A comparison between mobile and ubiquitous learning from the perspective of human–computer interaction

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Abstract: In this paper, the notions of mobile learning and ubiquitous learning are compared from the viewpoint of the nature of interaction between learners and computers. This comparison leads to better understanding of their potential and the differences between these notions.

Keywords: m-learning; mobile learning; u-learning; ubiquitous learning; p-learning; pervasive learning; eHCI; iHCI; ubiquitous computing.

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1 Introduction

The rapid development of wireless networks and mobile technologies has played a significant role in changing everyday lifestyles. Mobile technology and its services facilitate the way people communicate with each other and allow people to be linked together regardless of their physical locations. Hand-held devices currently available can be used to access and manage many kinds of data, ranging from text to heavy streams of multimedia. The increasing popularity of these devices has encouraged learning using mobile technology, widely known as mobile learning or m-learning. It has also encouraged the implementation of ubiquitous computing in education, for example, to provide context-aware educational applications. These are widely referred to as ubiquitous learning (u-learning) or pervasive learning (p-learning).

There are increasing numbers of individuals who have mobile devices that they carry with them almost continually. Consequently, it is estimated that there are over five billion mobile subscriptions around the world (BBC, 2010; ITU, 2010). This extraordinary growth in the number of mobile users has been vital in creating a growing interest in how these useful technologies can be used to enhance and expand learning.

Currently, mobile devices are being widely used in education as an instruction tool for learning. Many researchers have proposed different ways of using mobiles in education. For instance, wireless access to online resources allows the student to obtain information from the internet using their mobile. Also, it has been used to increase the interactivity of the ordinary classroom, to increase the level of thinking of the student by using educational games and to obtain situational information such as what can be noticed in fieldwork studies. Furthermore, mobile and pervasive technologies have been used to serve many purposes such as language learning, music education, student reminders and personal timetabling, work-based training and lifelong learning. All of these approaches are based on a different kind of technology of mobile handheld devices.

M-learning and u-learning are two different ways of utilising various technologies to expand the delivery of learning materials. In many current educational applications, both m-learning and u-learning environments make use of mobile devices for many purposes, such as a medium to present knowledge to learners. Both of them use similar technologies but may use them in different ways. Comparing m-learning with u-learning from the perspective of mobility or availability of learning materials is complex, and may lead to misconceptions and misunderstandings of their original ideas. There has been little research to determine the difference between m-learning and u-learning as to comparing how the learners interact with mobile devices in both environments. To this end, the contribution of this paper is as follows.

Presenting a comparison between m-learning and u-learning through considering the nature of interactions between learners and mobile devices to determine the difference between both environments and clarifying how the learners interact with mobile devices in both environments.

This comparison will provide a detailed picture of the potential and the characteristics of these learning approaches. Section 2 briefly clarifies the concept of ubiquitous computing, explains the difference between context and situation as used in ubiquitous computing describes the typical behaviour of context-aware systems and details the basic characteristics of ubiquitous computing applications. Section 3 highlights the differences between explicit Human–Computer Interaction (eHCI) and implicit Human–Computer Interaction (iHCI) and addresses the suitability of iHCI for ubiquitous computing. Sections 4 and 5 review some of the mobile learning and ubiquitous learning definitions. Section 6 discusses further differences between m-learning and u-learning. Section 7 highlights the perspective from HCI. Section 8 concludes the paper.

2 The concept of ubiquitous computing

The concept of ubiquitous computing was originated by Weiser (1991), who said that: “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it”. He clearly describes ubiquitous computing as a phenomenon that takes into account the natural human environment and allows the computer itself to fade into the background. Moreover, his vision refers to the collaborative or collective use of computer devices that might be embedded in a specific predetermined physical environment, thereby allowing users to interact invisibly with them.

The main aim of this idea is to create an environment in which the connectivity of devices is embedded in such a way that the connectivity is unobtrusive and always available. His vision involves introducing computers into people's lives, that is, putting computers into a daily living environment and instead of representing the everyday living environment in the computer (Loke, 2006).

When computing becomes ubiquitous, applied to learning, learners may acquire computational learning aid ubiquitously and depending on the actual situation of the learner, i.e. the learner does not then need to suffer a cognitive load (even if small) to switch between a task at hand and the need to learn something about the task itself; for example, consider assembling IKEA furniture – one switches between reading the instructions on one hand, and then actually performing the task of assembling the furniture on the other, and has the cognitive load of the switch as well as matching furniture parts with the diagrams in the instruction leaflet. But with ubiquitous computing, if computation is embedded in the furniture parts, each furniture part with a simple display, instructions can be on the furniture parts themselves (e.g. when two parts to be joined are matched, both parts light up at the same time, etc.), and similarly, with a task of using a new tool. Here the direct interaction between learners and computers is intelligence-augmented and situated, and helps learners to focus more on the task rather than on how the task is performed.

2.1 Context and situation

Understanding the context of entities involved in an applied ubiquitous application is an important component of ubiquitous computing (Satyanarayanan, 2001). The concept of context can be considered differently based on many factors such as the circumstance and the intended objectives of designed application. The consideration of what can be regarded as context varies from one application to another. However, the most useful definition of context was defined by Dey (2001), who stated "Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves".

Considering the context in this way could play an important role in increasing the intelligence of the interaction between computers and humans, which helps users to focus more on performing the intended task to a higher level. Each context-aware application is pre-programmed to collect only the contextual information needed, using sensing technologies (e.g. GPS, sensors and RFID) to determine the situation applicable to the current entity.

A definition of the situation is: "a combination of all the things that are happening and all the conditions that exist at a particular time in a particular place" (Longman Dictionary). Dey (2001) defines the situation as "a description of the states of relevant entities". Therefore, the relationship between context and situation in the ubiquitous environment relates to the group of contextual information affecting the intended entity that leads to an understanding of the situation. Referring to Loke (2004), a situation is also something that an agent (e.g. a human being) is able to 'carve' out in the mind, to identify as some aspect of the world that is relevant to a task or application at hand.

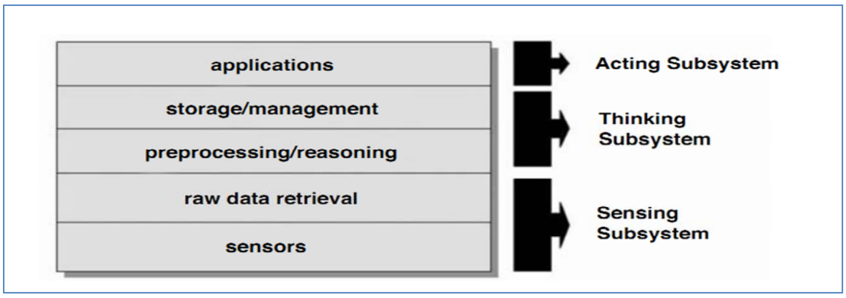
2.2 Behaviour of context-aware systems

The concept of the context-aware system was shaped by Weiser (1991) when he described a context-aware as a system which "adapts its behaviour in significant ways". It was first introduced by Schilit and Theimer (1994) as software that "adapts according to its location of use, the collection of nearby people and objects, as well as changes to those objects over time". A context-aware system was defined as, "a system that can respond intelligently to contextual information about the physical world acquired via sensors and information about the computational environment" (Loke, 2006). Dey (2001) states that "a system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Thus, the context-aware system considers; who is, where is, when is and what is, so as to interact intelligently with different entities such as users and the environment.

To gain a better understanding of this kind of systems, it is important to understand the nature of the abstract layered architecture of a context-aware system. This paper only highlights simple or general, abstract architecture, as it is not the primary purpose to discuss the different forms of abstract layered architecture. As mentioned previously, a context-aware system must understand the current context of the entities involved in a specific place to provide users with intelligent, seamless and unobtrusive interaction with computers. Many general abstracts are provided in the literature, however an abstract layered architecture from Baldauf and Dustdar (2004) is considered here as it is very simplified.

Figure 1 show that this abstract is divided into three main layers namely, sensing, acting and thinking; with each layer including a sub-layer to handle the computational tasks required.

Figure 1 Abstract layered architecture of a context-aware system (see online version for colours)



Source: Baldauf and Dustdar (2004)

These abstract layers work collaboratively with each other to perform pre-programmed tasks. Each layer consists of sub-layers to perform its assigned tasks. For example, the sensing layer is basically responsible for collecting and sensing contextual information about the current entities involved in the context-aware system (e.g. user, environment, etc.), and different kinds of sensors, wireless networks and raw data retrieval can be used. In the thinking layer, the information that has been gathered will be processed or stored based on the application's needs.

Finally, in the acting layer, the available information passed from the thinking layer, will be used to fulfil the requirements of the entities involved, based on certain defined preconditions or to perform the pre-programmed task (Loke, 2006).

In relation to m-learning and u-learning, while m-learning focuses on the mobile device and has the above layers refer more to the context of the mobile device/user surrounding the user (holding the device), the above structure in a u-learning environment would be more general, and could relate to the context of the user or users (even instructor and student(s)), the context of tasks, and reasoning is not only on the mobile device but involves potentially in a u-learning environment, reasoning not only on the mobile but on other supporting devices in the infrastructure, and acting is not confined to what happens on the mobile device but also can relate to what happens with other devices in the environment.

2.3 Characteristics of ubiquitous computing applications

There are many characteristics that distinguish ubiquitous systems from other computer systems, such as distributed ICT systems. The main characteristics of ubiquitous systems are as follows: firstly, they are situated in human-centred personalised environments, and interact unobtrusively with humans; and secondly, ubiquitous computing systems are part or embedded in specific predetermined physical environments, and thus sense more contextual information about the physical environment and the involved entities in ubiquitous system. Sensing makes ubiquitous systems more aware of involved entities, this awareness allows them to adapt to them and are able to act on them and control them (Poslad, 2009).

In the spirit of Weiser, the idea is that computing is carried out in a way that is situated with the user, not necessarily relating to any device on the (mobile) user; for example, the user when entering a lecture room may not carry any mobile device, but may interact with all the devices (the computer, the lights, the display projector, etc.) first by identifying him/her-self to the devices via biometrics, and then operating the devices via hand gestures and body movements recognised by the system.

3 Implicit versus explicit human–computer interaction

In the field of education, the nature of interaction between the learner and the computer devices must be carefully considered as this is essential to ensure the interaction is effective. A suitable and usable design for educational software is important to help learners effectively interact with devices to achieve the intended learning objectives of the implemented applications.

There are many design considerations for mobile learning applications. However, the aim of this section is to introduce the difference between explicit Human–Computer Interaction (eHCI) and implicit Human–Computer Interaction (iHCI). Understanding these ways of interaction is important as, it plays a role in reaching a point where the difference between m-learning and p-learning is fully realised and understood.

3.1 eHCI

Explicit Human–Computer Interaction is the ordinary kind of Human–Computer Interaction (HCI), this method of explicit interaction involves a high level of human intervention. Poslad (2009) states that: "Explicit HCI puts the user at the centre of the interactive systems, so that the control of the system, responds to and is driven externally by the user, rather than the system being driven internally".

In this mode interaction, the operation of the computer system is influenced by users' entries and activities. Users explicitly communicate with computers in different ways, based on a specific level of abstraction (command line, direct interaction using GUI, speech input and gestures, etc.). This conveys to the computer their expectations and needs. In this case, the computer has to be provided with more detail by the users in order to operate effectively.

3.2 iHCI

This type of interaction is much more intelligent than the eHCI as it does not expect users to provide it explicitly with the specialised entries to operate. It is dissimilar to traditional human–computer interaction; it is a new way of interacting that allows the computer to come closer to being able to interact naturally with humans, as people do between themselves.

The iHCI is defined as "an action, performed by the user that is not primarily aimed to interact with a computerised system but which such a system understands as input" (Schmidt, 2000). Further details about this concept are that it is "the interaction of a human with the environment and with artifacts which is aimed at accomplishing a goal. Within this process the system acquires implicit input from the user and may present implicit output to the user" (Schmidt, 2005). Accordingly, the "implicit input are actions and behaviour of humans, which are done to achieve a goal and are not primarily regarded as interaction with a computer, but captured, recognised and interpret by a computer system as input". He continues, defining the implicit output as the "output of a computer that is not directly related to an explicit input and which is seamlessly integrated with the environment and the task of the user" (Schmidt, 2005).

The iHCI makes use of many sensing technologies to determine the current context of the monitored environment, objects or entities, this sensed contextual information is considered as an implicit input to facilitate and support the implementation of such intelligent interaction. There are many examples of iHCI, one of them is an automatic light control (when the sensors do not detect any movement in the a room, the light is switched off) and another example is the intelligent ID card which is swiped in a card-reader machine to obtain access to a specific place, instead of entering a code as is the case with ordinary HCI systems.

3.3 HCI and ubiquitous computing

A ubiquitous computing environment consists of a group of devices interacting collaboratively with each other. Their interaction is hidden in such a way that it makes the user and the task the central focus. This interaction involves different kinds of information derived from different sources (e.g. users, environments, sensors, etc.). This exchanged information should be collected, shared, analysed, and interpreted, to achieve the goal of seamless and unobtrusive connectivity within the ubiquitous or pervasive environment.

In this environment, the eHCI is very complex and might not be a practical or efficient method of interaction that fulfils the requirement of achieving the goal of ubiquitous computing. Furthermore, in this environment, tasks are part of activities, which require many services offered by many devices that can be used simultaneously by many people to perform similar activities. In this heterogeneous and dynamic environment, users will be overwhelmed by the eHCI activity as more required services need more computer devices, which require more explicit input from individuals (Poslad, 2009).

Note that ubiquitous computing not only deals with implicit inputs, but most implicit interactions are used to enhance and facilitate explicit interactions (Schmidt, 2000). Thus, implicit inputs need to be collected using sensing technologies to reach the goal of the original ideas of ubiquitous computing (Weiser, 1991).

4 Definitions of mobile learning

Research reveals several different definitions for the basic concept of mobile learning. However, an agreed upon definition has not yet been achieved. The reason behind this could be the individual approaches of various experts and researchers in the way that they understand and perceive the mobile learning concept. It is an interdisciplinary area of research, meaning that different researchers from different backgrounds are working on this area of research due to the nature of the mobile learning research field. For instance, educators focus on learning aspects of m-learning, in particular how this technology may enhance learning theoretically from their educational perspective.

One of the most important factor that might play a role in providing further aspects of the definition is the confusing word 'mobile' (Yau and Joy, 2011). This word is associated with devices that can be carried or easily 'mobilised' and can also, be used to describe a learner who moves from one physical place to another. Indeed, the variety of definitions for mobile learning is influential in expanding the research opportunities. Some of these definitions are based on the physical mobility of individuals, with the focus being upon learners. Other definitions focus on the different technologies that are capable of delivering learning materials. For example, m-learning defined from a technological perspective as: "learning that takes place via wireless devices such as mobile phones, Personal Digital Assistants (PDAs), or laptop computers" (Dochev and Hristov, 2006).

The broader definition of m-learning, "any sort of learning that happens when the learner is not at a fixed, pre-determined location learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies" (O'Malley et al., 2003).

5 Definitions of ubiquitous learning

U-learning is defined in diverse ways by different people. This creates obstacles in understanding that a researcher could find confusing when seeking to define u-learning. For instance, whilst some do differentiate between the two terms, ubiquitous and pervasive computing, they can also be used interchangeably to refer to this new trend in computing (Ark and Selker, 1999). Also, pervasive computing can be understood as another term for ubiquitous computing (Loke, 2006).

Some define u-learning as not equal to learning with u-computing, but they regard u-computing technology as a special case of mobile learning (Hwang et al., 2008). In the opinion of some researchers, u-learning is considered to be an extension of m-learning. Also, pervasive learning has been defined as: “the latest trend in harnessing the technology to support learning. In this form of learning, the mediator is a pervasive computing environment (also known as situated computing, ubiquitous computing, embedded computing, ambient intelligence, or everywhere) which consists of interconnected, embedded computing devices such as portable computers, wireless sensors, auxiliary input/output devices and servers” (Laine and Joy, 2009).

It is noteworthy, in this definition by Laine and Joy (2009), that pervasive learning is treated as ubiquitous learning. Another definition that seeks to avoid the “learning anytime anywhere” label is that: “u-learning is a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way” (Yahya et al., 2010).

6 Discussion

In these above mentioned definitions, still the nature of u-learning might not be clarified in such a way that the researchers can differentiate between it and m-learning. The differences seems to be a matter of emphasis, whether one emphasises on mobility of user and/or device used in learning as m-learning or emphasising that learning can happen anywhere, in a situated way, and using a range of devices (including mobiles and/or devices in the environment).We also make the following observations.

- While m-learning focuses on mobile technologies and mobile devices (e.g. smartphones) to support learning, u-learning can happen without the use of mobile devices (e.g. in the IKEA furniture example earlier).
- U-learning can happen with new types of devices; consider the Sifteo cubes (see https://www.sifteo.com/), which mixes play with learning, with specially designed devices.
- U-learning can often involve a collection of different types of devices (one of them may be the user’s smartphone), working in close relationship with one another; e.g. in learning how to cook including choosing the right ingredients for a dish, a computer stationary in the kitchen may be used when the user is there to prompt the user about recipes and cooking instructions the user’s smartphone may be used to provide advice when the user is shopping for the right ingredients for a dish, and other computers may be embedded in the kitchen that simplifies tasks for the user (e.g. the oven downloads the right timings for a given recipe). In this case, the actual devices become less of a focus for the end-user, but appropriate learning environment is constructed out of the ecology of devices surrounding the user (where some of the devices might simple be everyday objects, embedded with networking, sensing and computational capabilities) (Langheinrich et al., 2000).

- U-learning may involve a collection of users, e.g. a platform for learning involving collaboration and collective artefact (virtual or physical) construction over time, in a community partnership setting; for example, in architecture, involving a collaborative project, multiple group members might be involved in the different stages, from design to model building, with appropriate computational aid.
- U-learning could involve more than just using the mobile device to deliver content once-off or even to make content accessible, but involves the continual maintenance of a relationship between learner and instructor (human or system) mediated by a plethora of devices acting in appropriate situations, collectively to support learning.

As mentioned earlier, a ubiquitous environment is heterogeneous, and consists of many computer devices that perform many tasks. In this environment, students may not need to carry mobile devices in order to learn. However, as far as learning is concerned, there are many successful approaches towards practically utilising ubiquitous technologies to support u-learning; for example, using mobile devices for many purposes, such as presentation tools, or a reader to read RFID tags. For instance, RFID-based system designed in order to detect the learning behaviours of students provide learning guidance in the real world for the science topic and provide personalised learning guidance in the authentic learning environment. In this system, students interact with groups of tagged plants in the predefined learning environment; the tags can be read by the RFID readers integrated in their PDA; in this predefined learning environment students are guided to the intended group of plants that they should learn about. Then after the interacting with them, the students will be given a group of questions to test their understanding (Hui-Chun and Gwo-Jen, 2010).

A survey conducted by Laine and Joy (2009) has shown that most of pervasive learning environments they evaluated used mobile devices for many purposes such as presentation tool. To clarify the difference between mobile and ubiquitous learning environments, this paper assumes that mobile devices are used in both environments.

Some of the papers describe u-learning use some terms that could be applicable for m-learning as well. It could be said – therefore, that, m-learning and u-learning are two different ways of applying various technologies to enhance or expand the delivery of learning materials. Two main confusing points can be seen in the literature pertain to the definition of m-learning and u-learning. These points are: learning anytime anywhere, and some characteristics of u-learning overlapping with m-learning.

6.1 Learning any time anywhere

Much of the literature reviewed for the purposes of this research focuses solely on "anywhere and anytime learning" or the learning that cannot be constrained by physical boundaries when defining both m-learning and u-learning. For instance, O'Malley et al. (2003) describe m-learning as: "any sort of learning that happens when the learner is not at a fixed, pre-determined location learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies". In contrast, u-learning is defined as: "a new learning paradigm in which we learn about anything at anytime, anywhere utilising ubiquitous computing technology and infrastructure".

From the mobility point of view, both definitions are almost alike. As mentioned both of m-learning and u-learning can make use of mobile devices as the medium to present the knowledge to learners or as an interface between learners and learning materials.

When mobile devices are used, learning potentially could take place in any context as the learners go about their everyday activities. Such learning would not be separated from daily functions, such as conversation, reading, surfing the internet, or watching television. Furthermore, these daily functions themselves can serve as a valuable learning resource. Indeed, "learning needs emerge when a person strives to overcome a problem or breakdown in everyday activity" (Vavoula, 2004).

The description anytime anywhere could be applied to both, as they support the expansion of knowledge. For instance, in the m-learning paradigm, the use of mobile devices is essential for many purposes, such as, access to the internet, access to wireless networks, and interaction with others. Therefore, if learners have access to the internet via 3G or wireless networks, they are able to learn anytime anywhere.

6.2 The overlap between some characteristics of u-learning and m-learning

Many characteristics suggested for u-learning may also be suitable for m-learning. For instance, the major characteristics of u-learning found in the literature are: permanency, accessibility, immediacy, interactivity and situation of instructional activities (Yahya et al., 2010, Hwang et al., 2008)

For the purpose of clarifying this problem, the interactivity characteristic (where learner can interact with peers, teachers and experts, through synchronous or asynchronous communication channels) is only considered here (Hwang et al., 2008). In both environments, this form of interactivity could be achieved if we consider it from the mobility point of view, so the difference is not clear. However, if it is considered from the HCI point of view, the difference can be clearer.

In the m-learning environment, a learner usually needs to explicitly interact with a mobile device, meaning that they can manually interact with experts, teachers and peers. But in the u-learning environment, the interaction is more intelligent, as the system can identify the context of the learner which helps the system to automatically advise the learner to interact with certain experts or teachers based on their locations and their problems.

The ability to collect implicit inputs, such as the current location of the learner in the case of u-learning, helps in providing learners spontaneously with the adaptive learning materials that suit for example their current location, circumstances, learning styles and proficiency level.

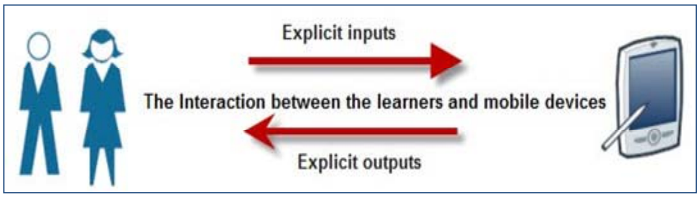
A characteristic that is more suitable for u-learning is the situation of instructional activities. To return to the main aim of ubiquitous computing, it can be found that technologies "weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991). The aim is to assist users in focusing more on performing a task rather than on how that task is performed. It is about a seamless and less obtrusive kind of interaction. To achieve this goal, the users' context should be understood and analysed to provide users with an intelligent kind of interaction (Poslad, 2009, Loke, 2006).

7 The HCI perspective

It is noticed; the ubiquity and portability of mobile devices increase their potential to be used in both m-learning and u-learning. So, it could be suggested that, another way to determine the difference between m-learning and u-learning is by comparing how learners interact with computers in both environments. To achieve this goal, the nature of interaction between learners and mobile devices is further considered.

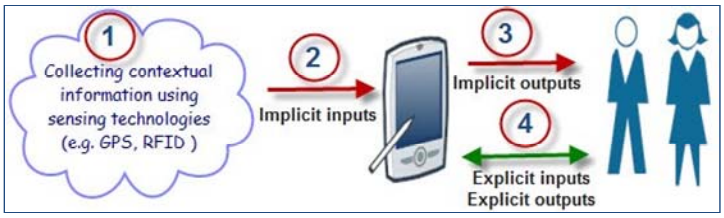
As mentioned, there are two types of interaction that occur between humans and computers, namely eHCI and iHCI. The interaction that best distinguishes m-learning applications is eHCI, as these require the learner to explicitly provide personal details (e.g. user name, password, etc.) to interact with them. For instance, Mengmeng et al. (2010) proposed a system for learning new vocabulary. This system expects the learners to send an empty mobile phone email that contains the required subject to request a test. Then learners will be provided with the tests that suit their profiles. This is one example for eHCI in m-learning environment. In many m-learning applications, it can be observed that the learner has to interact explicitly with the application to achieve the intended learning objectives (see Figure 2).

Figure 2 The iHCI interaction between the learners and mobile device in an m-learning environment (see online version for colours)



Typically, iHCI is the common way of interaction in u-learning applications. The application is able to automatically identify the learner and their current context, and then interact with them intelligently and help them to focus on performing specific tasks. For example, Ogata and Yano (2004) proposed a u-learning system that is built to enhance English vocabularies. The system first specifies the location of the user by 'sensing' his/her location to collect needed contextual information (implicit input). Based on these implicit inputs, the system automatically presents a suitable group of vocabularies that suit their current location (implicit output). After that, learners can interact explicitly with the given group of vocabularies to learn (Ogata and Yano, 2004). This interaction is eHCI, which will be continually enhanced by the iHCI (see Figure 3).

Figure 3 The iHCI/eHCI interactions between the learners and mobile (and other) device(s) in a u-learning environment (see online version for colours)



In line with idea of ubiquitous computing, u-learning aims to have the human–computer interface practically 'disappear' and become less intrusive, so that learning happens as aided, enabled, and enhanced by computers. For example, one can see the future of using brain-computer interfaces (e.g. http://www.emotiv.com/ is in this direction) for learning – such a device is wearable and so, in this sense, mobile, yet aims to obtain user inputs in new ways. In u-learning, the user may interact with computers, but may not, and perhaps should not, need to be distracted by or be conscious of, the computers she/he is interacting with – the user should not grapple with the learning technology but with the learning, aided by the technology.

8 Conclusion

In this paper, m-learning and u-learning are compared in general, and from the perspective of HCI. This comparison was undertaken as both these approaches of enhancing learning may make use of similar kinds of mobile devices. Using mobile devices in both environments may lead to misunderstandings when new researchers attempt to differentiate between these learning concepts. The difference between them can be understood by focusing on the required nature of interaction between learners and computer, and on the emphasis in applying technology and the types of computer technologies used: m-learning highlights the mobile computer as the centrepiece learning technology and the enormous possibilities mobile technology creates for learning, while u-learning, in the spirit of ubiquitous computing, does not highlight any device as the centrepiece learning technology; the computer(s) fade into the background, presumed to be embedded in the user's situation/context in a way unobtrusive, perhaps invisible, yet augmenting the learning process of the user (sometimes without the user even being consciously aware, or the user is aware of the technology, but the technology is subservient to the learning). Two methods of interaction were outlined, explicit HCI (eHCI) and implicit HCI (iHCI). In addition, understanding these methods of interaction is essential in preparation for future devices that can act and react automatically in support of learning processes without any human intervention, according to the situational context in which they are used.

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