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RESEARCH ARTICLE

Maintaining, changing and crossing contexts: an activity theoretic reinterpretation of mobile learning

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Although mobile learning is a popular topic in current research, it is not well conceptualized. Many researchers rely on under-theorized conceptions of the topic, and those who have tried to refine the ideas involved have found this to be complex and difficult. In this paper a new interpretation of the concept 'mobile learning' is offered, drawing on the tradition of activity theory. The interpretation focuses on the continuity of learning activities that take place in multiple contexts, which are embodied as the combination of the physical and social setting of the learning activities. The paper starts by sketching the current research context and then outlines the theoretical tradition within which the interpretation of 'mobile learning' is located. Then the new interpretation is offered and the concepts are applied to case studies to illustrate how this new understanding develops current thinking in the area. The paper concludes by discussing the implications for research of adopting such a perspective.

Keywords: mobile learning; context; activity theory

Introduction

Portable devices such as personal digital assistants (PDAs), mobile phones, laptops and tablet PCs have become increasingly integrated into many facets of our daily activities, including education. The number of mobile phone owners has risen in the last few years (e.g. 75% of the general population in the UK, 90% of young adults) (Crabtree et al. 2003) and the capabilities of these devices are increasing at a steady rate.

Portables are used in education to support students' learning inside and outside the classroom (Demb, Erickson, and Hawkins-Wilding 2004), lifelong learning (Sharples 2000) and location-based experiences (Price et al. 2003; Weal et al. 2003). Some educational institutes provide students and academics with portable technologies to be used for learning and teaching (Zelin and Baird 2002; Demb, Erickson, and Hawkins-Wilding 2004; McVay, Snyder, and Graetz 2005), as these devices are believed to offer portability, accessibility and convenience (Kukulska-Hulme, Evans, and Traxler 2005). In addition, as reported by Savill-Smith and Kent (2003) in their study on the use of palmtop computers, these devices are relatively inexpensive, provide access to information and promote the development of information literacy, collaborative learning and independent learning, all within the context of students' learning.

Many researchers in the field are interested in empirically studying mobile learning by exploring the possibilities and constraints introduced by mobile technologies for teaching and learning in different settings. For example, Waycott (2002) studied the possibilities and constraints introduced by PDAs that can change the activity of reading course material. She used activity theory to analyse PDAs as new tools for reading and to consider the context in which these devices are used. She conducted the study on a higher education online course, where students were given

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PDAs as a medium for reading course material. The study found that the portability of PDAs was the main benefit for students' reading course materials using these devices. The devices provided access to course material anytime and anywhere, thus changing the way students undertook reading. However, the limitations of PDAs, such as their small screen size and poor screen quality, limited their usability for reading activities. As a result, the devices did not replace the tools students usually used to support reading; instead they were used in conjunction with printed course materials and desktop computers.

Another example of mobile learning research is the educational game 'Savannah', developed by NESTA Futurelab and Hewlett-Packard Laboratories (Facer et al. 2004). 'Savannah' helps children to learn about lion behaviour by exploring a virtual savannah. The project aimed to 'explore how using mobile technologies in direct physical interaction with space and other players can be combined with principles of engagement and self-motivation to create a powerful and engaging learning experience' (Facer et al. 2004, 399). The game requires a group of six children to collaborate and play together, moving around the playing field, exploring the varied terrain of the savannah and discovering the resources that lions need to survive. The researchers found that the game successfully encouraged collaborative learning and the players reported enjoying the experience and learning about lions.

Despite the numbers of interesting studies, a well-conceptualized understanding of mobile learning has not emerged. Our aim is to clarify current misconceptions and to propose a definition of mobile learning that takes an activity theoretic approach and does not suffer from the objections one may raise against the definitions in current use.

Mobile learning

Different researchers have defined the term 'mobile learning' in a variety of ways. Some focused on the mobility of the devices and, hence, developed techno-centric definitions. In these definitions mobile learning is characterized as learning using mobile devices such as PDAs or mobile phones. For example, Kukulska-Hulme, Evans, and Traxler (2005, 1) defined wireless and mobile learning as 'learning delivered, enhanced or supported mainly or solely by wireless and mobile devices and their technologies'. However, the researchers admit that the definition is limited, as it places great emphasis on the technology and too little on learning. They called for a definition that focuses on the learning and the experiences of the learner. Lehner and Nösekabel (2002, 103) shared the same emphasis. They defined mobile education as 'any service or facility that supplies a learner with general electronic information and educational content that aids in the acquisition of knowledge regardless of location and time'. In addition, Sharma and Kitchens (2004) defined mobile learning as learning that is supported by mobile devices, ubiquitous communications technology and intelligent user interfaces.

However, we believe that these definitions focus more on the technology than learning itself. In addition, they ignore learning that is not mediated by the use of portable technologies or learning that is mediated by traditional devices such as handouts, even when, intuitively, this might be classified as mobile. O'Malley et al. (2003) shared this emphasis, as the researchers argued that mobile learning is any sort of learning that happens when the learner is not at a fixed, predetermined location. The definition discards the properties and type of device used to facilitate learning and focuses on the mobility of the learner rather than the mobility of the devices used. However, the researchers still argued that the employment of certain types of technology is what differentiates mobile learning from other types of learning; in spite of their theoretical position they retain their technical emphasis.

Other researchers defined mobile learning as an extension to e-learning. For example, Quinn (2000) defined mobile learning as 'elearning through mobile computational devices:

Palms, Windows CE machines, even your digital cell phone'. He described his vision of mobile learning as the intersection of mobile computing and e-learning where people have access to resources, search capabilities, rich interaction and support for effective learning and performance-based assessment. Quinn (2000) visualised mobile learning as 'elearning independent of location in time or space'. In addition, Traxler (2005) defined mobile learning as 'any educational provision where the sole or dominant technologies are hand-held or palmtop devices'. He argued that the definition 'merely puts mobile learning somewhere on e-learning's spectrum of portability'. Although these definitions look at e-learning provision, they remain techno-centric as they focus on the type of device used. For example, Traxler (2005) admitted that his definition is limited as it is 'rather techno-centric, not very stable and based around a set of devices'. In addition, these definitions are limited because they are based on the definition of e-learning, which itself is difficult to conceptualize. This hinders identifying the unique nature of mobile learning.

When these definitions, both techno-centric and those based on e-learning, are applied to real world examples many borderline cases where learning cannot be defined as mobile or static appear. This is because these definitions are based on the assumption that mobile learning occurs as a result of using portable technologies to aid learning in different physical locations. The definitions are focused on the technology rather than the learning practices that are mediated by the technology. They also discard all learning that is not mediated by the use of portable technologies. In addition, the definitions place overt emphasis on a change of physical location while discarding the social setting of learning activities. This point was addressed by Roschelle (2003), who illustrated the importance of understanding the social practices involved in using hand-held devices to facilitate learning. He reviewed a number of studies that explored the use of hand-held devices, such as classroom response systems and their application in classrooms. A classroom response system allows a teacher to pose a question (e.g. short answer or multiple choice) and collect and aggregate students' responses sent by individual hand-held response units. The review showed that using portable devices does not make learning mobile as the activity space of technology usage is the classroom space (Roschelle and Pea 2002). Portable technologies in the reviewed cases were used during the class to achieve certain objectives and some could not be used outside the classroom (e.g. classroom response systems). Roschelle (2003) argued that the case studies failed to establish a link between informatics and social practices as the researchers in the reviewed studies provided little insight into the social practices of hand-held use, presuming that the social practices surrounding education remain largely unchanged as the technology moves from desktops to hand-helds. He suggested that research attention should be directed towards 'understanding the social practices by which those new affordances become powerful educational interventions'.

Some researchers considered the emphasis of the social practices surrounding learning activities to develop their conception of mobile learning. These researchers' conceptualization of mobile learning also started as techno-centric definitions focusing on devices (Sharples, Corlett, and Westmancott 2002) and the potential for enabling lifelong learning (Sharples 2000). Soon, however, the focus became the learner, who is mobile, rather than the technology. For example, O'Malley et al. (2003) defined mobile learning as 'any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies'. In addition, Vavoula and Sharples (2002) considered learning to be mobile in three ways:

> in terms of space, i.e. it happens at the workplace, at home, and at places of leisure; it is mobile between different areas of life, i.e. it may relate to work demands, self-improvement, or leisure; and it is mobile with respect to time, i.e. it happens at different times during the day, on working days or on weekends.

These definitions diverted the focus from the technologies used to the mobility of the learner and the context of usage that extends learning to informal learning settings.

Sharples, Taylor, and Vavoula (2007) are developing a theory of mobile learning that addresses the relations between mobile technology and learning. They seek to encompass both learning supported by mobile devices and learning that is characterized by the mobility of people and knowledge. They argued that in order to create a theory of mobile learning, first, mobile learning should be distinguished from other forms of learning by showing that learners:

(1) learn across space as they take ideas and learning resources gained in one location and apply or develop them in another;
(2) learn across time by revisiting knowledge gained earlier in a different context which then provides lifelong learning;
(3) move from topic to topic by managing a range of personal learning projects instead of following a single curriculum;
(4) move in and out of engagement with technology.

Second, Sharples, Taylor, and Vavoula argued that a theory of mobile learning must embrace the considerable learning that occurs outside the classroom and lecture halls. Third, it must be based on contemporary accounts of practices that enable successful learning. Fourth, they suggest that the theory must take account of the ubiquitous use of personal and shared technology.

Based on this, Sharples, Taylor, and Vavoula (2007, 224) proposed a definition of mobile learning that focuses on the communicative interactions between the learner and the technology to advance learning in context that is shaped by continuously negotiated dialogue between people and technology. They defined mobile learning as 'the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies', which they described as a tentative definition. They based their definition on the conversational framework (Laurillard 1993), in which the conception of learning is based on the idea that communication, which is a feature of portable devices, is a central process in education as it helps people to negotiate their differences, understand each others' experiences and establish shared meaning. The definition is also based on activity theory, which is used to study mobile learning in relation to the context of learning activities. They conceptualized the context of learning as both the physical environment and the community (actors as both people and interactive technologies) that interact around shared objects.

As part of developing a theory of mobile learning Sharples, Taylor, and Vavoula introduced a framework for analysing mobile learning based on Engeström's (1987) expansive activity model. However, the framework was illustrated through a case study whose criteria were chosen from the data. Their illustration was descriptive rather than analytical, as they did not test their framework against other real world cases that do not match the framework exactly. The chosen case reflects on the four criteria proposed by the researchers as a basis for the theory of mobile learning discussed above. The case represents learning that occurs in an informal learning setting (a gallery) (second criterion) where visitors were supplied with the portable technologies (fourth criterion) to be used throughout their journey in the gallery. Portables were used to look for information about the paintings in the gallery and to communicate with each other (third criterion). The case represents mobile learning as learners used their devices to learn across space, time, move from topic to topic and move in and out of engagement with technology (first criterion).

We believe that the definition of mobile learning of Sharples, Taylor, and Vavoula represents a useful first step towards a better conceptualized definition of the term. The definition focuses on learning through conversations that take place across different contexts rather than locations, as in some of the previous definitions of the term. Critically, Sharples, Taylor, and Vavoula conceptualized context as the physical environment and the community that interacts around shared

objectives. This conceptualization helps with considering the community as being engaged in learning activities and the influence of these practices on learning. This gives a new perspective on mobile learning by considering factors other than location that influence it. However, Sharples, Taylor, and Vavoula's definition requires development. We believe that to understand mobile learning there needs to be a greater focus on learning practices that are directed towards the same objectives and take place across multiple contexts, instead of focusing on learners' communicative interactions with their peers and technology. This helps with identifying mobile learning and differentiating it from static learning.

By de-emphasising the focus on communicative interactions we promote a definition of mobile learning that can be conceptualized using activity theory alone and, therefore, we do not require the conversational framework. The conversational framework is mainly helpful when there is a need to understand how learners develop understanding of a specific matter through conversation with others or through 'conversation' with technology. This is not the case here, as we focus on learning as practice and not as the internal development process. As a result, activity theory is sufficient as an approach to defining mobile learning as it permits the study of learning practices, and is still able to account for communication between peers and technology by treating communication as an example of an activity, that are mediated by the use of tools in relation to the context of these activities. We believe that focusing on context helps with considering the setting of learning practices, comprising both the physical and social setting, which are believed to be essential in understanding learning practices (Roschelle 2003).

Given the limitations of the definitions of mobile learning, we believe that it is important to study mobile learning by focusing on learning activities that may be mediated by any kind of device (old or new) and the context of these activities, including both the social and physical settings. Therefore, using an activity theory perspective, we propose an initial definition of mobile learning as learning that occurs as a result of pursuing learning activities that are directed towards achieving some objective in multiple contexts (physical and social). This definition enables the study of real world cases to differentiate mobile and static learning. The theoretical framework outlined below draws on key concepts of activity theory that are of particular relevance in elaborating the definition. It provides a way of looking at learning activities and the continuity of these in multiple contexts. The concept of context is also illustrated below, as it represents a core concept of our conceptualization of mobile learning.

Activity theory

Activity theory was developed as an attempt to create a new form of psychology based on Marxist philosophy (Leont'ev 1978; Vygotsky 1978). Bannon (1997) and Kuutti (1996) demonstrated that activity theory is not actually a 'theory' in the strict interpretation of the term, as it is not 'a fixed body of accurately defined statements' (Kuutti 1996, 25). Rather, it consists of a set of principles that are open to interpretation and can be used as a foundation for more specific theories. The description presented here discusses the main concepts of activity theory that are helpful in conceptualizing mobile learning.

Activity theory is based on the idea that all human activities are mediated by the use of tools, both physical tools, such as technology, and conceptual tools, such as language, that are enabling and limiting. An activity system involves a subject whose actions are directed towards the achievement of some object through the use of tools. The object of the activity is to be understood as the 'purpose', rather than an artefact, and towards which the activity is directed. The existence of an activity is motivated by transforming objects to outcomes. Engeström (1987) expanded the activity system, shown in Figure 1, to include the social context of an activity represented in the community, rules and division of labour, shown in Figure 1. The community includes the people

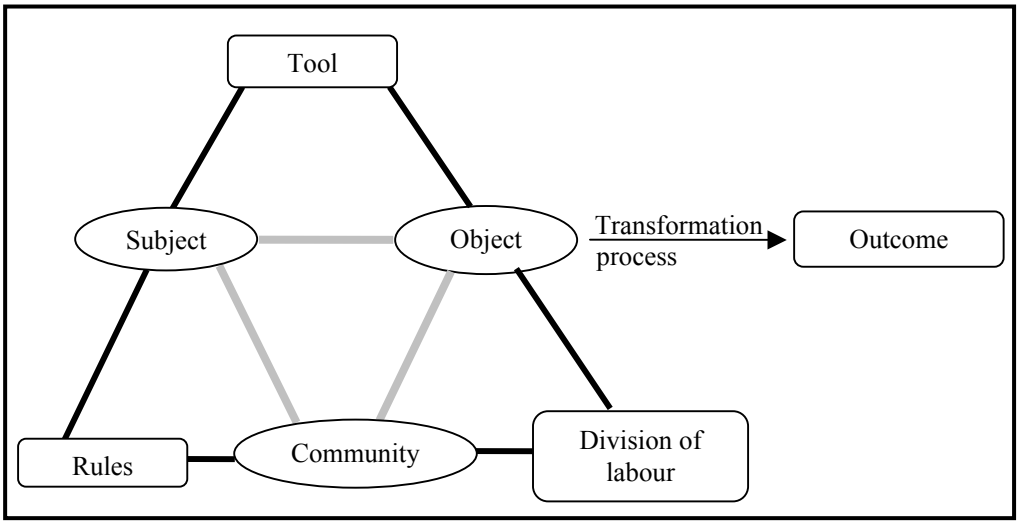

Figure 1. Engeström's expansion of activity theory.

that are involved in an activity and who share the same object. The rules cover both explicit and implicit norms, conventions and social relations within a community. The division of labour refers to the explicit and implicit organization of a community as related to the transformation process of the object into the outcome (Kuutti 1996).

Activity theory is used in research examining mobile learning (for example Sharples, Taylor, and Vavoula 2007) because it provides tools with which to study learners' activities that are mediated by the use of physical or conceptual tools. Therefore, from an activity theory perspective mobile learning should not be defined on the basis of the type of device used, as in some of the definitions of the term, as this type of learning can be mediated by any type of physical (old or new) or conceptual (symbolic or embodied) tool. Activity theory also provides an historical perspective on learning activities. This facilitates studying mobile learning by showing the continuity of learning activities that are directed towards the same objective in different contexts. Nardi (1996) argued that activities and their elements are in continuous development. In addition, the remains of previous activities are usually embedded in them as they develop, which requires historical analysis to understand the recent situation. Activity theory also places great emphasis on the relationship between context and human activities. Cole and Engeström (1991) suggested that in order to understand human activities it is crucial to understand how artefacts (such as tools and symbol systems) mediate the activity within the cultural context in which the activity is situated. In terms of studying mobile learning, studying context helps with understanding and considering the properties and constraints of the environment where learning takes place and the impact of the relations among individuals, artefacts and social groups within these learning activities.

Context

Understanding human activities requires understanding them within their context (Cole and Engström 1991). The concept of 'context' has been a source of endless confusion for Anglo-American psychologists. Over the last decade psychologists have come to distinguish between two general uses of the word. For example, Cole (1996) distinguished between context as 'that

which surrounds us' and context as 'that which weaves together'. In terms of the interactions between humans and technology these definitions map context as that which surrounds the human user of the technology and context as that which arises from the constructive interaction between people and technology.

The context that surrounds the human user of technology is roughly equivalent to the term 'environment' and refers to a set of circumstances with which the individual interacts and which influences individuals in various ways (Cole 2003). This is often represented as a set of concentric circles representing the different levels of context. For example, a student using technology is part of a lesson that is part of a classroom that is part of a university that is part of a community (Cole 1996). Understanding activities in relation to the environment where these take place helps with understanding how the task is shaped by the broader levels of context. In terms of the impact of context on learning activities, Sharples (2005) referred to the informational model of communication developed by Shannon-Weaver. The model states that the context that surrounds the human user of technology situates the learner in an environment from which the senses continually receive data that are interpreted as meaningful information and employed to construct understanding.

The context that arises from the constructive interaction between people and technology can be thought of as two moments in a single process that help in modifying objects to create supportive workspaces or forming ad hoc social networks of people with shared interests (Cole 1996). This definition of context is more focused on the social setting of the learning activities, which not only affects learning activities but is also affected by these activities. Vygotsky viewed context in this way, seeing humans as an embedded part of the social matrix so that their behaviour cannot be understood independently of this matrix (Cole 2003).

The complexity of understanding context has started to feature in research on the design of technology. For example, Dourish (2004) argued that 'context' plays a central role in ubiquitous computing where computing is embedded in the world around us. He suggested that as computation has moved 'off the desk' it is important to keep track of where it has gone, as the situations in which the technology is used became more variable and require further attention.

Dourish argued that since 'context' entered the area of computational design designers have hoped that incorporating context into interactive technologies can make these technologies more sensitive to the details of the specific setting of use. He relayed Suchman's (1987) critique that social scientists have often pointed out that conventional system designs fail to respond to the setting in which the action unfolds. These conventional systems may be more responsive to the different social settings in which they might be used, but they fail to address the sociological critique, which makes turning social observations into technical design problematic.

Dourish suggested that the notion of context in ubiquitous computing has a dual origin.

> On the one hand, it is a technical notion, one that offers system developers new ways to conceptualize human action and the relationship between that action and computational systems to support it. On the other hand, it is also a notion drawn from social science, drawing analytic attention to certain aspects of social settings. (Dourish 2004, 21)

To summarize, current conceptions of context in both social and technological research view it in terms of the features of the environment where learning takes place and the social setting of the learning activities. We believe that for the definition of mobile learning both conceptions of context should be considered, because this type of learning occurs as a result of pursuing learning activities across multiple locations. This helps in considering the factors that affect and are affected by the utilization of portable devices in multiple contexts, such as the impact of changes in the physical environment and the social setting within these environments on learning activities. Sharples, Taylor, and Vavoula (2007) also considered both conceptions for the definition of mobile learning. However, what differentiates our approach is the way in which we understand

the interplay between the physical and the social conceptions of context and the way social context is conceptualized through activity theory.

Mobile learning and context

Understanding learners' activities in relation to context is important in studying mobile learning as this type of learning occurs when learning activities are mediated by the use of tools (physical or conceptual) across different contexts. Therefore, we take context crossing as the basis for our conceptualization of mobile learning through activity theory. From an activity theory perspective we consider context as a mixture of the physical features and constraints of the location where learning activities take place and the social features of these activities, such as the social relations, norms and conventions and the division of labour within the learners' community.

Existing interpretations of activity theory for mobile learning

Activity theory has been used as a framework for studying mobile learning because it provides a framework for studying activities that are mediated by the use of tools and accounts for the context of these activities. For example, Sharples, Taylor, and Vavoula (2007) attempted to describe the activity system of mobile learning through the use of Engeström's (1987) expansion of activity theory by describing the relationship between people and technology. They used activity theory in combination with the conversational framework to indicate the importance of conversation and context in understanding mobile learning. Based on that, they developed a two layered version of Engeström's expansion of the activity system triangle. They argued that it is helpful to separate two layers of tool-mediated activities in order to analyse the activity of mobile learning. First, the semiotic layer describes learning as a semiotic system where learners' object-oriented actions are mediated by cultural tools and signs. The learner internalizes public language that is instantiated in writing and conversation, which then provides the resources for the control and development of activity (Vygotsky 1978). Second, the technological layer represents learning as an engagement with technology where tools, such as computers and mobile phones, are used as interactive agents in the process of coming to know. This layer creates a human–technology system to mediate agreements between learners (e.g. spreadsheets and concept maps) and aid recall and reflection (e.g. online discussion lists). The researchers suggest that these two layers should not be separated from each other nor be superimposed; they should be put in a continual dynamic where they can be moved together and apart, creating an engine that drives forward the analysis of mobile learning. Figure 2 shows Sharples, Taylor, and Vavoula framework for analysing mobile learning.

However, we believe that this framework is complicated because it introduces two layers to represent the semiotic and technological layers of an activity. We suggest that there is no need for these layers, because what concerns us when studying mobile learning is the learning activities that are mediated by the use of tools (physical or conceptual) in relation to the context of use (physical and social). Engeström's expansion of activity theory is sufficient for this as it has the ability to represent human activities (including the semiotic and technological elements of such systems) in relation to their context, eliminating the complexity introduced by the two layers proposed by Sharples, Taylor, and Vavoula's framework. Therefore, our conceptualization of mobile learning will be based on Engeström's expansion of activity theory as it provides a framework for studying learning activities that are mediated by any kind of tool (old or new, embodied or symbolic) and how these practices vary across physical location and considers the social context of learning activities through 'rules', 'community' and the 'division of labour'. This makes analysing the activity system of mobile learning simpler by focusing on the collective context embodied in the physical and social setting of learning activities.

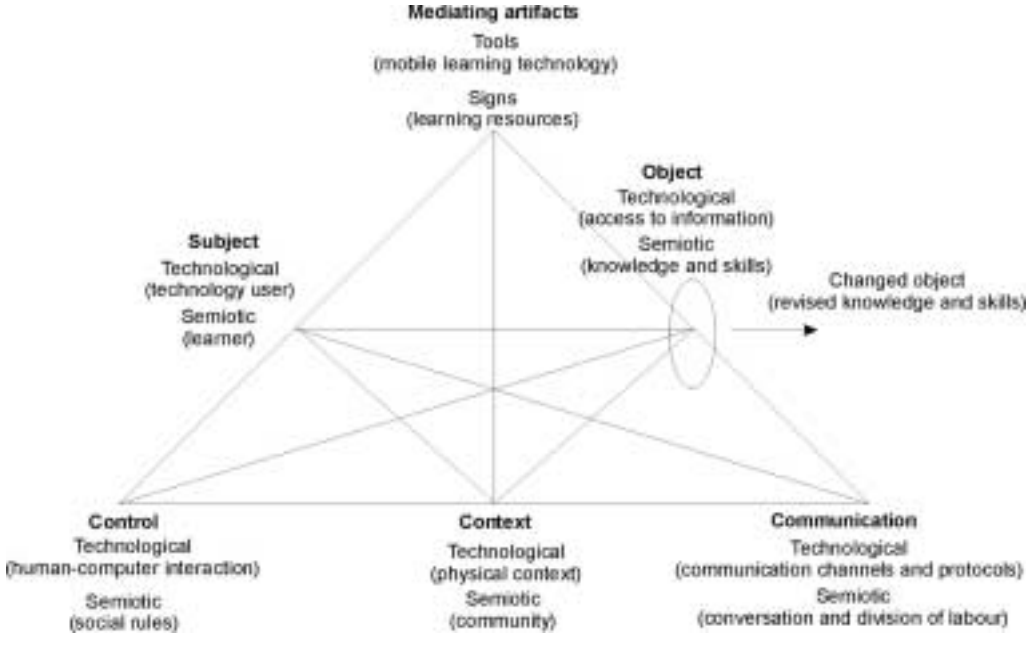

Figure 2. Framework for analysing mobile learning (adapted from Sharples et al. 2005).

Application

To illustrate our conception of mobile learning we draw upon our experience of an ongoing project in higher education which formed part of a Ph.D. research project investigating the concept of mobile learning. Three studies were conducted, focusing on how higher education students use both portable and conventional devices to aid their learning practices. The aim of the studies was to investigate the impact of utilizing portable technologies on students' learning practices. The data was mainly collected through observation of students in both formal and informal settings. Data was also gathered from log files collected from students' laptops, which showed the activities students pursued using them. Log files were particularly helpful in providing information about students' utilization of portables in settings where students could not be observed, such as at home. The observations and log files helped in looking at the continuity of students' learning in formal and informal settings.

The collected data were interrogated for cases that represent mobile (Table 1) and static (Table 2) learning based on the idea of context crossing discussed earlier. Context can be the physical features of the environment where learning takes place or the social setting of learning activities. We considered both conceptions through Engeström's expansion of activity theory. A change in the physical context was interpreted as a change in the location where learning activities took place, which also determined whether learning was mobile or static. A change in the social context was interpreted as a change in the rules and the division of labour that governed the students' community, which shares the same objective. Tables 1 and 2 provide some examples from our project data that use our two understandings of context to distinguish between mobile and static learning.

Tables 1 and 2 show that context crossing can be used as a basis for studying mobile learning and can differentiate it from static learning. Learning was considered to be mobile when a change

occurred in the physical location. In these cases learning activities directed towards the same objective were pursued in different physical locations over time. In addition, Tables 1 and 2 show that static learning occurred when the objective of a learning activity was achieved while the learner remained in the same location. Thus, using context as physical location helped with differentiating mobile and static learning. Tables 1 and 2 also show that in some cases of mobile and static learning changes occurred in the social context as a result of a change in the physical location or a change in the activity pursued. In these cases students' learning was more socially interesting than the cases where the social context was unchanged. Thus, using context as the social setting of learning activities helped in showing what is interesting about mobile learning.

Tables 1 and 2 show that using context crossing as a basis for defining mobile learning gives a different perspective on the term as it illustrates the relationship between context, both physical and social, and learning practices. The tables can represent both the technological layer as well as the semiotic layer proposed by Sharples, Taylor, and Vavoula without the need for complex overlapping activity systems or the conversational framework. However, the question remains, which of these cases represents 'real' mobile learning? Is it the case where context was represented as a change in both the physical and social contexts or any case where mobile learning was classified as a result of a change in the physical context alone? We believe that what is interesting for research is the cases where context crossing is represented as a change in both the physical and social contexts. This shows that there is more to mobile learning than pursuing learning activities across multiple physical locations.

Discussion

The current definitions of mobile learning are limited when used to analyse real world case studies. For example, some of these definitions are based on the assumption that learning is mediated by portable technologies which are used in different physical locations (location crossing). However, we have offered examples that show how learners not only use portable technologies (e.g. PDAs, laptops) to aid their learning activities, as conventionally studied in research, but also use conventional devices such as handouts and textbooks. This challenges the general understanding that traditional learning is static learning because learners use traditional devices to aid their learning, which usually takes place in the same classroom. Much traditional learning can be considered mobile because learners use conventional devices in the same manner as they use portable technologies to pursue learning activities across different contexts, such as at home or in a library. Therefore, definitions of mobile learning should cover conventional devices as well as any other technology. It should also consider learning that is mediated by conceptual tools as learners engage in different activities that aid their learning and may/may not use physical devices to aid that learning. For example, a student may use his laptop to view lecture slides in the classroom, review them at home and then practice what he has learnt in the laboratory in conducting an experiment. In this case, although the student is not using any type of device to aid his learning in the laboratory, he is undertaking an activity that aims at achieving the same objective, developing his understanding of a topic, as the activities pursued in the classroom and at home using a laptop. Therefore, learning in this case is considered mobile because the student pursued learning activities that are directed towards the same objective in different contexts, even if the student did not use a portable device to aid learning. Moreover, the definition of mobile learning should consider learning that continues to take place in the same location but over time, as in traditional education where lectures usually take place in the same classroom over the academic year. In these cases learning that is aimed at the same objective may continue in different contexts in between.

In addition, some uses of portable devices are effectively static, as the objective of the learning activity is achieved while the learner is in the same location. For example, if the calculator

Table 1. Examples of mobile learning.

Mobile learning	Context as physical location	Context as social setting
Case 1. The log files collected from a student's laptop showed that the student used her laptop to view lecture slides and take notes in the classroom, revise the slides, look for information on the web and write more notes on the slides at home, and then use the slides again to facilitate group discussion during a group meeting that took place the next day.	Students' learning in this case is considered mobile as the student continued using her laptop and working towards achieving the learning objective (develop her understanding of a topic) in different locations (classroom and home).	The social setting changes as a result of a change in the rules, division of labour and the community that the student belongs to. These changes in the social setting happen as a result of a change in the physical location and a development in the activity that the student is engaged in. **Rules:** *Classroom*: read from the lecture slides through the laptop and take notes *Home*: read through the lecture slides using the laptop, search the web for more information, and take more notes **Division of labour:** *Classroom*: students/instructor *Home*: Student **Community:** *Classroom*: Students and instructor *Home*: Student
Case 2. A student in a hospital placement uses the same handout to follow the instructor's discussion, take notes and practice diagnosing a patient in three different tutorial sessions that took place in three different tutorial rooms over three days.	The student's learning in this case is considered mobile as the student used his handout in three different tutorial rooms to achieve an objective (develop his understanding of a topic).	In this case the student used the printed material to achieve the same objective in three different physical locations. Thus the **rules** (read from the handout, listen to the instructor's illustration, take notes and practice on a patient) and the **division of labour** (students/instructor) of the students' **community** (students, instructor and a patient) did not change throughout the activity.

Table 2. Examples of static learning.

Static learning	Context as physical location	Context as social setting
Case 3. An instructor changes the way lectures are usually delivered which is based on illustration through slides and then asking students to write an essay posted on the VLE (virtual learning environment) at home in relation to the discussed topic and the instructor corrects that in her free time and posts students' grades online. The observed lecture was arranged to include all the above practices as the instructor started the lecture by illustrating a topic using some lecture slides downloaded from the VLE and then asked students to apply what they had learnt in the class by writing an essay about a topic that is posted on the VLE using their laptops. The instructor then corrected the essay for each student and gave them their grade during the lecture.	In this case the students' learning is considered static as students achieved the learning objective (develop their understanding of a topic) of the activity while they are still in the same location (classroom).	The social context of the lecture observed has changed in comparison to the previous lectures because of changes in the rules and the division of labour of the student's community. **Rules:** *Previous lectures*: view lecture slides and take notes using the laptop *Observed lecture*: view lecture slides, take notes using the laptop, write and essay using the laptop, and check the essay with the instructor **Division of labour:** *Previous lectures*: students/instructor *Observed lecture*: students/instructor **Community:** *Previous lectures*: students and instructor *Observed lecture*: students and instructor Changes in the social context occur as a result of the differences introduced to the format of the lecture. For example, the social context of the activity where the student is following the instructor's illustration and taking notes differs from that where the student is writing an essay in class. This difference can be seen in both the rules that apply and the division of labour. **Rules:** *During illustration*: view lecture slides and take notes *During essay writing*: read the essayquestion and write the essay using the laptop **Division of labour:** *During illustration*: students/instructor *During essay writing*: student

Table 2. *(Continued).*

Static learning	Context as physical location	Context as social setting
		Community: *During illustration*: students and instructor *During essay writing*: student
Case 4: A student uses his mobile phone while being in the library to capture a photo for an image in a book and transfer the photo to his laptop.	The student's learning is considered static as the student achieved the objective (capture a photo of an image in a book) of the activity while being in the same location (library).	The social context of the activity did not change as the **rules** (capture a photo and transfer it to the laptop) and **division of labour** (students) of the student's **community** (students) did not change throughout the activity.

Table 3. Illustration of context crossing as a basis for defining mobile and static learning.

	Context as social setting	
Context as physical environment	Conventional	Social setting changing
Location crossing	Mobile learning (e.g. lecture being moved to seminar room)	Socially interesting mobile learning (e.g. dispersed discussions during fieldwork)
Static	Static learning (e.g. lecture)	Socially interesting static learning (e.g. innovative lecturing [new teaching])

feature of a mobile phone is used in a lecture theatre to help solve mathematical problems usage of the device is static, as the learning objective is achieved while the learner remains in the same location. In such a case the learner maintains the context, with no crossing.

Defining mobile learning based on location crossing is not useful, as this puts too great an emphasis on the location where learning activities take place and ignores all other factors that affect these activities, such as the social setting. Therefore, we base our conception of mobile learning on the idea of context crossing. However, defining mobile learning based on context crossing has also not been helpful historically, as the definition of context itself is ambiguous. Cole (1996) and Dourish (2004) defined context as (a) what is constructed through the interactions between learners and technology or (b) what surrounds the human user of the technology. The conception of context in the first definition is misleading when used to define mobile learning because interactions between the learner and the technology can be constructed and changed even if the learner is physically static. This is also a problem for activity theory. From an activity theory perspective context changes as a result of a change in the social setting of the learner, represented as the community, rules and the division of labour in an activity system. This implies that all learning where the social setting changes is defined as mobile learning, even if the learner is physically static. For example, the community that the learner is part of changes when someone comes into the lecture room in which the learner is located, but, arguably, this is not something we would want to classify as mobile learning. Thus, the first definition of context is insufficient to support our definition of mobile learning. In the second definition context is represented as the location where the learner is and how the properties and constraints of that location affect learning activities. Context crossing here implies location crossing, as context changes for each location. Thus, the second definition of context is sufficient to define mobile learning based on the idea of context crossing, however, it discards the social context of the learning activities that help in studying what is interesting about mobile learning. For instance, if this conception is applied to Case 1, illustrated in Table 1, learning is defined as mobile because the learner pursued learning activities across locations. However, there will be no indication of the changes in the social context that occur as a result of using the technology, which, if represented, show what makes using portable devices for learning fun and socially interesting. Thus, what makes learning activities socially interesting is for the social context to develop in some way.

Neither concept of context crossing alone is a good basis for researching mobile learning. It is apparent that what actually interests us is the intersection of these definitions, where mobility happens as a result of location crossing and at the same time changes in the social context make mobile learning socially interesting. Based on that, we view context as the combination of the physical location, including the properties and the constraints of that setting, and the rules and the division of labour governing the learners' community. The activity system triangle in Figure 3

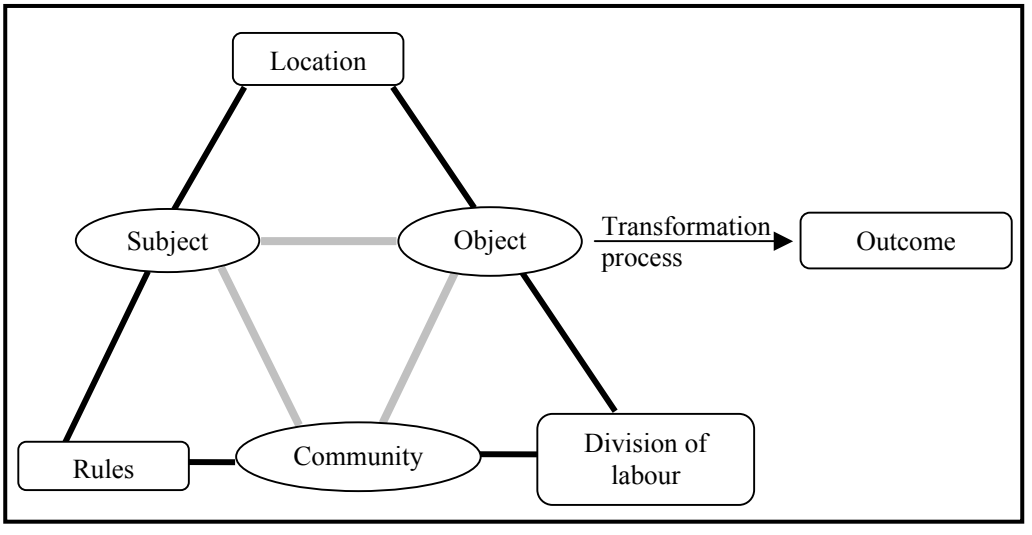

Figure 3. Framework for analysing mobile learning.

shows our representation of mobile learning based on the idea of context crossing, where location is represented in the activity system as the tool that enables mobile learning. Thus, mobility occurs when the subject and object are preserved but the location (conceived as a tool and including any available devices) is changed. In this reformulation the social context, which is presented in the rules, community and division of labour of the activity system, may or may not change. The situation becomes interesting socially when the bottom half of the activity theory triangle also changes. In contrast, Sharples, Taylor, and Vavoula representation of context in the activity system of mobile learning occurs through the 'community' component alone, which it was argued represents both the physical environment and the community of actors (people and the interactive technology) who interact around shared objectives.

Summarizing these discussions, Table 3 illustrates how mobile and static learning can be distinguished from one another. It also distinguishes between socially interesting mobile and static learning. Table 3 is based on the conception that mobile learning can be defined in relation to the concept of context crossing, where context is the conjunction of the location in which the learning activity takes place and the social setting, represented as the rules and the division of labour of the community that the learner belongs to. In Table 3 the intersection between context as change in location and context as change in social settings helps with identifying socially interesting mobile learning. However, it should be noted that as a consequence of activity theory's historical perspective we must recognize that what makes mobile learning socially interesting may dwindle over time, in which case learning that was interesting may become less so. Learning will still be either mobile or not – the historical aspect only affects one of the two dimensions when analysing a case.

Based on our conception of context crossing, illustrated in Table 3, mobile learning can be defined as learning that occurs as a result of pursuing learning activities that are directed towards achieving the same objective across multiple contexts (both physical and social).

Conclusions

The current definitions of mobile learning are problematic as they are focused on learning that is mediated by certain mobile technologies. Rethinking mobile learning in terms of context crossing

gives a new perspective on the term by shifting the focus from the technology used to the context of use. However, the current uses of context in defining mobile learning are ambiguous and unhelpful. This paper clarifies 'context' from an activity theory perspective as a combination of the properties of the physical location where the learning activity takes place and the rules and the division of labour within the community that the learner belongs to. This conceptualization helps in proposing a definition of mobile learning that does not focus on the utilization of mobile technology but on the forms of learning practice, involving any technology, old or new, and how these practices vary across contexts embodied in a combination of the physical and social settings of learning activities. This definition denotes that it is not the technology that makes learning mobile but the continuity of learning activities in different contexts (physical and social). The definition also helps in differentiating mobile learning from static learning, which was a weakness of previous definitions of the term.

We propose that future studies look at mobile learning in terms of learning activities taking place across contexts (both physical and social), placing more emphasis on the relationship between learning activities and social context, which has been shown to affect and be affected by learning practices. This also helps with studying what differentiates learning that is mediated by the use of portable technologies from learning that is mediated by the use of other conventional devices. For example, learning through portable technologies is not only affected by the social context of the learning activity, but also helps to create contexts that conventional devices cannot create and thus helps with creating new learning experiences. However, these experiences become routine over time. Future studies should also focus more on studying learning that continues to occur in the same location over time, such as in a classroom. These cases can clarify the relationship between learning activities that occur in the same physical context and the social context.

References

Bannon, L. 1997. Activity theory. IRIT. http://www.irit.fr/ACTIVITES/GRIC/cotcos/pjs/TheoreticalApproaches/Actvity/ActivitypaperBannon.htm (accessed October 16, 2006).

Cole, M. 1996. *Cultural psychology: A once and future discipline.* Cambridge, MA: Harvard University Press.

Cole, M. 2003. *Vygotsky and context. Where did the connection come from and what difference does it make?* Istanbul: International Society for Theoretical Psychology.

Cole, M., and Y. Engeström. 1991. A cultural-historical approach to distributed cognition. In *Distributed cognition,* ed. G. Salmon. Cambridge, UK: Cambridge University Press.

Crabtree, J., M. Nathan, and S. Roberts. 2003. *Mobile UK: Mobile Phones and Everyday Life.* London: Work Foundation/i Society.

Demb, A., D. Erickson, and S. Hawkins-Wilding. 2004. The laptop alternative: Student reactions and strategic implications. *Computers & Education* 43, no. 4: 383–401.

Dourish, P. 2004. What we talk about when we talk about context. *Personal and Ubiquitous Computing* 8: 19–30.

Engeström, Y. 1987. *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki: Orienta-Konsultit.

Facer, K., R. Joiner, D. Stanton, J. Reid, R. Hull, and D. Kirk. 2004. Savannah: Mobile gaming and learning? *Journal of Computer Assisted Learning* 20: 399–409.

Kukulska-Hulme, A., D. Evans, and J. Traxler. 2005. *Landscape study in wireless and mobile learning in the post-16 sector.* JISC. www.jisc.ac.uk/whatwedo/programmes/elearning_innovation/eli_outcomes.aspx.

Kuutti, K. 1996. Activity theory as a potential framework for human–computer interaction research. In *Context and consciousness: Activity theory and human–computer interaction,* ed. B.A. Nardi. Cambridge, MA: MIT Press.

Laurillard, D. 1993. *Rethinking university teaching – A framework for the effective use of educational technology.* London: Routledge.

Lehner, F., and H. Nösekabel. 2002. The role of mobile devices in e-learning – first experiences with a wireless e-learning environment. Paper presented at IEEE International Workshop on Wireless and Mobile Technologies in Education, August 29–30, in Växjö, Sweden.

Leont'ev, A.N. 1978. *Activity, consciousness, and personality.* Englewood Cliffs, NJ: Prentice Hall.

McVay, G.J., K.D. Snyder, and K.A. Graetz. 2005. Evolution of a laptop university: a case study. *British Journal of Educational Technology* 36, no. 3: 513–24.

Nardi, B.A. 1996. Studying context: A comparison of activity theory, situated action models, and distributed cognition. In *Context and consciousness: Activity theory and human–computer interaction,* ed. B.A. Nardi. Cambridge, MA: MIT Press.

O'Malley, C., G. Vavoula, J. Glew, J. Taylor, M. Sharples, and P. Lefrere. 2003. Guidelines for learning/teaching/tutoring in a mobile environment. Mobilearn Project. http://www.mobilearn.org/download/results/guidelines.pdf.

Price, S., Y. Rogers, D. Stanton, and H. Smith. 2003. A New Conceptual Framework for CSCL: Supporting Diverse Forms of Reflection through Multiple Interactions. In *Designing for Change in Networked Learning Environments. Proceedings of the international conference on computer supported collaborative learning 2003,* ed. B. Wasson, S. Ludvigsen, and U. Hoppe. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Quinn, C. 2000. mlearning: Mobile, wireless, in your pocket learning. *Learning in the New Economy,* e-magazine. http://www.linezine.com/2.1/features/cqmmwiyp.htm (accessed January 11, 2007).

Roschelle, J. 2003. Unlocking the learning value of wireless mobile devices. *Journal Computer Assisted Learning* 19, no. 3: 260–72.

Roschelle, J., and R. Pea. 2002. A walk on the WILD side: How wireless handhelds may change computer-supported collaborative learning. *International Journal of Cognition and Technology* 1, no. 1: 145–68.

Savill-Smith, C., and P. Kent. 2003. *The use of palmtop computers for learning. A Review of the literature.* London: Learning and Skills Development Agency.

Sharma, S., and F. Kitchens. 2004. Web services architecture for m-learning. *Electronic Journal of e-Learning* 2: 203–16.

Sharples, M. 2000. The design of personal mobile technologies for lifelong learning. *Computers and Education Journal* 34: 177–93.

Sharples, M. 2005. Learning as conversation: Transforming education in the mobile age. Paper presented at Seeing, Understanding, Learning in the Mobile Age. April 2005, in Budapest, Hungary.

Sharples, M., D. Corlett, and O. Westmancott. 2002. The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing* 6: 220–34.

Sharples, M., J. Taylor, and G. Vavoula. 2007. A theory of learning for the mobile age. In *The Sage handbook of elearning research,* ed. R. Andrews and C. Haythornthwaite. London: Sage.

Suchman, L. 1987. *Plans and situated actions: The problem of human–machine communication.* Cambridge, UK: Cambridge University Press.

Traxler, J. 2005. Mobile learning its here but what is it? *Interactions* 9, no. 1. http://www2.warwick.ac.uk/services/cap/resources/pubs/interactions/archive/issue25/traxler (accessed November 20, 2007).

Vavoula, G.N., and M. Sharples. 2002. KLeOS: A personal, mobile, knowledge and learning organisation system. Paper presented at IEEE International Workshop on Mobile and Wireless Technologies in Education, August 29–30, in Vaxjö, Sweden.

Vygotsky, L.S. 1978. *Mind in society: the development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Waycott, J. 2002. Reading with new tools: An evaluation of personal digital assistants as tools for reading course materials. *Association for Learning Technology Journal* 10, no. 2: 38–50.

Weal, M., D. Michaelides, M. Thompson, and D. De Roure. 2003. The Ambient Wood journals – replaying the experience. Paper presented at HYPERTEXT '03: the 14th ACM conference on Hypertext and Hypermedia, August 26–30, in New York.

Zelin, R.C., and J.E. Baird. 2002. Is a mandated laptop program a good idea for the classroom?: A student survey. Paper presented at the Business Education Support Team (BEST) Conference – Supporting the Teacher: Challenging the Learner, April 8–11, in Edinburgh, UK.