextual awareness of their *in situ* learning experience. Mitchell & Race (2005) used QR Codes to provide access to additional learning material which could be accessed via smartphones through a graphical 'quick response' link to web-based media; an approach that was found to inspire young learners to engage more. Chen, Chang & Wang (2008) found that mobile PDA and phone technology can provide tutors with mechanisms to scaffold, organise and communicate with learners, for example through calendar alerts of timetabled sessions and assessment submissions.

These examples highlight the importance of asking the question: who should be taking responsibility for organising the students' learning - the student or academic? How might this change now?

SMART TECHNOLOGIES

The potential of smartphones for learning

Technological innovation has continued to merge the functionalities associated with the mobile technologies of PDAs, MP3 recorders, video cameras and phones. This means it is no longer

necessary for students to purchase or choose between separate devices unless they have specialised high quality requirements (Han, Chung & Sohn, 2009).

Hardware convergence has been complemented by the emergence of smart device applications. There are, for example, numerous smartphone audio applications available, each of which have the potential to support students and academics in capturing different conversational learning experiences (Nortcliffe, Middleton & Woodcock, 2011). Audio recording applications are only one type of application, of course, and there are innumerable other applications available to smart device users for supporting student engagement with learning (Woodcock, Middleton & Nortcliffe, 2011).

In 2009 Hendery forecasted that smartphone ownership was expected to exceed the number of PC users in 2014. In 2009 that already represented 29% of the mobile phone market. There are over 600,000 iPhone apps (Costello, 2012) and 450,000 Android apps available to users (Paul, 2012). In terms of what end users are actually doing, Murphy (2012) claims that over 25 billion iPhone applications have been downloaded and Whitney (2012) estimates that 10 billion applications have been downloaded by Android users.

This level of adoption, therefore, suggests that education needs to look at the potential of smart device applications and how they are being used by students autonomously to support their learning.

The smartphone learner

Clough et al. (2007) identified how enthusiastic student smartphone users deployed their devices to support their personal organisation, indirectly improving their approach to study. Some of these students adapted the use of applications they already had installed to meet their learning needs rather than look for bespoke learning applications. The enthusiasts later recruited by Clough, Jones, McAndrew & Scanlon (2009) adapted their devices and a variety of mobile applications to support their need for: written, visual and aural data gathering; information retrieval, sharing and construction; collaborative learning activities; and contextual and constructivist learning.

Woodcock, Middleton & Nortcliffe (2012a) identified smartphone learners using a diverse range of applications to support their learning, though mainly for productivity, web browsing, and organising themselves. However, the following year subsequent research indicated an increase in the number of smartphone learners and the use of the smart devices for learning was found to be more focused, with web browsing becoming an important feature of student accounts (Woodcock, Middleton & Nortcliffe, 2012b). These results are consistent with Boticki & So's (2010) research of the student usage of the HTC smartphone for learning which found that students who used their phones for study in personal spaces were primarily browsing the Internet and for creating interactive digital pieces of work.

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Smart device learning mediated by educators

In higher education, students and staff are also beginning to use personal technology to support their academic practice in situations that cross physical and temporal boundaries (JISC, 2009) and educators are developing many specific ways in which smart devices can be used to support learning.

Yan (2009) considered how collaborative engagement with learning through smartphones could be developed by the academic and suggested this could be promoted by the provision of online learning suites and social tagging activities. Cochrane (2006) looked at the design of Web 2.0 social media in ways that supported social constructivist engagement and issues of accessibility to

smartphones users. Hwang, Chen, Chu & Chen (2012) have developed Web 2.0 learning technology so that it is readily accessible to smart devices to open up the potential for learning out of doors, for example for plant identification in the schoolyard. Huang et al. (2009) provided a micro-blogging facility so that it was accessible to smart devices in order to support peer supplementary teaching and collaborative learning. Boticki & So (2010) found that mobile devices can help the educator to redirect informal student inquiry-based learning into a more formally structured learning design.

However, Cochrane & Bateman (2010) found that much of the mobile learning initiated by students was serendipitous rather than being framed and planned by the academic and that students were not demonstrating the digital fluency that was initially expected of them. This recognition has emerged in several other studies of academic innovation, for example a study conducted by Röpke & Schneider (2012) looking at the embedding of QR codes in course texts and in a study by dos Santos Rosa Santana dos Santos, Valdeni de Lima & Kruger Wives (2012) where QR codes were embedded in lecture slides to provide additional dynamic learning material.

Again the question needs to be asked, is it appropriate for the educator to assume responsibility for the development of smart device content and, if so, are such approaches signalling an unnecessary, anachronistic student dependence on the academic?

Franklin (2011) suggests that smart devices create a new paradigm for educators to re-establish new learning communities and pedagogy to develop students' digital literacy skills and this, as Jewell (2011) notes, is particularly important because smart devices are becoming integral to professional practice. Smartphones, for example, are becoming more common and making a positive impact in the medical professions (Chen, Park & Putzer, 2010; Boulos, 2011).

Smart device applications developed by the educator for learning

The University of Leeds Medical School has developed an iPhone e-portfolio application to support the reflective practice of medical students on placement (JISC, 2011); however, the application also has the potential to support the reflective practice of any student on placement. At the University of Bradford the UoB smartphone application provides mobile accessibility to learning services resources for students, including information about the location of nearest IT room as well as access to the library search engine (JISC, 2011b). At Sheffield Hallam University the CrystalViewer iPhone application has been commissioned by a member of staff as a free educational learning tool to supplement lectures on Metallurgy (Disobedient Media, 2010). The University of Southampton has adopted an alternative approach to developing or commissioning smart device learning applications by engaging computing students who are able to tap into open data sets provided by the institution (Davies & White, 2012).

From digital voice to smart learners

Our research into the use of smart applications in higher education continues our enquiry into how technology can be used to enrich the personal academic experiences of students and staff. The advent of small mobile high quality audio recording devices created an opportunity for academics to audio record their own lectures and tutorials and to distribute these recordings to students via podcast channels without the need for costly institutional infrastructure and support (Nortcliffe & Middleton, 2006). However, lectures offer only one element of a blended learning experience in which the spoken word plays a central role. For example, formal and informal discussions between tutor and student are highly valued as a way of providing feedback on student work, albeit ephemeral in nature (Nortcliffe & Middleton, 2007, 2009a and 2009b). Making audio recordings of feedback conversations extends the life and value of important conversations by creating new opportunities for the conversation to be revisited later, as determined by the student. This disrupts patterns of learning potentially: students may now expect, or be expected, to reconnect

with earlier conversations to examine or reflect on their growth or discover new meanings in the conversation that may have been missed before (Nortcliffe & Middleton, 2008).

The introduction of smartphone audio applications, email communication applications and the integration of application functionality has enabled the academic to simplify and increase the efficiency of producing feedback on students' coursework leading to benefits for the academic and student (Nortcliffe & Middleton, 2011). Smartphones have also been shown to have a role in improving engagement with otherwise ephemeral project supervision (Nortcliffe, 2010). It is the portability and connectivity of the device that simplifies the process of capturing and distributing academic learning conversations, whether these are intrinsic (e.g. an intended part of project supervision or coursework feedback) or extrinsic and opportunistic (Middleton & Nortcliffe, 2011).

In our work it was felt that the extrinsic potential of the digital voice to enhance learner engagement, especially in relation to learner autonomy, needed to be explored further and, in pursuing this, it became evident that it is important to consider who should have responsibility for recording and distributing recordings. In 2009 we asked whether this should be the academic or the student; the question of whether an institutional audio visual service might have a role was no longer central in our work. We concluded that if the main benefactors are the students it was inappropriate for the responsibility to be assumed by the tutor (Nortcliffe, Rossiter & Middleton, 2009); a conclusion that was at odds with the growing literature on audio feedback where giving feedback on student work is usually understood as a duty of the academic, but in agreement with the idea of the student as self-regulating learner (Nicol & McFarlane-Dick, 2006). A shift in responsibility, it was felt, promoted digital literacy and employability.

Student audio autonomy

Several associated studies were generated from a year-long project which involved 100 student volunteers at two Sheffield universities. The students were each presented with a mobile audio recording device and, over a year, they were asked to report on how this helped them with their learning. They demonstrated diverse imaginative approaches to using the devices by making audio recordings of conversations with tutors, peers and others and by recording their own ideas as they occurred to them to support their coursework (Rossiter, Nortcliffe, Griffin & Middleton, 2009).

The project induction for the students advocated creativity and autonomy and consequently the many and diverse approaches developed by the students ranged from the management of learning data to examination preparation (Middleton & Nortcliffe, 2009). An project focus group identified how students had used their devices to support multifarious learning activities with many using their devices flexibly to address their changing needs and opportunities with recordings being made for independent and group study. Students explained,

I try to carry it around with me all the time just for anything that crops up. (Student A)

I've used it for seminars, group work and lectures as well. And I used it on my placement as a kind of diary record. (Student B)

I use it for little groups when we're doing group work seminars, meetings with my supervisor. I find it really useful for revising. I record my [written] notes and then listen back to it again and again and again. (Student C).

From the student perspective the common themes identified through the related studies confirmed how the device removed constraints in terms of time, access to people and the physical space they used for learning (Middleton, Nortcliffe & Owen, 2009). The mobile audio device enabled them to blend the formal, semi-formal and informal learning opportunities available to them.

Nortcliffe, Middleton & Rossiter (2011) considered the mobile audio devices to be discrete, highly mobile, and simple to use for capturing otherwise ephemeral events.

In summary, the devices promoted learner autonomy by supporting their transition from formal provision into wider, self-determined contexts - the technology followed the learner whatever the their learning status; a shift from the need for the learner to engage through predetermined facilities in a premeditated way (Nortcliffe & Middleton, 2010).

METHODOLOGY

Research focus

Research into how students are using smart devices for learning conducted during the last two years at Sheffield Hallam University in the Faculty of Arts, Computing, Engineering and Science has identified that smart device ownership in the student population of 5,300 is increasing from 69% (with a confidence interval of 7 for a 99% confidence level) in 2010-2012 to 87% (with a confidence interval of 3.8 for a 99% confidence level) 2011-2012. The later 2012 study (Woodcock, Middleton & Nortcliffe, 2012b) put smart pad ownership at 1% (with a confidence interval of 1.13 for a 99% confidence level).

This analysis led to the qualitative study presented in this chapter. The research asked the following question:

How are students using smart devices, including smartphones and tablet PCs, to support their learning and why?

Participant selection

Sheffield Hallam University students known to own smart devices from the Computing and Engineering departments were invited to attend one of two workshops offered on consecutive days. Twenty three were invited by a fellow student in the Computing department and a further twelve students from Engineering and Computing departments were invited by the faculty researcher to attend the workshop.

The invitation explained the research was interested in the applications used by students to support their studies. The invited students were demographically diverse in terms of age, gender and background.

However, only five students took part: three at the first workshop and two at the second workshop. Four were final year students, the other was in his second year of study. All were studying a Computing-related course, and all were male and in their early 20s.

Participation was affected by the scheduling of the research which sought to ensure the activity was seen as being separate from teaching and that it did not conflict with scheduled assessments. Further, many of the students have part-time jobs and were involved in exam revision.

Represented technologies

Four of the students owned Android phones and tablets (pads) and the other student owned an iPad2 tablet and an Android phone. The preference for Android devices is likely to be affected by the sample's inherent computing interest and the relatively open architecture the Android affords programmers. Students on Computing courses are more inclined or required to use a wider variety of technology to support their studies than arts-based students, for example (Kennedy et al., 2006). In debates about the propensity of younger students to more readily take to digital technology, Bennett, Maton & Kervin (2008) noted how students in some disciplines displayed different levels of engagement.

Approach

The approach took the form of a Show'n'Tell workshop: it was important the students were not only research subjects, but that they were likely to be interested in and responsive to the ideas presented by their peers, being self-motivated, curious and already engaged in the subject. The workshop was scheduled in non-teaching time and it was made clear that student involvement would have no direct bearing on any assessment of their academic work.

The students were invited to give a 5 minute presentation on each of a number of applications installed on their smart device, selecting those that they regularly use to support their learning. In

particular they were asked to set out the benefits they had identified in using the application in their studies. The workshops were therefore run as semi-structured focus group using a media elicitation method. The demonstrations were video recorded with the students' permission and, following the presentations, a discussion about the applications involving all presenters and the researcher was conducted and audio recorded (Cohen, Manion & Morrison, 2000). Finally the students were asked to complete a short paper-based survey composed of ten questions presented as Likert scale fields with accompanying open comment fields. The survey, therefore, provided a more detailed and structured qualitative evidence base with respondents informed by both the presentations and the ensuing discussion.

RESEARCH RESULTS

A concurrent survey conducted by a student studying Computing (Armstrong, 2012) revealed that 87% of 474 respondents from Sheffield Hallam University, Faculty of Arts, Computing, Engineering and Science (student population 5,300) stated they owned a smartphone. Android phones were most common amongst the students (41%). Ownership of other smartphones was: iPhone 29%; Blackberry 16%; and other/unknown 12%.

Show 'n Tell smart device applications for learning

The students identified a number of useful smart device applications that they used to support their learning. Following an analysis of the Show'n'Tell focus group transcriptions, the common theme was how the devices could be applied to enhance student engagement through providing ubiquitous access to their study, as shown by the following student comments:

Student A: [Google Drive] Crack it open on tablet, mobile, wherever.

Student D: My main thing is I don't connect my iPad to a PC regularly. What I want is the means... to access my files without connecting a cable or connect to my home network. A major selling point is to access my files wherever I go.

Student B: [It's] handy, portable. You pick up your phone, see you've got work to do.

Student E: [I work on my dissertation] when I am on the bus.

The applications used by students to support their studies can be further categorised into four types of study behaviour:

- Productivity;
- Organisation;
- Communication;
- Multi-tasking.

The rationale given by students for their use of an application typically fulfils one or two of these themes. For example, students explained how the Facebook and Dropbox applications were useful for supporting their organisation and communication, especially with group-work;

Everyone is on Facebook... It's an easy and simple way of keeping in contact and discussing what is going on... Good for organising, like events... group-area, setting up a meeting. It shows on the Calendar. (Student A)

I use DropBox. I need to use files use for groupwork. The best things is you can share folders and if one person makes changes that are inappropriate or deletes [files]... you have access for free to previous versions. (Student D)

[DropBox is] very useful. [You can] look at documents ...save them and upload them ...can't edit on the smart device live ...you have to download ...[It] keeps a history of all the versions of documents, so if you delete something accidentally you can easily reload the document. (Student C)

Student B highlighted an alternative to DropBox for aiding production, organisation and capturing learning materials is Evernote, as provides the functionality to capture and insert images and audio recordings into Evernote notes.

Evernote...you can create notes, ..you can take snapshots of lecture materials...slides or anything that is written down in seminar on blackboard...tag in your notes and tag them together and share your notes...share them [by emails] (Student B)

It was also reassuring to note that couple of the students were using audio recording applications to gather formal learned conversations, which is consistent with previous research (Middleton & Nortcliffe, 2009a).

Voice Recorder...I found pretty useful...to take notes in lectures, I find I nod off and go into my own little zone, I can take recording and listen to key parts of the lecture. (Student B)

[Phone voice recorder] record in lessons and lectures, when they are talking about a very important subject...transfer them across to laptop listen to them again...[when re-listen] to gather notes especially if you miss the crucial points in the lesson.(Student C)

Student E explained how he used the Final Countdown timer app for the iPhone to help him manage his work. "It shows you in the app and on the home screen [of the phone], how long you have got left."

Student B talked about how he used Google Calendar. "It syncs to my Gmail. If [the tutor] adds updates, it notifies me."

Student C also valued Google Calendar. "It helps you organise your life so much more easily, especially as I have got a terribly short memory."

The students particularly valued the applications that helped them to organise their study time and applications that supported their multi-tasking. Student E, for example, discussed how useful he found OverSkreen, an app designed to make the tablet's web browser float over above other applications. This functionality helped him work in the other application while viewing learning resources on the Web, thereby removing the disjointedness of toggling between applications.

Many of the applications demonstrated in the Show'n'Tell session, however are dependent upon wireless connectivity, Student E highlighted the importance of identifying Wi-Fi hotspots using WiFi Analyzer app, "You can see where are the best WiFi signal nodes".

Some of the applications noted as being particularly useful by students in the Show'n'Tell workshops and recommended as being useful for any student are shown in table 1 alongside some notes on their benefits and limitations.

Table 1: Smart Device Applications for Learning - examples of applications discussed by focus group participants, May 2012

Application	Study behaviour	Functionality & Benefits	Limitations
Any.do <i>Android</i>	Organisation	Create a task list by typing or voice input which can sync with Google tasks. Set priorities, lists into folders and tick off of tasks when complete. Create collaborative to do lists and share via Any.do members, Facebook or email. Requires less information to create than a Google task entry. Presents an easy to use view of all pending tasks.	Further editing and the edition of more information is required when synced with Google tasks.
Dropbox <i>Android and Apple</i>	Productivity Communication	Synchronise, upload and download files. Create DropBox shared folders for groupwork. Limited free storage space supports version control. For groupwork purposes, it shows where edits have been made to documents. DropBox enables the user to easily access and read or view files and returns the user to the same location in a previously viewed file upon exiting the application.	Poor rendering of PowerPoint slides perfectly. It does not play any animation in files. Files have to be downloaded and opened in another application to edit them which result in the concurrent editing of files by group members and loss of data. Registration is required. Though the first 2Gb are free costs escalate after that. Shared folders use memory from each member's storage quota.
Evernote <i>Android and Apple</i>	Productivity	Enables the user to type, capture images, and manage audio recordings. The notes can be uploaded for backup and stored online with Evernote. Documents and images can be shared with other Evernote users. Enable users to upload the output of other sources to the Evernote cloud, e.g. notebooks made in the iPad Penultimate.	Sharing limited to other registered Evernote users.
Facebook <i>Android and Apple</i>	Communication Organisation	Enables students to chat synchronously. This facilitates autonomous peer support and is helpful for groupwork. Students organise meetings via Facebook and the calendar entry synchronises with Google Calendar.	Facebook is notoriously a distraction when accessed in both formal and independent study time.
Final Countdown <i>Android</i>	Organisation	Users enter important deadlines which are shown on the home page of the smart device. Items can be configured to illustrate a regular visual notification of the countdown in time for assessments submission deadlines, functionality not provided by most calendar applications. This is particularly beneficial for assessments with distant deadline dates that can be easily forgotten.	Once a countdown has been initiated the application is always running and has been known to contribute to the freezing of some Android devices.

Application	Study behaviour	Functionality & Benefits	Limitations
Gmail <i>Android and Apple</i>	Communication	Gmail synchronises with the university student Gmail. All the functionality of Gmail on the smart device is more effective than the university's own mail app, which doesn't support the attachment functionality.	None were identified.
GoDocs <i>Apple</i> and Google Drive <i>Android</i>	Productivity Communication Multi-tasking	Provides access to a user's Google cloud application account, for example Google Docs. The user can share documents with other users and edit files live on the smart device. Changes made by other group members are easy to identify and therefore whether they are contributing to the groupwork.	The only Google application not supported is Google Chat though it also does not support viewing presentation slides. The device needs to be connected to the Internet to view and edit files.
Google Calendar <i>Android and Apple</i>	Organisation	Create, send and accept invitations for meetings and set up alerts. Supports synchronisation of multiple calendars (i.e. desktop, smart device, Facebook, etc). Data includes time, location and subject, of event, notes or message, and availability participants. Enables students to organise their time for timetabled sessions and study management including groupwork meetings and assessment planning.	None were identified.
OverSkreen <i>Android</i>	Multi-tasking	The web browser application is able to work as a window above other applications or the device's home page. Enables the user to breakout from the full-screen display of other applications and multi-tasking. For example, making notes in Evernote while reading articles found through Google Scholar.	None were identified.
SmartOffice <i>Android and Apple</i>	Productivity	Office tool that enables the user to create and edit MS Office documents, spreadsheets and presentations off-line. Files can be downloaded from Google Drive and DropBox and edited off-line. Images can be inserted into documents from smart device camera or photo library. Files can be shared via email in MS Office file extension format or PDF.	Users cannot save files to Google Drive or DropBox, therefore the user cannot move from device to device to edit files when the power on the devices fails.
Voice Recorder <i>Android</i> (except on Samsung Galaxy Nexus) * Nortcliffe et al. (2011b) provided a comprehensive review of iPhone and iPad audio recorders for learning	Productivity	Saves files in 3GA format, file type, but can be changed on a PC by changing the file extension to MP4. Effective voice recorder for collecting learning conversations whether in groupwork, class, or lecture. Users can search by title of files or date. Audio files can be shared by email or transferred to Google Drive or other file sharing apps.	The files are 3GA, therefore 25 minutes recording is 11Mbytes, so they soon become too large for an email attachment.

Application	Study behaviour	Functionality & Benefits	Limitations
WiFi Analyzer <i>Andriod and Apple</i>	Productivity Communication	Enables the user to identify the optimal WiFi hotspot for online productivity and communication activities. The application clearly displays signal strength as the user roams between WiFi hubs or plays increasingly intense audio alerts as the user approaches the optimal wifi signal strength.	None were identified.

Smart Devices for Learning Questionnaire Results

The student workshop participants completed a short survey after the Show'n'Tell demonstrations. This was to gather additional qualitative results on how Smart devices are supporting their studies, table 2. Though a small scale study the Likert and open question responses indicate a student consensus that is the smart devices have changed every aspect of their studies for the better. It has changed how they engage in and outside the classroom with their studies and their peers in group-work assessment. The smart devices and applications have made their learning more ubiquitous, personalized and assisting them to define when they learn; in and outside the formal curriculum. The students also agreed using smart devices is aiding their personal professional development for employment through the development of their mobile digital fluency and commercial networking via using the LinkedIn app.

Table 2: Smart Devices for Learning Questionnaire Results

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Does not apply to me
<i>Using your device to support your learning was a factor in your decision to purchase your device (or ask for it as a gift)</i>	2	2			1	
<i>How?</i>	<p><i>Agree:</i> "The use of apps was very appealing", "Use all the apps to complete work", "For my touchpad, I could see the benefit of an instant access to the timetable." <i>Disagree:</i> "Price and function only."</p>					
<i>My smart device has changed how I study</i>	1	4				
<i>Why?</i>	<p>"I don't need to use my laptop all the time", "makes it easier to get important notes from lectures by voice recording or making digital notes", "content consumption", "It records my lectures and I use my phone to keep connected remotely", "Being able to communicate in real time is very useful."</p>					
<i>My device has changed how I access information, resources, activities and/or people relating to studying on my course</i>	2	3				
<i>In what ways?</i>	<p>"Don't need to get my laptop out of my bag to look for information", "I am to access my work from anywhere", "I have found it useful to be able to pull documents from web to view them instantly anywhere", "Facebook and group-work", "Editing docs on the go"</p>					

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Does not apply to me
<i>Using my device has changed the way I think about how I study</i>	1	3	1			
<i>How?</i> <i>Agree:</i> "I am able to have a more flexible work time", "I can use my tablet wherever I can", "Locations, I can work everywhere."						
<i>My device has changed how I contribute to or engage with groupwork</i>		3	1		1	
<i>How?</i> <i>Agree:</i> "Being able to edit documents as a group is useful", "Calendar and facebook", "It is very useful for making notes and recording meetings", <i>Disagree:</i> "Not use for groupwork"						
<i>My device has changed how I engage in or contribute to lectures, seminars and other taught situations e.g. Google Searching, note making, etc.</i>	1	3	1			
<i>How?</i> <i>Agree:</i> "Search terms is useful", "I record lectures and discuss what I don't understand via facebook", "Making notes easier" <i>Neither:</i> "Note taking, but limited"						
<i>My device has changed when I engage in my studies</i>	1	2	2			
<i>What change in times have you noticed?</i> <i>Agree:</i> "Contact consumption", "Gave me the ability to work away from desk", "I can access everything everywhere including in bed" <i>Neither:</i> "I still do my studies when it suits me"						
<i>My device has changed where I engage in my studies</i>	1	2	2			
<i>What change in locations have you noticed?</i> <i>Agree:</i> "Yes it means that I can complete assignments on the bus", "I am able to engage more in lectures." <i>Neither:</i> "Locations, I can work everywhere"						
<i>I am selective in how I use my device to support my studies</i>	1	2	1		1	
<i>In what ways are you selective?</i> <i>Strongly disagree:</i> "Use it for everything, all assignments, revision, note-taking" <i>Agree:</i> "Avoid content creation", "Sometimes I use my phone for more of a entertainment system"						
<i>I regularly look for apps that may help me informally and formally engage with my studies</i>	2	1	1		1	
<i>How methodical are you?</i> "If I know what I want I will search for it and I also look through the top apps", "I use whatsapp to communicate with people and I also use Facebook chat to talk." <i>Strongly disagree:</i> "I use web mostly, avoid apps."						

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Does not apply to me
<i>My personal smart device complements or is replacing existing ways of studying (including with other technology) at university or outside university.</i>	1	1	2		1	
<i>Explain more about this change</i>						
<i>Agree: "I hardly use my laptop anymore", "Notepad and organisers have been replaced with Calendar and Google Drive."</i>						
<i>Neither: "I believe that smart devices could, but [have] not replace[d existing ways of working]."</i>						
<i>Using a smart device makes me a better student</i>	1	2	2			
<i>Comment</i>						
<i>"I can be more efficient doing my work", "It means I can spend more time on my assignments."</i>						
<i>Using a smart device enhances my employability</i>	1	4				
<i>What connections do smart devices have with employability do you think?</i>						
<i>"various contacts via LinkedIn", "I can use app to look for jobs, etc", "Because they may want to implement mobile devices into their workplace."</i>						
<i>My device helps me learn with other students</i>		3	1			1
<i>Why?</i>						
<i>Agree: "I can connect to my group using facebook", "using Facebook and Google Drive to share documents and thoughts"</i>						
<i>Does not apply to me: "I don't work with others"</i>						

DISCUSSION

App typology for analysing study behaviours

This small study explored the hypothesis that students are being innovative in their use of smart devices to support their formal and informal engagement as learners. It found that students valued the flexible access to learning that their devices and installed applications offered them and they appreciated how this helped them to be more organised and productive, whether they were working independently or with others.

The respondent group was very small and of a similar demographic: all male, early twenties and from similar disciplines. This affected the nature of the apps that were discussed in the focus groups. The development of a typology is useful as it begins to highlight the informal and formal study behaviours that students associate with smart, personally owned technology. We have used Productivity, Communication, Multi-tasking, and Organisation as categories based upon the descriptions by students for how applications are used and valued. More work involving other disciplines is needed in this area to develop this analytical typology.

Some references to apps were made in passing which were not addressed in detail during the focus groups. References to communication apps, for example, indicate how some students who are not co-located appreciate the means to easily communicate with each other.

Students changing the nature of their engagement

The students highlighted how the devices helped them to multi-task: they used the smart technology to remain actively engaged in their work across the nominally demarcated boundaries of life, work

and study. For example, Student A reported how, with an imminent deadline, he edited his Google Doc on Google Drive while he was cooking his evening meal.

A recurring theme in the focus group discussions was how personal smart devices promote persistent 'always on' behaviour. Student D observed, "It is really interesting the way people expect people to use technology is to be focusing on one or two things at once. The way people really use technology, it is more chaotic than that." The appearance may be of chaos, but clearly there is purpose and personal motivation underpinning the use of smart devices in informal situations.

The nature and purpose of student engagement has changed therefore and is quite different to what might be expected in an account of a formal taught situation. The technology has changed the learning environment and, arguably, can be described as the learning environment. The student has control of this technological environment as we concluded in earlier work on the use of personal audio recorders (Middleton and Nortcliffe, 2011). This affects their motivation, sense of their own responsibility as learners, sense of ownership over their learning and their perception of their learning efficacy and autonomy. The idea of persistent autonomous engagement appears to be valued by the students. It is not suggested that prior to smart technologies a student would only ever engage in their studies in a formal way and on campus, rather that access to powerful, connected computing from anywhere and at any time encourages the student to use the tools in ways that they believe are productive and generally helpful.

This persistent use of personal smart technology also suggests a change in the role of technology in education: it is perhaps less instrumental and more pervasive, being less task orientated and more environmental. Taking an environmental view helps us understand how smart technologies promote productive learner engagement in terms of interactivity and organisation as much as how they are used to access substantive content.

The results illustrate how communication and interactivity are behaviours valued by the students. Their descriptions of groupwork show how smart applications enabled group members to work together even when they were not co-located. Respondents described how they used Google Docs, DropBox and other file sharing tools to produce group reports and noted how support for version control was helpful. Version control functionality, according to the student testimony and accounts from other studies (Dearman & Pierce, 2008), was not only useful, but it enabled them to manage their documentation professionally and this demonstrates how behaviours developed at university have implications for digital literacy and employability. These are seen to be further enhanced when considering the management of personal technology; how students take responsibility for identifying and evaluating their personal technologies. The self-selection of online services, for example, added authenticity to their project work.

There are cognitive and psychological implications that need to be considered too: how does an 'always on' state of mind affect the learning, the study-life balance and the wellbeing of the student? Persistent autonomous engagement with learning raises questions about the intensity and the quality of the students' engagement with their learning and their course in general. Again, there are potential implications here for digital literacy and employability, as well as for learning and teaching, and further work is needed to look at the cognitive and psychological dimensions of this area of disruptive innovation.

This study has allowed us to begin to explore the potential of positive, disruptive innovation underpinned by the autonomous adoption of smart device technology by students. At this stage change is happening *around* engagement with existing forms of formal provision, however, the nature of the formal provision itself has not been disrupted to any great degree. In the future we would expect the design of formal provision to take account of the flexibility afforded by smart devices and to be cognisant of the possible shift towards greater learner autonomy. Before this shift is possible, however, curriculum designers will need to see greater student ownership of interoperable smart devices and a shared expectation of the value of such technologies to learning.

Creativity and academic influence

The examples referred to in this study, unlike our previous work, do not provide evidence of students' intentional creative engagement with the technologies; however, as the benefits of using smart devices gain wider recognition we would expect more creative engagement with the possibilities. The essential learning task had not changed in this study, it was the learner's behaviour. This suggests that academics need to reconsider the formal pedagogy in order to appreciate the full potential of disruptive innovation. At the same time, as noted earlier, learner creativity and critical thinking coupled with confident, self-regulated learner autonomy need to be developed before widespread adoption of smart technologies and behaviour can happen. Furthermore, greater understanding of the potential needs to be developed to influence the purchasing behaviours of students as they evaluate personal technologies on entry to university or while studying. It is not clear how, or if, influence over such decisions can happen, or if it is a question of students gaining familiarity and confidence with their smart devices. For example two weeks after the Shown'n'Tell event the researcher (as an academic) observed Student C initiate a creative innovative use of their smart device in a group assessment feedback session. The activity involved Skype app on the Student C's HTC smartphone connected to the University WiFi, and a PC connected to the internet belonging to a fellow group member at home for medical reasons. The use of Skype enabled the physically non-attending student to actively participate, contribute, reflect and receive the group feedback with his fellow group peers from the academic (researcher). The smart technology experience was seamless, nonintrusive and enabled all parties to benefit from the feedback learning experience.

Therefore from our own point of view, as academics and educational developers, there remains a question of what we can or should do about developing innovation in the use of smart technology. Especially when considering the way academics practice is changing through use of their own personal smart devices to support student learning, Nortcliffe & Middleton (2011). The answer is possibly just to observe the change as an organic phenomenon. However, the emerging evidence suggests it is useful to challenge assumptions about the long-standing behaviours and expectations of both students and staff about accepted practice. We suggest it is timely to pay more attention to the rich and meaningful ways that students are developing themselves for their engagement with the curriculum by using their own smart devices.

The idea of Bring Your Own Device (BYOD) is an expression of disruptive innovation. There are clearly perceived benefits to this changed state of engagement, whether considering study, work or a mix of the two. However, further work is needed to look at the quality of engagement and the opportunities that exist for changing learner and academic expectations.

REFERENCES

- Armstrong, M. (2012). An investigation into how e-learning applications can effectively be seeded to students with smartphones, *Undergraduate computing programme project report as part of BSc Computing*, Department of Computing: Sheffield Hallam University.
- Bennett, S., Maton, K. & Kervin, L. (2008). The "Digital Natives" debate: a critical review of evidence. *British Journal of Educational Technology*, 39, 775–86.
- Bligh, D. (2000). *What's the use of lectures?* San Francisco: Jossey-Bass.
- Boticki, I. & So. H. (2010). Quiet captures: a tool for capturing the evidence of seamless learning with mobile devices. In: *Proceedings of the 9th International Conference of the Learning Sciences* (pp. 500-507), June 29–July 2 2010. Chicago, Illinois.
- Boulos, M. N., Wheeler, S., Tavares, C. & Jones, R. (2011). How smartphones are changing the face of mobile and participatory healthcare: an overview, with example from eCAALYX. *Biomedical Engineering Online*, 10, 24.

- Bowers-Brown, T. (2006). Widening participation in higher education amongst students from disadvantaged socio-economic groups, *Tertiary Education and Management*, 12(1), 59-74.
- Bower, J. L. & Christensen, C. M. (1995). Disruptive technologies: catching the wave, *Harvard Business Review*, January–February 1995.
- Brown, J. S. (2000). Growing up digital: how the web changes work, education, and the ways people learn. *Change: The Magazine of Higher Learning*, 32(2), 10-20.
- Burgess, P. W. (2000). Real-world multitasking from a cognitive neuroscience perspective. *Attention and Performance*, 18, 465–472.
- Camargo, M., Bary, R., Boly, V., Rees, M. & Smith, R. (2011). Exploring the implications and impact of smartphones on learning dynamics: the role of self-directed learning, Paper presented at the Concurrent Enterprising (ICE), 2011 17th International Conference, 20-22 June 2011, 1-11.
- Chen, G. D., Chang, C. K. & Wang, C. Y. (2008). Ubiquitous learning website: scaffold learners by mobile devices with information-aware techniques. *Computers and Education*, 50, 77–79.
- Chen, J., Park, Y. & Putzer, G. J. (2010). An examination of the components that increase acceptance of smartphones among healthcare professionals, *Electronic Journal of Health Informatics*, 5(2), e16.
- Christensen, C. M. (1997). *The innovator's dilemma: when new technologies cause great firms to fail*, Boston, Massachusetts, USA: Harvard Business School Press.
- Clough, G., Jones, A.C., McAndrew, P. & Scanlon, E. (2008). Informal learning with PDAs and smartphones, *Journal of Computer Assisted Learning*, 24(5), 359-371.
- Clough, G., Jones, A., McAndrew, P. & Scanlon, E. (2009). Informal learning in online communities of mobile devices enthusiasts. In: M. Ally (ed.), *Mobile learning: Transforming the delivery of education and training*. Athabasca: Athabasca University Press, 100–112.
- Cochrane, T. (2006). Learning with wireless mobile devices and social software. Paper presented at the 23rd ASCILITE Conference, 3-6 December 2006. Sydney.
- Cochrane, T. & Bateman, R. (2010). Smartphones give user wings: Pedagogical affordances of mobile Web 2.0. *Australasian Journal of Educational Technology*, 26(1), 1-14.
- Cohen, L., Manion, L. & Morrison, K. (2000). *Research methods in education*. 5th edition. London and New York: Routledge and Falmer.
- Corbeil, J. & Valdez-Corbeil M. J. (2007). Are users ready for mobile learning? *Educause Quarterly*, 11, 51–58.
- Costello, S. (2012) How many apps are in the iPhone app store? *About.com Guide*. Online at: <http://ipod.about.com/od/iphonesoftwareterms/qt/apps-in-app-store.htm>, retrieved on 01 May 2012.
- Cowan, N., Nugent, L. D., Elliott, E. M., Ponomarev, I. & Saults, J. S. (1999). The role of attention in the development of short-term memory: age differences in the verbal span of apprehension. *Child Development*, 70, 1082–1097.
- Davis, H. & White, S. (2012). Institutional personal learning environments – paradise or paradox? Keynote paper presented at the 17th April 2012 at 4th International Conference on Computer Supported Education, 16th-18th April 2012. Porto, Portugal.
- Dearman, D. & Jeffery S. P. (2008). It's on my other computer! computing with multiple devices. In: *Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems (CHI '08)*. ACM, New York, USA.
- Disobedient Media (2010). 3D Crystal Viewer app released. Blog available at: <http://disobedientmedia.co.uk/blog/2010/10/18/news18oct10/>, retrieved on 01 May 2012.
- dos Santos Rosa Santana dos Santos, N. Valdeni de Lima, J. & Krug Wives, L. (2012). Integration of technologies in the development of interactive educational content. Paper presented at the 4th International Conference on Computer Supported Education, 16th-18th April 2012. Porto, Portugal.

- Edwards, M. B. & Gronlund, S. D. (1998). Task interruption and its effects on memory. *Memory*, 6(6), 665–687.
- Fischer, S. C., Morris, K. A. & Joslyn, S. (2003). Measuring multi-tasking ability. Report prepared for the *Office of Naval research by Anacapa Sciences, Inc*, (pp. 157) Available at <http://handle.dtic.mil/100.2/ADA417039>. retrieved on 01 May 2012.
- Franklin, T. (2011). Mobile learning: at the tipping point, *The Turkish Online Journal of Educational Technology*, October 2011, 10(4), 261-275.
- Han, J., Chung, S. & Sohn, Y. (2009). Technology convergence: when do consumers prefer converged products to dedicated products? *Journal of Marketing*, 73(4), 97-108.
- Hembrooke, H. & Gay, G. (2003). The laptop and the lecture: the effects of multitasking in learning environments. *Journal of Computing in Higher Education*, 15(1), 46–64.
- Hendery, S. (2009). Great gadget, stratospheric price. *New Zealand Herald*, 9 July, (p. B4). Available at <http://www.nzherald.co.nz/technology/news/article.cfm>? retrieved on 01 May 2012.
- Huang, Y. M., Jeng, Y. L. & Huang, T. C. (2009). An educational mobile blogging system for supporting collaborative learning. *Journal of Educational Technology and Society*, 12(2), 163–175.
- Huang, Y.-M., Chiu, P.-S., Liu, T.-C. & Chen, T.-S. (2011). The design and implementation of a meaningful learning-based evaluation method for ubiquitous learning. *Computers & Education*, 57(4), 2291–2302.
- Hwang, G., Chen, B., Chu, H. & Cheng, Z.S. (2012). *Development of a Web 2.0-based ubiquitous learning platform for schoolyard plant identification*, Paper presented at the 2012 Seventh IEEE International Conference on Wireless, Mobile and Ubiquitous Technology in Education, Available at <http://ieeexplore.ieee.org.lcproxy.shu.ac.uk/stamp/stamp.jsp?arnumber=06185043>. retrieved on 01 May 2012.
- Janis, I. L. (1972). *Victims of groupthink: a psychological study of foreign-policy decisions and fiascoes*. Boston: Houghton Mifflin.
- Jeng, Y. L., Wu, T. T., Huang, Y. M., Tan, Q. & Yang, S. J. H. (2010). The add-on impact of mobile applications in learning strategies: a review study. *Educational Technology & Society*, 13(3), 3–11.
- Jewell, S. (2011). Productivity via mobile phones: Using smartphones in smart ways, *Journal of Electronic Resources in Medical Libraries*, 8(1).
- JISC (2006). Designing space for effective learning: a guide to 21st century learning space design. Available at: http://www.jisc.ac.uk/uploaded_documents/JISClearningspaces.pdf. retrieved on 01 May 2012.
- JISC (2011a). University of Leeds Medical School, In: *Mobile Learning infoKit*, 55-57. Available at: <https://files.pbworks.com/download/ukYXA3QiTL/mobilelearninginfokit/50760424/mobile-learning-infokit.pdf>. Retrieved on 14th February 2012.
- JISC (2011b). University of Bradford, In: *Mobile Learning infoKit*, 50-54. Available at: <https://files.pbworks.com/download/ukYXA3QiTL/mobilelearninginfokit/50760424/mobile-learning-infokit.pdf>, retrieved on 01 May 2012.
- JISC (2009). Effective practice in a digital age: a guide to technology-enhanced learning and teaching. Available at: <http://www.jisc.ac.uk>. Retrieved on 8th February 2012.
- Jones, C. Ramanau, R., Cross, S. & Healing, G. (2010). Net generation or Digital Natives: Is there a distinct new generation entering university? *Computers & Education*, 54(3), 722-732.
- Kennedy, G., Krause, K., Judd, T., Churchward, A. & Gray, K. (2006). First year students' experiences with technology: are they really digital natives? Melbourne, Australia: University of Melbourne. Available at: http://www.bmu.unimelb.edu.au/research/munatives/natives_report2006.rtf. retrieved on 01 May 2012.
- Kukulska-Hulme, A. & Traxler, J. (eds), (2005) *Mobile learning: a handbook for educators and trainers*. Open and flexible learning series, London: Routledge.

- Lee, I. (2006). Ubiquitous computing for mobile learning. *Asia-Pacific Cybereducation Journal*, 2(1), 17-28.
- Lohnes, S. & Kinzer, C. (2007). Questioning assumptions about students' expectations for technology in college classrooms. *Innovate*, 3(5), Available at: <http://www.innovateonline.info/index.php?view=article&id=431>. Retrieved on May 2012
- Mayes, T., Morrison, D., Mellar, H., Bullen, P. & Oliver, M. (2009). *Transforming higher education through technology enhanced learning*. York: Higher Education Academy.
- Middleton, A. J. & Nortcliffe, A. (2009a). Audio, autonomy and authenticity: constructive comments and conversations captured by the learner. Poster presented at the ALT-C 2009 "In dreams begins responsibility" - choice, evidence, and change, 8-10 September 2009, Manchester: UK.
- Middleton, A., Nortcliffe, A. and Owen, R. (2009). iGather: learners as responsible audio collectors of tutor, peer and self reflection. Paper presented at the *A Word in User Ear - Audio Feedback Conference*, 18 December 2009, Sheffield: UK. Available at: <http://research.shu.ac.uk/lti/awordinuserrear2009/>. Retrieved on 12th February 2011.
- Middleton, A. & Nortcliffe, A. (2011). Smartphone feedback: pervasive and meaningful exchanges and interventions, Paper presented at the ALT-C 2011 - Thriving in a colder and more challenging climate, 6-8 September 2011, Leeds: UK.
- Mitchell, K., & Race, N.J.P. (2005). uLearn: facilitating ubiquitous learning through camera equipped mobile phones. Paper presented at the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05).
- Murphy, D. (2012). Apple's App Store hits 25 billion downloads: how many per iPhone? *PCMag.Com*. Available at: <http://www.pcmag.com/article2/0,2817,2401122,00.asp>, retrieved on 01 May 2012.
- Nicol, D.J. & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: a model and seven principles of good feedback practice, *Studies in Higher Education*, 31(2), 199-218.
- Nortcliffe, A. (2010). iPhone supervision and feedback: a case study In: Middleton, A. (ed.), *Media-enhanced feedback: case studies and methods*. Papers produced to support the Media-Enhanced Feedback event, 27 October 2010, Sheffield: UK, Available at: http://ppp.chester.ac.uk/images/4/43/Middleton-Media-enhanced_feedback_proceedings-final.pdf, retrieved on 01 May 2012.
- Nortcliffe, A.L. & Middleton, A. (2006). Audio lecture notes: supplementary lecture materials with added value, *NADO News The Official newsletter of the National Association of Disability Officers Ltd*, Summer 2006.
- Nortcliffe, A. & Middleton, A. (2007). Audio feedback for the iPod generation. In: *Proceedings of International Conference on Engineering Education*, September 2007, Coimbra: Portugal.
- Nortcliffe, A. & Middleton, A. (2008) A three year case study of using audio to blend the engineer's learning environment, *Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre*, 3(2).
- Nortcliffe, A., Rossiter, J.A. & Middleton, A. (2009). Students using digital audio interventions to enhance their learning experience. Paper presented at The Higher Education Academy Annual Conference 2009 "The Future of the Student Learning Experience", 30 June - 2 July 2009, Manchester: UK.
- Nortcliffe, A. L. & Middleton, A. (2009a). Understanding effective models of audio feedback. In: Rajarshi Roy (ed.), *Engineering education perspectives, issues and concerns*, Shipra Publications, India.
- Nortcliffe, A. & Middleton, A. (2009b). Effective assignment feedback through timely and personal digital audio engagement. In: John O'Donoghue (Ed.), *Technology-Supported Environments for Personalized Learning: Methods and Case Studies*, Hershey Pennsylvania, USA: IGI Global.

- Nortcliffe A. & Middleton, A. (2010). Student Audio Notes Project: lessons from the autonomous use of MP3 recorders by students to enhance their learning, *CPLA Centre for Promoting Learner Autonomy A Centre for Excellence in Teaching and Learning Case Studies: Volume 1*, I. Moore, J. ElfvingHwang, K. Garnett & C. Corker (eds), 2010, 151-164. Available at: http://extra.shu.ac.uk/cetl/cpla/resources/CPLA_Case_Studies_Volume_1.pdf, retrieved on 01 May 2012.
- Nortcliffe, A. Middleton, A. & Woodcock, B. (2011). Evaluating the use of audio smartphone apps for higher education learning. Paper presented at the Audio Engineering Society 130th Conference, May 2011. London, UK.
- Nortcliffe, A. & Middleton, A. (2011). Smartphone feedback: using an iPhone to improve the distribution of audio feedback. *International Journal of Electrical Engineering Education Special Edition*. 48(3), 280-293.
- Oblinger, D. (ed) (2006). *Learning spaces*. EDUCAUSE, Available at: <http://net.educause.edu/ir/library/pdf/PUB7102a.pdf>, retrieved on 01 May 2012.
- Oliver, B. & Goerke, V. (2007). Australian undergraduates' use and ownership of emerging technologies: implications and opportunities for creating engaging learning experiences for the Net Generation. *Australasian Journal of Educational Technology*, 23(2), 171–186. Available at: <http://www.ascilite.org.au/ajet/ajet23/oliver.html>, retrieved on 01 May 2012.
- Ophir, E., Nass, C. & Wagner, A. D. (2009). Cognitive control in media multitaskers. In: *Proceedings of the National Academy of Science of the United States of America*, 106(37), 15583–15587.
- Paul, I. (2012). Android market hits 450K apps, challengers abound, *PC World*. Available at: http://www.pcworld.com/article/250765/android_market_hits_450k_apps_challengers_about.html, retrieved on 01 May 2012.
- Röpke, J. & Schneider, G. (2012). MORE - Mobile Referencing System for Printed Media. Paper presented at the 4th International Conference on Computer Supported Education, 16th-18th April 2012, Porto, Portugal.
- Rossiter, J.A., Nortcliffe, A., Griffin, A. and Middleton, A. (2009). Using student generated audio to enhance learning, *Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre*, 4(2).
- Ruth, A. (2012). Chalkface; interface; screen face: moving the metaphor of teaching toward the nexus of teaching and learning. *Research in Learning Technology*, 20(2).
- Sakamura, K. and Koshizuka, N. (2005) Ubiquitous computing technologies for ubiquitous learning. In: *Proceeding of the International Workshop on Wireless & Mobile Technologies in Education*, 11–18.
- Santos, I.M. & Ali, N. (2012). Exploring the uses of mobile phones to support informal learning, *Education and Information technologies*, 17(2) pp 187-203
- Sharples M., Taylor J. & Vavoula G. (2007) A theory of learning for the mobile age. In: R. Andrews & C. Haythornthwaite (eds) *Sage Handbook of elearning Research*, 221–247. London: Sage Publications.
- Sharples, M., Arnedillo-Sánchez, I., Milrad, M. & Vavoula, G. (2009). Mobile learning: small devices, big issues. In: N. Balacheff, S. Ludvigsen, T. Jong, A. Lazonder & S. Barnes, (eds), *Technology-Enhanced Learning*, Part IV, 233-249. Springer Netherlands.
- Shin, D., Shin, Y, Choo, H. & Beom, K. (2011). Smartphones as smart pedagogical tools: Implications for smartphones as u-learning devices, *Computers in Human Behavior*, 27(6), 2207-2214.
- Sheng, H., Siau, K. & Nah, F. F. (2010). Understanding the values of mobile technology in education: a value-focused thinking approach. *SIGMIS Database*, 41(2), 25-44.
- Song, L. & Hill, J. (2007). A Conceptual model for understanding self-directed learning in online environments. *Journal of Interactive Online Learning*. 6(1), 27 - 42.
- Traxler, J. (2009). Learning in a Mobile Age, *International Journal of Mobile and Blended Learning*, 1(1), 1-12.

- Traxler, J. (2010). Students and mobile devices, *ALT-J, Research in Learning Technology*, 18(2) 149–160.
- Tucker, T.G. & Winchester, III., W. W. (2009). Mobile learning for just-in-time applications. In: Proceedings of the 47th Annual Southeast Regional Conference (ACM-SE 47). ACM, New York, NY, USA. Available at <http://doi.acm.org/10.1145/1566445.1566469>, retrieved on 01 May 2012.
- Vavoula, G. & Sharples, M. (2008). Challenges in Evaluating Mobile Learning. Paper presented at the mLearn 2008 Conference.
- Vozenilek, J., Huff, J. S., Reznek, M. & Gordon, J. A., (2004). See one, do one, teach one: advanced technology in medical education, *Academic Emergency Medicine*, 11(11), 1149-1154.
- Whitney, L. (2012). iOS, Android apps surpass 1 billion downloads in final week of 2011, *CNET*. Available at: http://news.cnet.com/8301-1023_3-57351300-93/ios-android-apps-surpass-1-billion-downloads-in-final-week-of-2011/, retrieved on 01 May 2012.
- Woodcock, B. (2011). An investigation into the benefits and limitations of mobile learning applications used for computing studies in higher education, *Undergraduate computing programme project report as part of BSc Computing*, Department of Computing: Sheffield Hallam University.
- Woodcock, B., Middleton, A. & Nortcliffe, A. (2012a). Considering the smartphone learner: developing innovation to investigate the opportunities for students and their interest, *Student Engagement and Experience Journal*, Available at: <http://research.shu.ac.uk/SEEJ/index.php/seej/article/view/38/Woodcock>, retrieved on 12th April 2012.
- Woodcock, B., Middleton, A. & Nortcliffe, A. (2012b). Smart device potential for student learning, 4th International Conference on Computer Supported Education, 16th-18th April 2012, Porto, Portugal.
- Wu, T. T., Yang, T., Hwang, G. & Chu, H. (2008). Conducting situated learning in a context-aware ubiquitous learning environment, *Wireless, Mobile, and Ubiquitous Technology in Education*, 2008. WMUTE 2008. Fifth IEEE International Conference, 23-26 March 2008, 82-86. Available at: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4489792&isnumber=4489772>, retrieved on 01 May 2012.
- Yan, C. (2009). How to implement collaborative learning in Web2.0: take three applications for example. Paper presented at the Symposium on IT in Medicine and Education, 14-16 August 2009, 627-631.

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