Handbook of Research on Digital Information Technologies:
Innovations, Methods, and Ethical Issues

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Chapter XXV
Human Factors and Innovation with Mobile Devices

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ABSTRACT

Advancements in technology are a significant driving force in educational innovation, but a strong focus on technology means that human aspects and implications may not be given the attention they deserve. This chapter examines usability issues surrounding the use of mobile devices in learning. A key aim is to empower educators and learners to take control of personal devices and realise their potential in relation to teaching and learning. The background section reviews the development of usability studies and explores why mobile device usability presents specific new challenges. The impact of changing requirements in education, and new visions for ways of thinking and competences that learners should be acquiring, are also examined. Finally, the chapter provides a set of concepts that can inform conversations between educators and learners, mobile system engineers, developers, support staff, and others.

INTRODUCTION

Every new wave of technological innovation poses fresh challenges with regard to its compatibility with the people who are to make use of it and with existing social and cultural practices. The widespread, rising ownership of mobile devices is one key development that educators need to examine and reflect on as it starts to make its mark in all types of teaching and learning activity, both formal and informal. Advancements in technology are acknowledged as being a significant driving force in educational innovation and new technologies are often explored as a way to enhance teaching and learning, but a strong focus on technology inevitably means that human aspects and implications are often relegated to second place. It is only by raising levels of understanding and awareness of human factors that we can work towards achieving some kind of balance.

Mobile learning--using portable devices such as cell phones, personal digital assistants, per-

sonal media players, and ultra-portable PCs--is rapidly becoming a popular way of accessing and producing digital information on the move, and communicating and collaborating with others. The majority of mobile learning activity takes place on devices that were not designed with educational applications in mind, however, and furthermore, an assumption is frequently made that users know their personal device so well that it is not necessary to give them much support or training. This may contrast with experience of support and development that both instructors and learners receive in connection with the use of their desktop computer. As we start to experience 'the third wave of computing' (Dix et al., 2004, p. 184), in which devices far outnumber people, the device will become less personal again, although user interactions and content could become more personal.

Despite decades of usability research, problems with understanding the user interface and with performing essential tasks are still often reported by users, both on desktop and mobile systems. Arguably, the situation may be even getting worse, as open source software is not always tested for usability, and ever-changing interfaces put constant demands on users, who perceive that they have less and less time to keep up with the latest developments. What is more, in mobile scenarios users may have difficulties getting access to specialist technical support or to people with similar devices who can offer friendly help. They may also be relying on continuous online access to learning networks and resources, which in reality can be difficult to achieve. Therefore, new factors come into play that must be identified and analysed.

AIMS AND SCOPE

This chapter reflects critically on progress in usability and on recent developments in human-computer interaction, with particular reference to findings from studies of mobile learning. Usability cannot be considered in a vacuum: requirements specific to education have to be taken into account, but bearing in mind that educational goals and methods are constantly being redefined (e.g. Beetham & Sharpe, 2007; Laurillard, 2002). Accessibility and personalisation, which address the match between a user's individual (possibly special) needs and the device they are using, are also important. User skills and competences must be taken onto account. Increasingly, there is a need to paint a more detailed picture of the circumstances in which electronic tools are used, and the factors impacting on the quality of the experience for the human user.

The aims of this chapter are to present the issues in such a way as to empower educators and learners to take control of personal devices and to realise their potential in relation to teaching and learning, and second, to provide a set of concepts that can inform conversations with mobile system engineers, developers, and support staff. Over time, a holistic understanding of user experience can emerge from these conversations. An initial set of factors impacting on the usability of mobile devices in education has been documented by Kukulska-Hulme (2006). Placing human factors at the centre, the longer term ambition is to develop a set of concepts with reference to user skills and competences, giving greater clarity to discussions around the human needs of mobile technology users in activities connected to education, frequently undertaken whilst travelling and in other situations involving mobility.

BACKGROUND: USABILITY AND MOBILE DEVICES

Although much of the work in usability focuses on the evaluation of a user interface, over a decade ago Nielsen (1993) explained usability in terms of a system's overall acceptability, which included social aspects and practical aspects

(such as reliability, cost, compatibility, and usefulness). Preece, Rogers, and Sharp (2002) have subsequently done a great deal to promote the concept of 'user experience,' with its focus on enhancing and extending the way people work, communicate, and interact. In recent years there has been a growing interest in motivational and affective aspects; for example, Porter et al. (2005) emphasise emotional and 'pleasure' needs, while Dix et al. (2004, p. 156) have stressed that "…it is not sufficient that people can use a system, they must *want* to use it." Usability research is also becoming more attuned to the requirements of different subjects or disciplines; Kukulska-Hulme and Shield's work (2004) on 'pedagogical usability' has included a focus on the requirements of different academic disciplines, as exemplified by the discipline of language learning. In Web sites that support language learning, usability might depend on whether the site uses the first or target language and on its ability to support multimodal and intercultural communication. The ways in which language experts conceptualise user interfaces may also be specific to the culture and sub-cultures of their discipline. These aspects can be hard to quantify and measure, but it does not mean that they are less important.

Usability continues to be reinterpreted in the light of new understandings and evolving contexts of technology use. Despite these advancements, however, Cooper (2004) and Nielsen (2005) have continued to point out the usability shortcomings of current computer software and technology. Schneiderman (2002, p. 26) identified users' attitudes as an important issue: "There is no magic bullet that will bring widespread use of low-cost devices that are easy to learn, rapid in performing common tasks, and low in error rates," predicting that change would only come about through users upgrading their expectations and demanding higher quality. Usability evaluator Baker (2006, p. 11) makes a similar point about user reticence to make demands on device manufacturers: "…the frustration felt by users is not always targeted towards the device or product… many who have new mobile devices will often blame themselves for not reading the 300-page manual which came with it if they experience a problem." As yet, there is no real evidence of change in user attitudes in this respect. Device manufacturers, having "for years only pursued male wallets" (BBC, 2002, p. 7), have begun taking notice of the different needs and priorities of female customers, but this still largely translates into a focus on the style and fashion aspects of new gadgets--their outward appearance rather than the way they work.

There are many physical and psychological differences between people impacting on their learning and experiences with technology, but it is usage differences that are sometimes overlooked. Usage differences are particularly interesting in relation to mobile devices. As noted by Benyon et al. (2005, p. 33), novice and expert users have very different requirements, and then there are so-called 'discretionary users'--those who are quickly put off using a system if things are difficult to do. Mobile devices require a relatively long term personal commitment, on an ongoing basis, whilst accommodating different types of usage within one device.

The usability of mobile devices has generated its own literature (e.g., Weiss, 2002; Gilbert et al., 2005), which is set to expand over the next few years. The rate at which new devices and models come on the market means that usability is essentially a moving target. Each manufacturer has a different interface, and mobile devices are continually being replaced with new models, even before users have got to know them well. A review and synthesis of usability issues across a range of mobile learning projects (Kukulska-Hulme, 2006) found that the issues reported in the research literature could be summarised under four main headings: Physical attributes of mobile devices (e.g., size, weight, memory, battery life); Content and software applications; Network speed and reliability; The physical environment.

The research showed that the same usability issue can be perceived differently depending on the circumstances in which the technology is being used. In their theoretical work on mobile learning, Sharples et al. (2006, p.19) have remarked that "…the relative lack of usability in the technological domain inhibits developments in the semiotic." There is little evidence that usability problems might be fading away, in spite of some wishful thinking about increasingly intuitive interfaces and more sophisticated users.

There is another intriguing aspect of mobile technologies that makes it difficult to work on usability in relation to user requirements. Mobile devices are often used in real-world situations where unpredictable things can happen; people can respond constructively to such events (Suchman, 1987), but capturing what happened and feeding it back into technology designs is an enormous challenge. The highly personal and portable nature of mobile devices is also encouraging exploratory uses, and it is hard to predict what users will do. Those involved in designing mobile devices have been noticing that "new solutions are utilized in ways that never even occurred to their designers" (Keinonen, 2003, p. 2). Uses may also become more elaborate over time: Gilbert et al. (2005, p.207) have drawn attention to the period after initial use of a mobile service, "during which the scope of use expands to fulfil emergent needs." In their summary of key messages about learning with handheld technologies, Faux et al. (2006) point out that personal ownership of a device must go hand in hand with a more autonomous learner role, which means learners being encouraged to make choices about when and how they use their device to support learning.

There are many ways of acquiring a mobile device; it may be a personal purchase, a gift, a loan. Its subsequent use may evolve according to the duration of ownership, whether the device was wanted, emergent wants or needs. Users may never discover all the features of their device before moving on to another one. How people get to know the features and possibilities of their mobile device over time has not been well researched to date, but social networks are sure to play a role, as well as the extent to which mobile services and content are 'pushed' in their direction by various providers. It has been observed that younger users may be quicker to master a new device; for example, based on their work with schoolchildren, Faux et al. (2006, p. 5) advise that "learners will develop a facility with the devices quite quickly, often led by class champions," but at the same time they add that learners should be encouraged to share their new knowledge with others. The next section examines requirements that are of particular concern to educators and learners engaged in mobile learning.

REQUIREMENTS IN EDUCATION

User-centred system design and evaluation have traditionally been driven by the concept of a 'task', task analysis being the process of analyzing the way people perform their jobs (Dix et al., 2004, p. 511). If learning were conceived of as performing a job, it might be straightforward to apply task analysis, but in reality this only works in quite circumscribed activities where everything about a learning task is very clearly defined and the focus is on observable behaviour. Rekkedal (2002) has suggested that mobile learners in distance education need to be able to perform tasks such as studying the course materials, making notes, writing assignments, accessing a forum, sending and receiving e-mail, and communicating with a tutor. These simple labels conceal great complexity in how materials might be studied and how communication might actually take place. Ryan and Finn (2005) have also commented on the difficulty of task analysis in relation to mobile learning 'in the field,' in the course of their attempts to define the generic requirements of users who typically operate out in the field, that is, geologists, archaeologists, journalists, techni-

cians, police. There are multiple challenges are: representing what a learning task consists of; observing the task when it happens in faraway or variable locations; capturing how it is played out in practice.

Educational activity can sometimes be better understood by system designers when it is seen as an example of a 'rich context' involving different people, the spaces they meet in and the physical artefacts they use (Dix et al., 2004, p. 639-49). Current reference works on interactive system design certainly emphasize the importance of context, defined in terms of the "human, physical, organizational, historical and social environment in which a technology is used" (Benyon et al., 2005, p. 163), and recommend user participation in capturing requirements.

In relation to mobile learning, lessons from the MOBIlearn project (O'Malley et al., 2003, p.32) suggest observing "the usability requirements of all those involved in the use of the system in any way (learners, teachers, content creators) to assure system acceptability," considering the context of use and that the learner should be able to receive personalised information that is valuable in a given context. Pehkonen and Turunen (2003) have also argued that user-centred design means, not only planning learning goals and actions, but also specifying different contexts of use and the requirements of different 'actors', which might include teachers, students and even parents. Luckin et al. (2005) have defined a learning context as an 'ecology of resources' and have shown how technology can link different resource elements within and across learning contexts. Technology nowadays has to support collaboration, co-construction of knowledge, cooperative problem-solving, and distributed cognition (distributed between people and external artefacts or tools). This stretches human imagination in addition to testing the limits of existing tools.

If knowledge acquisition is becoming progressively less important, and ways of creating and synthesizing knowledge are seen as the way forward in education, technology will also need to evolve to support these developments. At Harvard Business School, Gardner (2007) has argued that the 21st century will belong to people who can think in certain ways, and to this end he identified five types of 'mind' that should be cultivated: the disciplined mind; the synthesizing mind; the creating mind; the respectful mind; and the ethical mind. This still assumes mastery of a discipline, that is, a particular profession, vocation or craft, but the selected ways of thinking are partly a reflection of how technology is forcing us to adapt. Disparate pieces of information must be synthesized, new questions must be asked, a respect for other cultures must be shown, and social conscience must drive our thinking on both a local and a global scale.

In a similar vein, Morgan (2007, p. 10) argues that in our changing world, the new economy needs "people who are innovative, flexible, creative, and who have high levels of emotional and social intelligence;" he cites the UK's New Curriculum initiative (2007) which posits that an information-driven curriculum is unlikely to equip young people adequately for adult life in the new century. The New Curriculum proposes five categories of competences that should be developed in young people--competences for learning, citizenship, relating to people, managing situations (time, change, emotions, etc.), and managing information. Although addressing different groups--adults and school students--there is a great deal of overlap between these attempts to map out the thinking and skills required in today's world and for the future. There is also a sense that education is in a state of flux, asking fundamental questions about its own aims and methods. The ways in which new technology is used in teaching and learning both reflects and drives forward these developments.

THE HUMAN BEING AT THE CENTRE OF INNOVATION AND CHANGE

If both technology and education are changing fast, it is not surprising if an individual caught up in these changes will find it hard to make sense of what is happening and what it might mean. It is useful to focus on some of the opportunities and challenges that present themselves to today's learners and how they relate to mobile technologies and their usability.

Mobility

Against a landscape of continual change we can discern some emerging patterns, such as greater learner mobility. This encompasses the sense of being able to spend time studying in another country, as well as the day-to-day mobility associated with new forms of work and evolving lifestyles that may sometimes merge with work. The daily mobility aspects may rely on mobile devices and services, and could be well-supported by them if issues of usability did not get in the way. In his guidelines for designers of handheld devices, Weiss (2002, p. 66) advises:

Whether in the back of a taxi or walking down the street, people are likely to need their handhelds to perform in distracting situations. ...designs must include context and forgiveness. .... Wireless users may be using their leisure time to gather information, but they typically have immediate goals.

Designing for mobile users should therefore begin with some exploration of how their mobility and the changing contexts they find themselves in impact on their thinking and their learning. A daily commute to work on the bus or by car might possibly present an opportunity to engage in mobile learning (Corbeil & Valdes-Corbeil, 2007), but it will probably be different from what can be done throughout the day, on a long train journey or on a plane.

New Thinking

A personal challenge for users of mobile devices is to get to know their device with a view to perhaps channelling their thinking through this device, in response to suggestions that what really matters is the ability to be flexible, innovate, create, synthesize, and develop one's social, ethical, and emotional intelligence. Could it be that mobile devices will help to focus attention on these valued ways of thinking, both on the part of their users and their designers? Knight (2006, p. 203) suggests that the ultimate goal of human-computer interaction (HCI) should be "to promote the benefit of well-being through a value-centred design approach" based on key ethical goals--autonomy, benefiance, non-malefiance, fidelity, and justice. This is in contrast with the functional and 'suprafunctional' (emotion and pleasure) goals of current interface design.

Any new technology can prompt users to question whether it is really helping them to learn and to think, but in reality people may not take the time to reflect on their experience, or even know how to do that. The New Curriculum mentioned earlier, draws attention on the ability to understand how to learn, take account of one's preferred learning style, and to learn to think. This assumes not only guidance on how to do these things but a great deal of personal reflection on progress. Perhaps the next step in the development of mobile applications should be tools that specifically support the development of some of the skills and competences that are being promoted by educationalists. With regard to competences in managing situations and managing information, relevant applications already exist but even those come from a different era and may need to be redesigned for the future.

Informal Learning

An important realisation is that mobile devices are proving themselves to be well suited to support informal learning. Scanlon et al. (2005) have been exploring what possibilities exist for science learners in informal settings, and in projects across many subject domains it is not unusual now to find a stated aim of developing systems or materials for informal learning. Fallahkhair et al. (2005) have developed a system to support informal mobile language learning, while Bradley et al. (2005) report on the development of materials for a mobile local history tour. In other situations, mobile devices are used more spontaneously for informal learning, using the device features and software that are available for general use. Some progress is also being made in understanding innovative practice at the level of the individual empowered by a personal mobile device and social networks that may amplify or modify its use (Kukulska-Hulme & Pettit, 2006; Pettit & Kukulska-Hulme, 2007).

In his book on informal learning, Cross (2007) claims that this type of learning deserves much more attention within organisations, as it can be credited with fuelling innovation and agility. Comparing most formal and informal types of learning across several dimensions including intentionality, timing, location, and so on, he concludes that most informal learning is incidental, unstructured, with unstated outcomes and fuzzy content. It can take place whenever needed and in any location. Although Cross does not say so, the alignment of mobile devices with informal learning is clearly an aim that needs to continue to be explored. To this end, learners themselves have to become more aware of when and how they learn informally, and whether their mobile device can assist them in this process.

KEY CONCEPTS FOR CONVERSATIONS

It has never been easy to communicate about human issues in relation to technology use – technical language typically presents a barrier that non-technical users find hard to overcome (Kukulska-Hulme, 1999). Even today, when familiarity with technology is often assumed, a set of concepts is needed to feed the conversations that educators and learners need to have with each other and with mobile system developers, IT support staff, and others who are immersed in the latest technologies and use them every day. A better understanding of user experience can emerge from these conversations and inform further developments.

In Kukulska-Hulme (2006), factors impacting on the usability of mobile devices in education have been mapped out, on the basis of a review of usability issues that emerged from across a range of mobile learning projects (Figure 1). This mapping can be extended to a set of questions that can be discussed. The key issues relate to six main aspects of mobile learning--the device being used, networks or connectivity, the user, other people, tasks engaged in, and the locations where learning happens. In conversations about desktop systems, the focus would typically be on the personal computer and the user, but in mobile learning there is a far greater need to discuss:

- **Locations of use**: are they suitable for the type of learning envisaged, will quiet or privacy be available if required, will there be continuity of use across different locations, can location-based context be incorporated into the learning experience?

The questions that might be raised around the other five key aspects will also be different to previous conversations around older technolo-

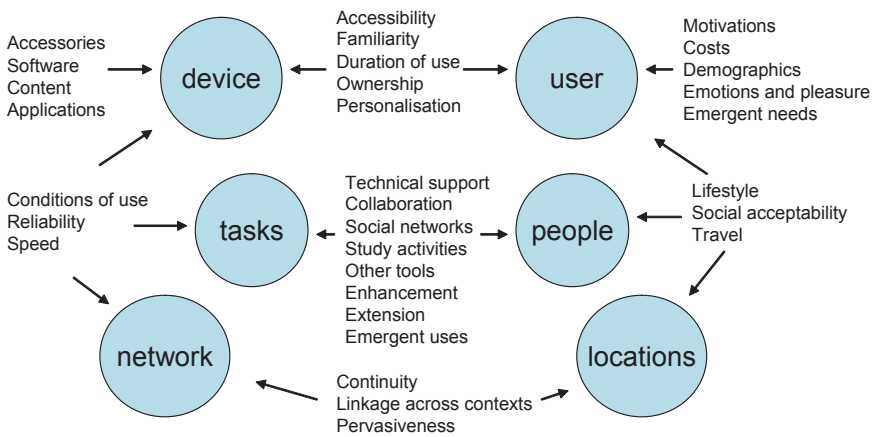
gies. Here are some suggestions for what should be discussed:

- **The user**: How self-motivated is the learner, how familiar with all features of the device, what reward will come from mobile learning, can the device be adapted and personalised to suit specific needs, will it fit with lifestyle?
- **Other people**: Who can support the learner on the go, what spontaneous or pre-planned collaboration can take place, what communities can the learner be part of, what do others interacting with the mobile learner need?
- **Tasks engaged in**: Will there be tasks set by instructors or learner-generated tasks, will speed of network access impact on the task, is the task confined to the mobile device or does it connect with other environments and tools, do interruptions matter?
- **The device being used**: What input devices and other accessories are available, how long will the learner keep the device, is there compatibility or conflict with other tools being used?
- **Networks that might be used**: Are the wireless networks reliable, can learners manage to get connected, are they dependent on connectivity, what are the costs involved?

In addition, there is a cluster of questions to be asked about the less predictable and longer term requirements and outcomes of mobile learning, which can connect with any of the six aspects already mentioned:

- How are planned learning activities enhancing or extending current learning or current practices?
- What new habits and competences are learners expected to develop?
- What new kinds of social networks is mobile learning helping to develop?
- How are uses of a mobile device evolving over time?

Figure 1. Factors impacting on the usability of mobile devices in education (©2006, Agnes Kukulska-Hulme. Used with permission)



- How can unpredictable or emergent needs and uses be captured so that learners, educators, and system designers can learn from this experience?

CONCLUSION

The present chapter is a contribution to the development of a human-centred perspective on the use of mobile technologies in education. We may be moving away from a world in which the use of any new technology was associated with going on formal training courses in to order to become proficient in its use, towards a world where more informal learning will happen among colleagues and friends, often in connection with travel and other forms of everyday mobility. This informal learning needs to be better understood, and its connections with formal learning need to be worked out. Mobile devices can play a role in developing that understanding as well as supporting both formal and informal learning as and when it takes place.

Technology-led developments are a fact of life even in education, but it is important to insist that human factors should be placed at the centre of innovation with mobile devices if their full potential is to be realised. A crucial aspect of this is encouraging and supporting jargon-free conversations around mobile learning, taking known usability issues as a starting point and extending them to take in the less predictable and evolving outcomes that are associated with mobile learning.

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KEY TERMS

Accessibility: A term interchangeably used with 'usability' or even 'availability,' but its core meaning is the extent to which a system can be used successfully and comfortably by users with disabilities or special needs.

Human-Computer Interaction: Within computer science and systems design, this area of concern involves the design, implementation and evaluation of interactive systems in the context of the user's task and work.

Informal Learning: Learning that is not organised and structured by an institution. It may take place in environments that already have some connections with learning, that is, museums and art galleries, or anywhere the learner chooses.

Mobile Learning: Learning with personal, portable devices; it enables learners to build knowledge and construct understandings in different contexts, and often changes how people learn and work.

Personal Digital Assistants (PDAs): Small, handheld computers, typically used for time management, simple applications and communication. PDA functionality is increasingly being integrated with mobile phones.

Pervasiveness: The aim of pervasive computing is to create a computing infrastructure that permeates the physical environment so that

computers are invisible, that is, chips are embedded in everyday objects.

Usability: A computer system's usability is based on measurements of users' experience with the system, but the focus tends to be specifically on the user interface.