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Using Activity-Oriented Design Methods (AODM) to investigate mobile learning

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Introduction

The past few years have witnessed significant interest and developments in researching mobile learning, with a lot of important contributions being made towards understanding and defining mobile learning (Kukulska-Hulme and Traxler, 2005; Sharples, et al., 2007; Wali et al., 2008; Winters, 2007). However, current research efforts are being redirected towards a new agenda to establish appropriate methods for investigating mobile learning, as this book testifies (see also Kjeldskov and Graham, 2003; Hagen et al., 2005). This chapter contributes to this research effort by articulating how to adapt Activity-Oriented Design Methods (AODM – see Mwanza, 2002) for use in mobile learning research.

Mobile learning in perspective

Mobile learning as a research field has accumulated valuable insight to help us understand (a) the nature of learning that takes place, (b) the environments in which learning takes place, and, (c) tools that mediate learning. In this regard, two perspectives appears to dominate the interpretation of the concept of mobile learning: first, those that define mobile learning from the point of view of the *portability* of technological tools or devices used to mediate learning activity; second, those that understand mobile learning from the point of view of the *mobility* of learners whilst using portable devices and wireless technologies to support learning. The first definition of mobile learning is commonly associated with early research in mobile learning that emphasised the personalised nature of mobile learning due to the prominent use of personal digital assistants (PDAs) and other handheld devices to support learning (Waycott and Kukulska-Hulme, 2003; Sharples, 2000; Vavoula and Sharples, 2002). This vision of mobile learning is driven by the assumption that mobile learners are proactive in their ability to learn independently using a range of mobile technologies to initiate, manage and support learning anytime and anywhere (Nabeth et al., 2008; Sharples, in this volume). In the meanwhile, the second definition of mobile learning is largely inspired by recognition of the significance of flexibility in the way that learners access and use mobile devices and wireless technologies to support learning in various settings (Caudill, 2007; Luckin et al., 2005; Scanlon et al., 2005; Zurita and Nussbaum, 2004). For example, mobile learners generate content in both physical and digital environments for learning. In digital spheres, mobile learners are able to collaborate with peers through mechanisms such as mobile instant messaging systems (Kadirire, 2007; Parviainen and Parnes, 2003) wikis and mobile blogging. In physical spheres, mobile learners are able to enhance their learning experiences by engaging in direct physical interaction with both real and virtual environments. For example, in the Savanna project (Facer et al. 2004), a

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combination of simulation games, handheld devices and wearable computers, and, wireless networking were used to create a gaming experience that responds to changes in the learner's physical environment. Therefore, this fusion of portability of devices and mobility of learners create new possibilities for mobile learners to enhance their learning experiences through sharing interactive experiences and co-construction of knowledge.

Finally, rapid advancements in the design and integration of mobile devices and networked technologies into day to day activities are creating new perceptions about the exploitation of mobile technologies in teaching and learning. Consequently, there is growing demand for customised, efficient and flexible systems for supporting learning in various settings. However, fulfilling learner demand for customised support requires better understanding of activities, operational contexts and purposes for which mobile devices are deployed to support learning. Therefore, our position with regard to methods for researching mobile learning focuses on evaluating the interaction between the two elements of portability of tools and mobility of learners in relation to the context of use and purpose for using mobile devices to mediate learning. In practice, this entails considering both HCI factors and social-cultural perspectives as important elements to consider when evaluating mobile learning. Whilst HCI factors can be addressed by conducting learner technology interaction studies as traditionally considered in HCI studies (Dix et al., 2003; Preece et al., 1994) and in Mobile HCI research (Kjeldskov and Graham, 2003; Hagen et al., 2005), social-cultural perspectives need to be addressed by evaluating issues relating to learner motives (Jones and Issroff, 2007) and the context of use as explored in social-cultural studies of human activity (Bannon, 1990; Leont'ev, 1978; Mwanza, 2002; Mwanza and Engeström, 2003; Mwanza-Simwami et al., 2009; Scanlon and Issroff, 2005; Taylor et al., 2006; Uden, 2007; Vygotsky, 1978; Wali et al., 2008).

In order to address research issues raised in foregoing discussions, this chapter will consider how Activity-Oriented Design Methods (AODM – see Mwanza, 2002) can be used to investigate mobile learning. The paper begins by describing activity theory, which is the theoretical framework that underpins the development and use of AODM. The section that follows introduces AODM. Key features of AODM methodological tools are outlined. Thereafter, we describe how AODM tools and techniques were applied in various systems design and e-learning projects. Finally, we discuss how AODM tools can be adapted for use in mobile learning research. The paper concludes by reflecting on the benefits of using AODM tools as a method for investigating mobile learning.

Activity Theory – an introduction

Activity Theory (AT) is a descriptive framework for understanding human activities as processes that continuously develop and redevelop over a period of time, and, as a result of influences from the context in which human activities are carried out (Leont'ev, 1978 and 1981). Therefore, the basic unit of analysis in activity theory is human activities, or 'what people do'. According to Leont'ev (1978), the concept of activity refers to specific forms of human practices that are socially formed and always involve elements of consciousness. AT is therefore, committed to understanding both individual and collective practices from a social-cultural and historical perspective.

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Central to theorising in activity theory is the concept of tool mediation, which presents the view that human beings develop and use tools to help them achieve targeted objectives. The concept of 'tools' is used here to refer to both physical tools (e.g. PDAs, mobile phones, etc) and conceptual tools such as human language and software applications. Activity theory is focused on establishing the means by which human beings master and use tools in everyday activities from a social, cultural and psychological perspective. This line of thinking is based on the understanding that the tools that human beings use to mediate their activities facilitate the performance of actions at hand whilst at the same time they reveal and transform the individual's mind. For example, through the development and use of psychological tools, human beings internally transform their own and other people's perceptions of the activity that they are engaged in. At the same time, by developing and using physical tools, human beings externally transform the activity that they are engaged in. Therefore, the idea of studying human activities as developmental processes is crucial for identifying changes and contradictions that exist in an activity. Contradictions serve as the means by which new knowledge about the activity being examined emerges (Engeström, 1987).

Leont'ev (1981) explains that the concept of activity entails a complete system of human practices that has a structure. The structure of human activity can be understood as a dynamic and self-regulating system that is motivated towards the fulfilment of needs or objectives. In the meanwhile, human objectives are achieved by engaging in practical activities that are mediated through both physical and mental actions. In turn, human actions are directed towards the achievement of conscious goals, whilst at the same time, actions are satisfied through specific operations, whose successful execution is dependent on the conditions under which a particular action is performed. For example, a mobile learner wishing to share knowledge with colleagues using a smart phone to support mobile instant messaging will initiate the actions of: establishing the online availability of colleagues, selecting colleagues from the contact list, typing short messages and attaching files to send. However, successful execution of the operation of sending the messages and files will be dependent on whether or not the learner has adequate bandwidth and continuous connection to a wireless network (see Balachandran et al., 2003; Kadirire, 2007). If not, the operation of sending mobile instant messages and files will fail even if the actions leading to the execution of these operations had been successful.

In summary, activity theory seeks to explain the social and cultural embeddedness of human activities by linking them to issues relating to motives of those involved in carrying out activities, and, the nature of the relationships that exist between and among those participating in activity (Leont'ev, 1978). Finally, by emphasising the social and cultural embeddedness of human activities and tool usage behaviour, activity theory recognises the unity of consciousness and activity (see Kaptelinin and Nardi, 2006). Activity theory was developed by Russian psychologists S.L. Rubinstein and A.N. Leont'ev, and, has its roots in the works of Lev Vygotsky – another Russian psychologist of the 1930s (Leont'ev, 1981; Vygotsky, 1981/1930). Vygotsky emphasised the idea that human beings' interaction with objects of the environment is mediated through the use of tools and signs (Vygotsky, 1978). This idea is illustrated in Vygotsky's original model of human activity as shown in Figure 1.

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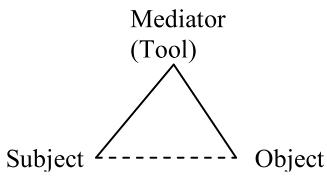

Figure 1: An adaptation of Vygotsky's original model of human activity (Mwanza, 2002, p.55)

Engeström (1987) developed a model that helps to capture and unify key concepts of activity theory by adding the 'rules and regulations', 'community' and 'division of labour' components to Vygotsky's original model of human activity. The added components together with the 'tools' component that was originally introduced by Vygotsky (1978) serve as mediators of a collective activity system. The various components of an activity system are shown in Figure 2.

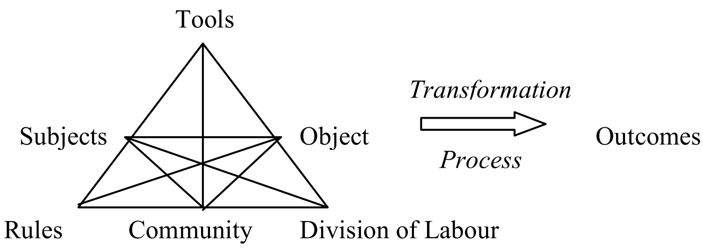

Figure 2: The Activity System (Engeström, 1987)

Figure 2, shows the various components of Engeström's model of human activity, which is also known as the activity system. The activity system captures the various components of human activity into a unified whole. Participants in an activity are portrayed as *subjects* interacting with *objects*[1] or objectives of an activity in order to achieve desired *outcomes*. In the meanwhile, human interactions with each other and with objects of the environment or context (*community*) in which activity is carried out are mediated through the use of *tools*, *rules* and *division of labour*. Mediators represent the nature of relationships that exist within and between participants in an activity in a given community. The activity system reflects both the collaborative and collective nature of human

[1] The term 'object' should not to be confused with the 'object-oriented' concept used in the computing science and programming fields of study. In AT, 'object/s' refer to the motivational or purposeful nature of human activity. The motive of human activity is reflected through the '*object*' or '*objective*' of that activity. Therefore, AODM introduced a hyphened '*object-ive*' (see Table 1 and Table 2) in order to reflect and emphasise the purposeful nature of human activity through the object component of the model of human activity (see Mwanza, 2002, p.67)

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activity through the 'subject' and 'community' components. When researching mobile learning, this approach to modelling human activity would draw the researcher's attention to issues to consider when evaluating mobile learning, such as, understanding the: (a) inter-relatedness of learning episodes in mobile learning; (b) history of the development and use of mobile devices in the learning activity being investigated; (c) role of tools, rules and regulations, also the division of labour as mediators of learner activities.

This chapter will now introduce Activity-Oriented Design Methods (AODM – Mwanza, 2002) as a research method that can be used to operationalise key concepts of activity theory using the activity system (Figure 2) as a model for unifying these concepts.

Activity-Oriented Design Methods (AODM)

Activity-Oriented Design Methods (AODM) was developed as an analytical and practical approach for applying key concepts of activity theory to HCI research and practice (Mwanza, 2002). AODM present *four methodological tools* designed to support early phases of computer systems design namely: the processes of gathering and analysing systems design requirements, systems evaluation, and, communicating design insight to stakeholders in the design activity. The four methodological tools incorporated in AODM are discussed below.

AODM Tool 1: Eight-Step-Model

The Eight-Step-Model		
Identify the: -		*Question to Ask*
Step 1	*Activity* of interest	What sort of activity am I interested in?
Step 2	*Object-ive*	Why is the activity taking place?
Step 3	*Subjects*	Who is involved in carrying out this activity?
Step 4	*Tools*	By what means are the subjects performing this activity?
Step 5	*Rules & Regulations*	Are there any cultural norms, rules or regulations governing the performance of this activity?
Step 6	*Division of labour*	Who is responsible for what, when carrying out this activity and how are the roles organised?
Step 7	*Community*	What is the environment in which this activity is carried out?
Step 8	*Outcome*	What is the desired *Outcome* from carrying out this activity?

Table 1: AODM's Eight-Step-Model (Mwanza, 2002, p.128)

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Description

The *Eight-Step-Model* (ESM) is used to translate the various components of Engeström's model of human activity (Figure 2) in terms of the situation being examined. This entails working through the eight steps shown in Table 1 to gather and analyse data that will provide initial information about the activity and the context in which it is carried out.

AODM Tool 2: Activity Notation

The Activity Notation				
Actors (Doers)	~	Mediator	~	Object-ive (Purpose)
Subjects	~	Tools	~	Object
Subjects	~	Rules	~	Object
Subjects	~	Division of Labour	~	Object
Community	~	Tools	~	Object
Community	~	Rules	~	Object
Community	~	Division of Labour	~	Object

Table 2: AODM's Activity Notation (Mwanza, 2002, p.152)

Description

Table 2 presents AODM's *Activity Notation,* which is used to reduce complexity in activity analysis by facilitating the modelling and decomposition of the activity system through the production of sub-activity triangle models (see Figure 3). This enables the researcher to conduct a detailed analysis of human activity. The operational procedure of the Activity Notation is enhanced by using *three-operational guidelines* that facilitate:

(a) Levelled abstractions during analysis by enabling the decomposition of the main activity system into sub-activity triangles.
(b) Reduction of cognitive complexity when analysing an activity system by generating sub-activity triangles to work with. The sub-activity triangles are united through the shared object of the main activity system.
(c) The analysis of relationships *within* and *between* the various components of the main activity system so as to identify contradictions.
(d) Detailed and more focused analysis by generating research questions based on sub-activity triangles.

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Figure 3 (see below) illustrates how an activity system might be decomposed and modelled into sub-activity triangles through use of the Activity Notation.

AODM Tool 3: Technique of generating research questions

The Technique of Generating General Research Questions
1) What Tools do the Subjects use to achieve their Objective and how?
2) What Rules affect the way the Subjects achieve the Objective and how?
3) How does the Division of Labour influence the way the Subjects satisfy their Objective?
4) How do the Tools in use affect the way the Community achieves the Objective?
5) What Rules affect the way the Community satisfies their Objective and how?
6) How does the Division of Labour affect the way the Community achieves the Objective?

Table 3: AODM's Technique of Generating General Research Questions (Mwanza, 2002, p.155)

<u>Description</u>

The *technique of generating research questions* shown in Table 3 is used to operationalise sub-activity triangles resulting from the decomposition process so as to support data gathering and analysis from an AT perspective. Six general research questions based on components of the activity system are presented to aid the development of a wide range of both general and more focused research questions. These research questions can be used to analyse user interactions with each other and with tools or technologies being used to mediate activity as shown in Figure 3. Questions can also be used to examine the relationships that exist within and between the various components of sub-activity triangles (see Figure 3). This technique also facilitates detailed abstraction through decomposition and operationalisation of sub-activity triangles (see Figure 3).

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AODM Tool 4: *Technique of Mapping Operational Processes*

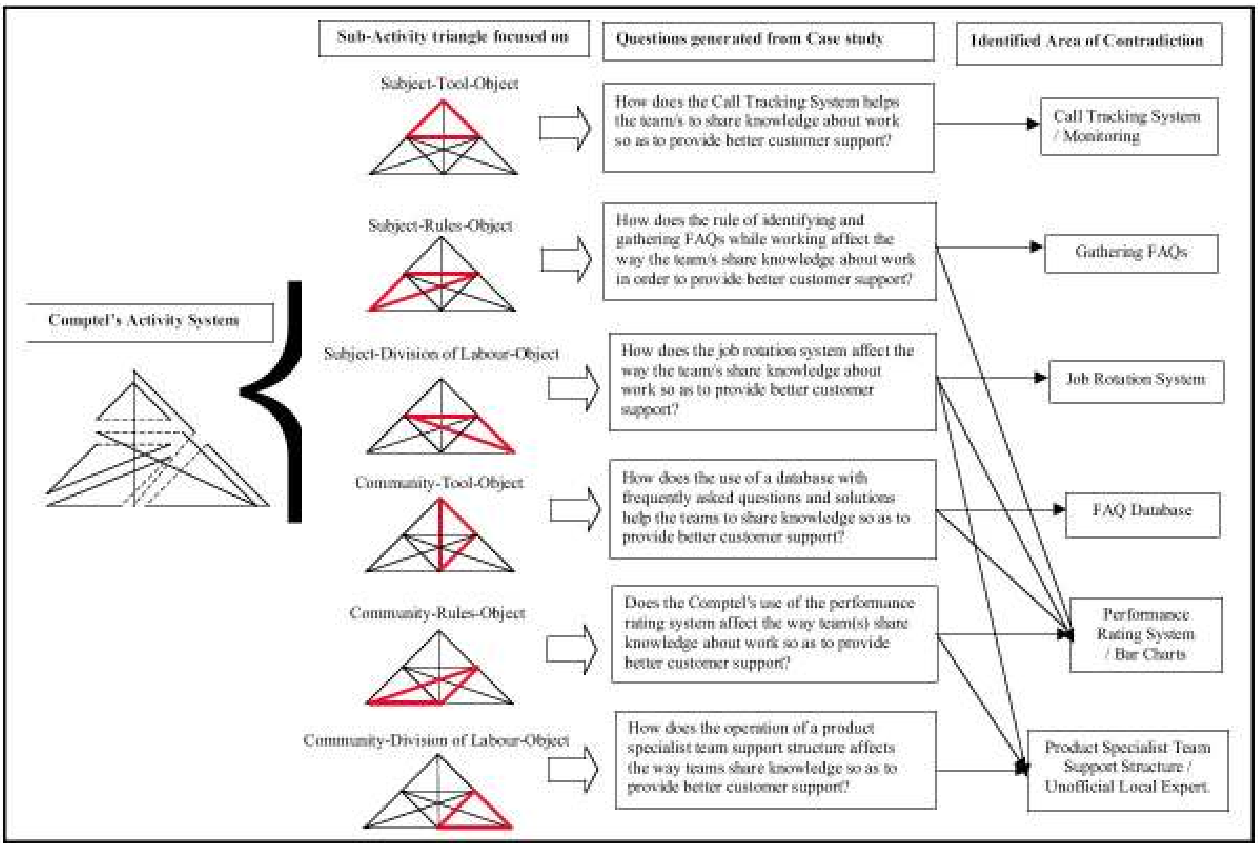

Figure 3: AODM's Technique of Mapping AODM Operational Processes (Mwanza, 2002, p.162)

<u>Description</u>

Figure 3 presents AODM's technique of *Mapping Operational Processes* (MOP) which is used to interpret and communicate research findings. MOP is a cognitive support tool that makes it easier to understand AODM entities and operational procedures by presenting a visual representation of the transition of the activity analysis from the decomposition of sub-activity triangles to the generation of research questions, and the identification of contradictions or problems in the activity. Contradictions are identified when results of an activity analysis do not match with desired outcomes or when problems emerge whilst the learner is interacting with tools or with other learners participating in that activity. For example, a contradiction is identified when a mobile phone fails to transmit a short message due to poor network connection. Problems may also occur as a result of rules and regulations that restrict or prevent the learner from carrying out a task e.g.

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mobile learners may not be allowed to take and share digital photos in certain parts of an international airport. MOP works like a concept mapping tool that facilitates understanding of the operational process as well as communicating study findings.

The four AODM methodological tools presented above can be applied systematically or iteratively in a six stage process presented as follows.

Stage 1. Interpret the situation being examined in terms of activity theory
Stage 2. Model the situation being examined
Stage 3. Decompose the situation
Stage 4. Generate research questions
Stage 5. Conduct a detailed investigation
Stage 6. Interpret and communicate findings

A detailed explanation of how the four AODM tools can be applied in the six stages outlined here will be presented later when discussing how to 'use AODM tools to investigate mobile learning'.

Previous use of AODM

AODM tools have been successfully used to inform design and investigate practices in several system design and evaluation projects mainly in the field of e-learning. For example, AODM tools were used to support information gathering and data analysis processes in a large e-learning project (i.e. the Lab@Future project[2]) that was funded by the European Union (EU) to design and evaluate new technologies for supporting learning in European high schools (see Courtiat et al., 2004; Baudin et al., 2004; Mwanza and Engeström, 2003). AODM methodological tools were also successfully used to support and enrich metadata abstraction and information management practices in the Lab@Future e-learning project (see Mwanza and Engeström, 2005). AODM tools were used to support systems requirements gathering in another large international e-learning project (i.e. Mobilearn project[3]) that was focused on investigating the design and use of mobile devices to support mobile learning (see Sharp et al., 2003). More recently, AODM has been taken up in the field of Computer Supported Collaborative Learning (CSCL) where AODM tools were used to develop a comprehensive understanding of practices of collaborative knowledge building

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[2] The Lab@Future project was a European funded research and development project focused on anticipating future technological support needs for European youth. The project started in May 2002 and ended in April 2005. The author worked on this project as part of the University of Helsinki team. Further details of the project are available at www.labfuture.net/

[3] MOBIlearn was a European-led worldwide research and development project focused on exploring advancements in mobile technologies by amongst other objectives, defining theoretically-supported and empirically-validated models of mobile learning. The project started in July 2002 and ended in December 2004. The author participated in this project as part of the Open University team. Details of the project are available at http://www.mobilearn.org/

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among course design teams and their students (see Greenhow and Belbas, 2007). The broad exploitation of AODM tools demonstrates that this method can be flexibly adapted for use in various fields including mobile learning. The chapter will now discuss how AODM can be used to research mobile learning.

Using AODM tools to investigate mobile learning

In order to apply AODM to mobile learning research, we recommend that the investigator begins by familiarising themselves with theoretical concepts of activity theory, as a basic understanding of AT concepts is vital to appreciate the richness of the framework of AT and to appropriately label and interpret components of the activity system. The actual process of applying AODM tools to researching mobile learning would involve working either systematically or iteratively through the six stages of AODM as recommended below.

Stage 1. Interpret the situation being examined in terms of Activity Theory
Begin by understanding existing practices in the environment or context in which mobile devices are being used to support learning. The initial task would be to interpret the activity triangle model or activity system (Figure 2) in terms of the mobile learning activity that you want to investigate. It is therefore important to identify a specific activity of interest to research within mobile learning. This entails working through the open-ended questions that are incorporated within the Eight-Step-Model (Table 1) so as to meaningfully translate the various components of the activity system in terms of activity theory. ESM can be used on its own as an open-ended questionnaire or aide memoire in observational studies. Research outcomes will be in the form of qualitative data such as descriptive narratives of practices of the context of use and tools used to mediate learning. Through this translation process, general information about learner practices, mediators and contextual issues would be gathered.

<u>Example use of AODM's ESM in the Mobilearn project</u>

Within the Mobilearn project's Open University (OU) case study (Sharp et al., 2003), AODM's ESM tool was used to gather information about practices of OU first-aiders. We needed to find out about work patterns of OU first-aiders, e.g. did they move about and outside their normal work environment to attend to first-aid incidents? Step 7 of AODM's ESM enabled us to answer that question. We also needed to find out what activities were carried out by OU first-aiders so that we could narrow down to a single activity of interest that we would target for detailed investigation. Step 1 in ESM enabled us to achieve this. We discovered that OU first-aiders carried out various activities within the remit of rendering first-aid at work. These activities included: attending to personal injuries and accidents at work; attending first-aiders' meetings and training courses to refresh their practical skills e.g. to share experiences and information about how to use new first-aid equipment. We also needed to gather information about tools that first-aiders used when carrying out their activities. ESM's Step 4 enabled us to establish that OU first-aiders used portable devices

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such as blood pressure monitors and defibrillators when attending to first-aid incidents. First-aiders also used both landline based office telephones and mobile phones to communicate and share experiences about first-aid incidents.

Example use of AODM's ESM in the Lab@Future project

In the Lab@Future project (Baudin et al., 2004, Courtiat et al., 2004, Mwanza and Engeström, 2003, Mwanza and Engeström, 2005), AODM's ESM was used to gather information about user practices, tool use, context of use, etc, in the various case studies used as part of the systems design requirements capture. Working as part of the University of Helsinki team, we initially gave representatives of the nine partners[4] that were participating in this project a basic introduction to AT. This happened during one of the project meetings. Thereafter, partners were asked to use ESM in observational studies and during interviews with case study participants in order to gather specific information about human activities in those case studies. For example, by working through ESM's Step 7, a case study carried out in Slovenia established that teaching and learning activities in the subject area of environmental awareness were carried out in both the school setting (i.e. scientific laboratories) and in the natural environment through field trips and the 'school in the nature' programme (see Mwanza-Simwami et al., 2009, Mwanza and Engeström, 2003, Mwanza and Engeström, 2005). Again by working through ESM' Step 4, we were able to establish that both learners and teachers used portable devices such as cameras to take photos of items of interest during field trips. Students and teachers also used portable devices such as test tubes to collect water samples from lakes to be used when testing for pollution in scientific laboratories.

ESM enables the researcher to gather huge amounts of qualitative data, which in most cases is complex, therefore, other AODM tools are required to support the investigative processes of analysing emerging issues, and, in order to effectively communicated information to stakeholders.

Stage 2. Model the situation being examined

During the second stage of using AODM, information gathered in *Stage 1* is used to produce an activity system of the situation being examined. This modelling process makes it possible to interpret and verify the correctness of the information gathered about learner practices in the setting being studied. Modelling also supports the process of communicating information gathered to other stakeholders. However, it is difficult to conduct a critical analysis of learner activities in the activity system generated at this stage because the information gathered is too abstract or general. This is due to the fact that the activity system produced at this stage is complex because it incorporates within it several other processes or sub-activities that together make up the main activity system. To address this situation, a levelled abstraction of this complex activity system is required so as to reveal the various sub-activities and relationships incorporated within the activity system. For

[4] The nine partners involved in the Lab@Future project were drawn from both industry and academia in several European countries. English was the official working language on the project. However, partners had their own country specific official working languages including: French, Greek, German, Finnish and Slovenic.

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example, when investigating mobile learning, the researcher would typically produce an activity triangle model from the information gathered in Step 1 of ESM. If we use the Lab@Future case study of learning about environmental awareness as an example, the resulting triangle would have items such as cameras and test tubes under the 'tools' components of the case study's activity system. The model show study specific and meaningful interpretations of the various components of the activity system produced.

Stage 3. Decompose the activity system

At this stage AODM introduces the *Activity Notation* to decompose the complex activity system that was produced in Stage 2. This decomposition helps to reduce complexity by introducing smaller manageable constitutive units or sub-activity systems to work with. These sub-activity systems are linked together through the shared object or objective of the main activity system. The shared object is that of the main activity system produced in Stage 2 and is common to all components. The activity system produced in stage 2 is further divided into sub-activity triangles as shown in Figure 3.

Stage 4. Generate research questions

Stage 4 uses the AODM's *technique of generating research questions (Table 3)* to produce research questions that are based on sub-activity systems or components resulting from the decomposition in Stage 3. Each research question is therefore directly linked to a particular sub-activity system or component within the main activity system. Generating research questions in this way makes explicit the link between research questions generated and the various components of the main activity system. Research questions generated at this stage can then be used to support further data gathering and analysis. The questions can also be used to support the process of evaluating and validating whether or not learner objectives are being met. Figure 3 gives an example illustration of the generation of research questions. As an example, in the Mobilearn project, after gathering, analysing and modelling data (AODM stages 1 to 3) about practices of OU first-aiders, we wanted to conduct a detailed investigation about tools that first-aiders used to capture and share knowledge whilst on the move attending to first-aid incidents. The combined use of ESM and the Activity Notation enabled us to establish that whilst both office telephones and mobile phones were used to communicate with other first-aiders and stakeholders such as hospital emergence departments when attending to first-aid incidents, other portable devices such as cameras or cameras phones would have been useful for capturing images of injuries in order to enrich data shared amongst stakeholders. These devices were not in use at the time of the study.

Stage 5. Conduct a detailed investigation

At this stage, it is possible to conduct a detailed and more focused investigation that uses the research questions generated in stage 4. Research questions can be used in interviews, questionnaires, and observations. At this point, it is worth mentioning that AODM does not stipulate how to conduct interviews or observations when using the generated research questions. We considered such an elaborate approach to be too restrictive and not suitable for all purposes.

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Whilst AODM is focused on providing a well-structured application procedure, the need to be flexible in the method's application mechanism is equally vital.

In addition to this, research questions generated in stage 4 can also be used as pointers to what to look for when analysing data gathered during the study. During data analysis, the investigator would examine relationships that exist *within* and *between* learners and tools used to mediate learning activity so as to identify contradictions or problems. The aim of this kind of analysis is not to find or predict possible solutions for the identified contradictions, but instead to obtain a comprehensive understanding of the means by which these contradictions develop, from a social-cultural and historical perspective. For example, in the Mobilearn project's OU first-aiders case study, detailed analysis of the relationship between tools and first-aider practices revealed a possible contradiction between first-aiders' use of portable devices such as mobile phones to communicate with others whilst attending to an incident, and, the requirement to concentrate on stabilizing the victim as part of the first-aid task. Contradictions emerge due to the fact that both tasks require mental concentration and use of hands. Having gathered and analysed data during a detailed investigation, the next step is to interpret and communicate findings.

Stage 6. Interpret and communicate findings

In the final stage of applying AODM tools, the information obtained in stage 5 is interpreted and communicated to other stakeholders by re-modelling the activity system of the situation being examined. At this stage, it is also possible to graphically show the mappings between sub-activity systems and research questions generated in Stage 4, and also the identified areas of conflict. This kind of mapping is illustrated in Figure 3. The technique of mapping components and operational processes provide a reversible conceptualisation of the various entities and operational processes that exist when using AODM. Using this approach, it is possible to identify and map contradictions onto the sub-activity triangle component in which they exist. The AODM technique of modelling mappings of entities and operational processes helps the investigator to explicitly communicate observed conflicts or problems in the learners' relationships with others and their own use of mobile devices to support learning. Finally, the technique of mapping operational processes directly support the AT notion of capturing the historical development or transition of human activities as part of the investigation. This element of AODM is particularly important for research in mobile learning as it could help to link the relationships between learning episodes (Vavoula and Sharples 2002) and learner objectives. The idea of capturing the transition of learning activities can also enable the researcher to understand the relationships between various episodes of mobile learning, many of which happens in various settings that include both formal and informal settings (Scanlon et al., 2005).

Conclusion

There are currently no universally accepted methods for investigating mobile learning. This chapter has proposed Activity-Oriented Design Methods as a structured and flexible method for investigating mobile learning. AODM presents a theoretically grounded descriptive approach for investigating human activities and tool usage behaviour in the context in which activities are carried out.

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Key benefits of using AODM to researching mobile learning include, first, its capability to allow the researcher to investigate the *relationship* between learner *motives* and technology usage behaviour. AODM methodological tools facilitate a holistic approach to investigating *mediators* of human activities by studying tools in use, rules and regulations, and division of labour, whilst linking observations to targeted goals and desired outcomes. Second, AODM can be used to investigate the inter-connectedness of learning episodes in mobile learning through its supports for levelled abstractions and decomposition of learner activity models. This approach also helps to capture the developmental transition of learner behaviour and the analysis of contradictions that exist in learner activities.

Weaknesses and shortfalls of AODM include, first, the requirement for users to familiarise themselves with basic theoretical concepts of activity theory (Mwanza, 2002, Greenhow and Belbas, 2007). Methodological tools presented in AODM attempt to closely interpret key concepts of activity theory so as to capture the richness of this framework in their operational structure. However, this AT orientation can discourage some researchers. Nevertheless, as pointed out by Greenhow and Belbas, (2007), the benefits of being able to characterise the messiness of real world practices in a way that is valuable to others in context outweigh any possible challenges. Second, studying activities of mobile learners in naturalistic settings or context can be challenging due to the fact that mobile learners operate in constantly changing environments (e.g. on the move), therefore, it is difficult to predict when a learning episode or event will occur or what tools will be in use. AODM addresses these issues by providing support for analysing complex social behaviours through decomposition whilst providing a mechanism for making the inter-relatedness of interaction processes more explicit. Finally, AODM can easily be integrated with other methods that the researcher chooses to use.

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