Towards a task model for mobile learning: a dialectical approach

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Towards a Task Model for Mobile Learning: a Dialectical Approach

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Abstract
Our approach to understanding mobile learning begins by describing a dialectical approach to the development and presentation of a task model using the socio-cognitive engineering design method. This analysis synthesises relevant theoretical approaches. We then examine two field studies which feed into the development of the task model.

1. Background

The past five years have seen a rapid growth in research, development and deployment of mobile technologies to support learning. Although research in this area began with the seminal work of Kay and colleagues at Xerox PARC (Kay & Goldberg, 1997) it is only recently that both technology and educational needs have converged. The new technology includes multimedia-equipped mobile phones, personal digital assistants (PDAs) and pen tablet computers; the new emphasis in education is on supporting the learner, in collaboration with peers and teachers, through a lifetime of education, both within and outside the classroom. This new area of personal mobile learning is distinctively different from learning within schools and colleges, and from the traditional notion of continuing education, with its emphasis on equipping people with the skills and knowledge for a rapidly changing society. It also brings with it a need to re-conceptualise the interaction between learning and the design of mobile technology.

2. General Aims

Our approach to understanding the domain of mobile learning begins by describing a dialectical approach to the development of a task model for mobile learning using the socio-cognitive engineering design method (Sharples et al 2002) in the context of a large European funded project called MOBIlearn (IST-2001-37440).

We introduce the socio-cognitive engineering design method, highlighting the role of the task model in systems design. The model is informed by general requirements, theory and field studies. We describe the initial approach to the gathering of requirements, which illuminated the need for a theoretical analysis of the sphere of activity in mobile learning. This analysis attempts to synthesise relevant theoretical approaches, from socio-cultural and activity theory and from learning as conversation. We then examine some field studies which feed into the development of the task model. This leads us to a first articulation of the model. Future field studies will validate the model, and lead to its onward development.

The process is described as dialectical because this first articulation of the model will be used to inform the design of learning environments and tasks. As we evaluate the effectiveness of those designs, through field studies, we will feed our findings back into the development and refinement of the task model. At the same time, though, those learning experiences may shape and possibly change the ways that learners appropriate and use the technologies they have now been introduced to – i.e. exposure to technology may not leave users unaffected. Thus, the technology shapes user behaviour, and that behaviour in turn affects the way that users perceive technology.

This cyclic and dialectical process is the only way to fully capture the complexity of learning in a mobile environment, particularly if we wish to ensure that we have fully understood how to create pedagogically sound activities for learners. To achieve this, we will argue that there is a separation between the semiotics of a learning situation – in terms of the knowledge, language and conceptual resources needed for effective learning – and the embodiment of these functionalities in specific devices or constellations of devices. We also argue, along with others (e.g Sariola et al, 2001), that the focus should be on the learner being mobile, rather than defining ‘mobile learning’ as learning that takes place through the use of mobile devices.

3. The socio-cognitive engineering approach to systems design

Socio-cognitive engineering (Sharples et al 2002) is a coherent approach to describing and analysing the complex interactions between people and computer-based technology, so as to inform the design of socio-technical systems (technology in its social and organisational context). It extends previous work by providing an integrated framework for socio-cognitive system design that incorporates software engineering, task engineering, knowledge engineering and organisational engineering.

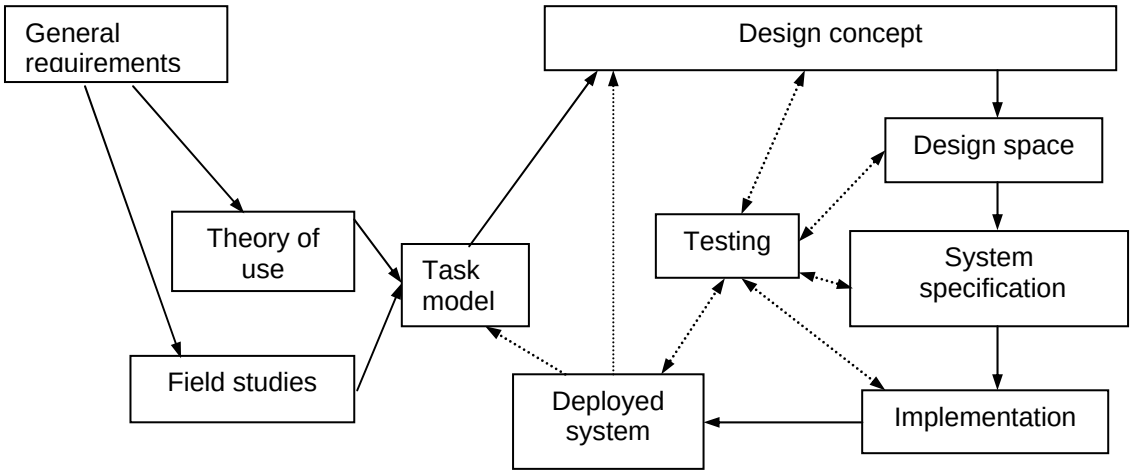

Figure 1: Overview of the flow and main products of the design process

Socio-cognitive engineering has similarities to contextual design (Beyer & Holtzblatt, 1998) in its approach of studying human activities and work practices in order to support them with new technology. Contextual design as formulated by Beyer and Holtzblatt is aimed at defining customer-centred systems that are based on a sound understanding work practices. Our aim is to define human-centred, socio-technical systems (people in interaction with personal technology) that are based on a sound understanding of how people think, learn, perceive, work and interact.

Figure 1 gives a picture of the flow and main products of the design process. It is in two main stages: a stage of activity analysis that sets constraints on the design and analyses how people work and interact with their current tools and technologies; and a stage of design of new technology. Our emphasis in this paper is on the first of these, the activity analysis.

The activity analysis starts by specifying the general requirements and constraints for the system to be designed. This sets out the type of activities to be supported by the new technology (such as learning and knowledge management), the general domain (such as learning in a museum) and any general constraints (such as time and budget available for the system design). This leads to two parallel studies, an investigation into how the activities are performed in their normal contexts, and a more theory-based study of the underlying cognitive and social processes. The outcomes of these two studies are synthesised into a task model. The aim of the task model is to provide a coherent account of how the activities are performed, the people involved, their contexts, the tools and technologies they employ, the structure of the tasks and an account of their cognitive processes, management of knowledge, and social interactions.

3.1 The role and significance of the task model

Sharples et al (2002) point out that users are important sources of design information and may be partners in the design process. Interviews with users can illuminate problems and breakdowns in their current work and

technology, as well as mismatches between different viewpoints, such as teacher and student, or manager and employee. Users are often good at expressing preferences and choosing between competing products. They may often, but not always, be able to articulate their methods of working, the basis for decision making and the ways in which they structure and deploy knowledge and skill. They may also provide a guide to language and terminology.

But, the authors suggest, users are not always reliable informants. They may idealize their methods, describing the ways in which they would like to or have been told to work, rather than their actual practices. Although users may be able to describe their own styles and strategies, they may not be aware of how other people can perform the task differently and possibly more effectively. Furthermore, basing design on a survey of user preferences can result in new technology that is simply an accumulation of features, rather than an integrated system.

Key contributions of the socio-cognitive approach lie in the enriched view of users' tasks and the context of use, which allow us to integrate theoretical insights into cognitive processes underlying actions and activities. Importantly, the socio-cognitive method clearly distinguishes studying everyday activity using existing technology, from studying how the activity changes with proposed technology. It forces us to acknowledge the dialectical relationship between learners and artifacts – using artifacts changes the learner's activities, and this in turn affects the way the learner wants to use the artifacts. Learning is viewed as a distributed activity, so we will need to understand the range of actions and opportunities which are on offer to mobile learners, and seek ways of extending this range to support what learners want to do – even if they themselves do not yet know what that is.

As mentioned earlier, Figure 1 shows that there are three important contributing strands to constructing the task model – general requirements, a theory of use and field studies. We now discuss each of these in turn.

4. General Requirements

General requirements for a mobile learning environment were developed in a project funded by the European Union, the MOBIlearn project (IST-2001-37440) through the use of a scenario refinement process, more fully described elsewhere (Taylor and Evans 2005). The goal of the MOBIlearn project is to develop a pedagogically sound mobile learning environment. We used scenarios in the project to fulfil a dual function. The first was to assist in the process of 'envisionment' (Carroll, 1995) of the mobile learning environment, and to develop a shared understanding of its potential for learning. The second was to begin considering requirements to enable us to progress towards the design of field studies. Of the many scenarios generated, 3 were selected to be fully developed as test scenarios.

The next step was to refine these scenarios identifying what the basic requirements were for mobile learning, and to pull out the common elements. This gave us a general top-down view of the essential elements of a mobile learning environment, as identified by informed experts, which we needed to augment by examining user behaviour in context, to flesh out

the detail in a bottom-up fashion. This method has much in common with the approach to scenario development described by Cugini et al (1999). The proposed scenarios were then calibrated, or grounded, by gathering user data from learners and teachers within the context of the domain.

4.1 Requirements

Many requirements emerged from the scenario refinement process (some 700), some of them obvious and low level (e.g. devices which are meant to be portable need to be light enough to carry; users need to be able to connect their devices to other devices). More interestingly, what emerged were three requirements for a model of learning that would serve the project:

- *Model Requirement A:* the learning model needs to incorporate perspectives on group communication/activities and the social dimension of learning.

- *Model Requirement B:* the learning model must be able to describe existing activities with current technologies, as well as new emergent activities as a result of introducing new tools.

- *Model Requirement C*: the learning model must provide a framework for analysis of activities of learners and ways of understanding how activities relate to goals.

These requirements set a target for the development of a learning model, and are a summary of what teachers and learning technology experts felt was essential for a learning model to address in the mobile domain. Model Requirement C identifies the need to be able to analyse activities, and relate them to goals. What are those activities?

The second set of requirements addresses this question. The initial most important requirements and common elements which emerged from all the scenarios with respect to activities, or tasks that users want to perform, are:

- *Task Requirement 1:* support for communication and collaboration amongst actors (to include learners, teachers, resources, groups etc.)

- *Task Requirement 2*: support for capturing information, annotation of documents or resources, personalisation of information and messaging, and all processes essential to learning (e.g. preparation, reflection, archiving etc.)

- *Task Requirement 3:* awareness of the context in which activities are taking place, to include awareness of other devices in the environment, other people and services

- *Task Requirement 4:* immediate and seamless access to services, resources and people.

These general requirements were successively unpacked and refined to produce hundreds of specific requirements, too many to detail here. But it

became clear that if we were to achieve the goal of providing good pedagogical environments for learning, we needed the theoretical input to create the model of learning in the mobile setting which would adequately encompass the requirements. We discuss this in the following section.

5. A theory of use for mobile learning

Most theories of pedagogy (as distinct from theories of learning) fail to capture the distinctiveness of mobile learning. This is because they are theories of teaching, predicated on the assumption that learning occurs in a classroom environment, mediated by a trained teacher. Thus Watkins and Mortimore (1999) reviewed three phases of research literature on pedagogy, with a focus on:

- different types of teachers,
- the contexts of teaching, and
- teaching and learning.

It is only the last that is of direct relevance to mobile learning. The second focus is important, but only with a shift in emphasis to the contexts of *learning*, rather than of teaching. Changing the focus from teaching to learning reveals a much broader horizon of activity.

Livingstone (2001) makes a useful distinction between internal and external initiation and structure of learning, shown in Figure 2.

	External structure	*Internal structure*
External initiation	Formal teaching	Resource-based learning
Internal initiation	Voluntary learning	Informal learning

Figure 2: Initiation and structure of learning (adapted from Livingstone 2001)

Traditional teaching is initiated by demands external to the learner, including the curriculum and examination system, and structured by a classroom teacher. Learning may be externally initiated, but structured by the learner, as in resource-based learning where learners are encouraged to manage their own study, but within the constraints of a curriculum. It may also be initiated by the learner, but externally structured, for example in professional or personal development, where the learner opts to study in an evening class or coaching session. Lastly, learning may be both initiated and structured by the learner. Vavoula (2004) has extended this categorisation to include the process and object of learning, and who has control over it. Her typology covers learning where the process is not prescribed and the object is unspecified, as in unintentional informal learning

Such informal learning activity has been described as the “hidden iceberg” of learning (Livingstone, 1999). Livingstone and colleagues questioned

1562 Canadian adults about their informal learning activities. The study revealed the breadth of informal learning. On average an adult spends 15 hours per week in informal learning, and this was generally consistent across age and social class (apart from the 18-24 age group, which spent on average 23 hours per week in informal learning). It contrasted with an average of about four hours per week of study in organised education courses.

Any theory of mobile learning must embrace the considerable learning that occurs outside the classroom and is personally initiated and structured. It must also account for the dynamics of learning. Increasingly, we work away from our normal working environment, at home, on trains, in airport lounges. Such work includes both formal and informal learning (Waycott, 2004). Physical mobility is one aspect of the dynamics of learning. Others include a continually changing social environment and access to resources, as we move in and out of communication with the Internet or other knowledge spaces, and as colleagues become available physically and online. We shall use the term 'context' to refer to the combined physical, information and social setting of learning, which for mobile learning in particular is in continual change.

Lastly, a relevant theory of learning must embrace contemporary accounts of the practices and ontogeny of learning. Learning is a constructive process, involving the active construction of knowledge. It is a both a social and a cognitive activity, occurring within a rich milieu of physical and cultural tools, settings and social interactions. And it comprises not only a process of continual personal development and enrichment, but also the possibility of rapid and radical conceptual change.

Thus, theories of learning must be tested against the following criteria:

- Do they account for both formal and informal learning?
- Do they analyse the dynamic context of learning?
- Do they theorise learning as a constructive and social activity?

We shall argue that no single current theory of learning satisfies these criteria entirely, but that two are particularly appropriate and complementary: these are post-Vygotskian theories of mind, culture and activity as applied to learning; and theories of learning as conversation, developed by Pask and Laurillard. There is not the space here to discuss these theories in depth, but fortunately both are thoroughly and elegantly expounded, by Daniels (2001) on Vygotsky and pedagogy, and Laurillard (2002) on learning as conversation. In this paper we shall only discuss how these can contribute towards a task model for mobile learning.

5.1 Sociocultural theories of learning

Sociocultural theory, and its near relation activity theory, derive from the work of Vygotsky (1978), who attempted to describe learning and development as a process mediated by tools. The tools include both physical artefacts and semiotic constructs including language and society. In activity theory, the focus is on the activity itself, including the processes by which social, cultural and historical factors shape human functioning (Daniels, 2001). Vygotsky's original writings have been examined and

developed, initially by Russian academics including Leont'ev and in recent years by Western theorists including Cole, Wertsch and Engeström. Activity theory has been applied to the study of pedagogy, notably by Daniels (2001), and to the analysis and design of technology-mediated activity by Kuutti and others (e.g. Koschmann, Kuutti and Hickman, L. 1998; Virkkunen and Kuutti,2000; Tuikka and Kuutti, 2000; Iacucci and Kuutti, 2002).

Engeström proposes five principles of activity theory, that "stand as a manifesto of the current state of activity theory" (Daniels, 2001). In summary, they are as follows:

- Activity is the focus of analysis. Individual and group actions can only be understood in relation to an interwoven system of activity.

- Activity systems are multi-voiced. They include many perspectives, traditions and interests which are in continual interaction and change, giving rise to inevitable conflict that demands analysis and resolution.

- Activity systems are shaped over time. Current activity can only be fully understood by taking a historical perspective, to understand how it has been shaped and transformed by previous ideas and practices.

- Contradictions are sources of change and development. Activities are open systems, such that the introduction of new ideas and practices can cause conflict with existing ways of acting and describing. The process of resolving such tensions may lead to new understanding and thus to opportunities for change.

- Activity systems contain the possibility for expansive transformation. They go though extended periods of qualitative change, as the contradictions are internalised and resolved, leading to the emergence of new structure, tools and activity.

Sociocultural and activity theory provides a very different perspective on learning and development to previous theories of behaviour and mind. As a systems theory, it is suited to the analysis of collective behaviour, such as a classroom or workplace, but it has also been applied to the analysis of the individual learner. Vygotsky proposed the Zone of Proximal Development (ZPD) as a way to understand the contradictions between a learner's personal understanding and the external opportunities afforded by teachers and peers. By working within the region between what a learner can currently achieve unaided, and what is possible with outside support, a teacher can continually help the child to strive and develop.

Activity theory provides a framework to analyse the mediating role of new technology in activity of learning, and the inevitable contradictions that arise from introducing new technology into an environment such as a classroom or workplace.

In recent years, the original formulation by Vygotsky of the relations between a *subject*, such as a learner, an *object* ("objective" is a more accurate translation of the Russian), such as a course of study, and *tool*,

such as a teacher or a text, has been expanded by Engeström (1987) into a generalised activity system that also includes *rules*, *community*, and *division of labour* (see Figure 3). This expansive activity model is a powerful analytic tool that has been applied to the understanding of practice in classrooms and workplaces.

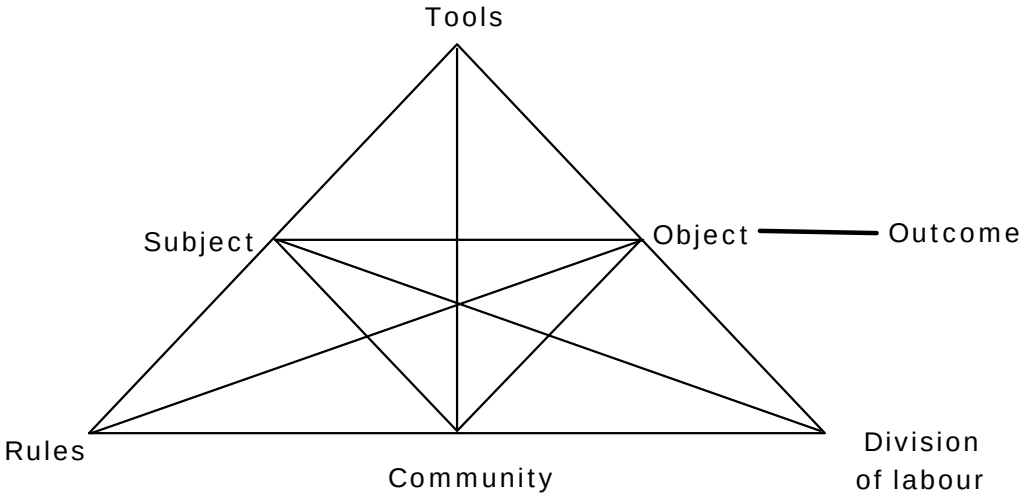

Figure 3 – Engeström's (1987) extended activity system

The introduction and appropriation of technology is itself an activity system, and so can be analysed with the tools of activity theory. Waycott (2004) has applied Engeström's expansive model to the process of appropriating wireless technology for learning and knowledge working. Waycott derives a model of the Tool Integration Procedure (discussed further below) which illustrates how new tools can resolve contradictions in the tool user's activity, but also how such tools can also introduce contradictions of their own.

However, the very benefits of the expanded activity model are also its limitations. By focusing on particular elements of the activity system, and on activity itself, the model inevitably de-emphasises other aspects that may be important to a full understanding of the processes of learning and of technology appropriation. Returning to Engeström's five principles, we would suggest that they fail to give sufficient emphasis to the following:

- Learning is conversation. All learning is a process of internal conversation with oneself, to understand new phenomena and resolve internal contradictions, and external conversation with peers, with teachers, and nowadays with interactive artefacts such as computers. The role of conversation has been extensively analysed by Sociocultural theorists such as Bakhtin (1999) and more recently by Heath and Luff (1982), but, as Daniels (2001) points out, although Engeström's work addresses the production of the outcome, he does not discuss the production and structure of the tool itself. There is, therefore, a resulting "…lack of theory of structure of discourse as a cultural artefact" (Daniels, 2001, p. 135).

- Activities are contextual. All activity is performed in contexts, and these are historic constructs. Cole (1996) makes an important distinction between context as “that which surrounds us” and context as “that which weaves together”. Activity is not only occurring *in* a context, but it also creates context through continual interaction and change. Engeström certainly describes the characteristics of activity theory as ‘contextual and oriented at understanding historically specific local practices, their objects, mediating artifacts, and social organization’ (Engeström, 1996). The expansive activity theory sets activity within a social and cultural context, but does not sufficiently theorise about the nature of context – for example contexts as historic constructs. Engeström (1993) points out the danger of the relative under-theorising of context: ‘Individual experience is described and analysed as if consisting of relatively discrete and situated actions while the system or objectively given context of which those actions are a part is either treated as an immutable given or barely described at all.’

- An activity system can understand itself. Human activity systems are reflexive; they have the possibility to analyse themselves, and through self-examination to reveal contradiction and to deliberately explore future paths without actually following them. This ability to hypothesise and predict is an essential aspect of any system that learns through introspection and self-awareness. We haven’t space for a detailed discussion of this issue, but note Giddens’ (1984) comment:

> ‘Human social activities, like some self-reproducing items in nature, are recursive. .. they are not brought into being by social actors but continually recreated by them via the means whereby they express themselves as actors. In and through their activities agents reproduce the conditions that make these activities possible.’

Thus, we suggest that sociocultural and activity theory, while providing a powerful analytic tool has its limitations. For the purposes of developing the Task Model, we have also explored an alternative theory of learning, Conversation Theory. It is a similarly extensive framework for analysing and designing the practices of learning and, like activity theory, it takes a systems perspective. It differs in that its prime focus is conversation, not activity.

5.2 A Theory of Learning as Conversation

An encompassing theory of learning based on conversation is Pask’s Conversation Theory (Pask 1976). It derives from cybernetics, the study of communication and control in natural and artificial systems, and its more recent extension to second order cybernetics, the study of the mechanisms by which a system can understand itself. The relevance to our Task Model is in its view of learning as a process of “coming to know”, by which learners in cooperation with peers and teachers, construct an interpretation of their world. This ‘radical constructivism’ (von Glaserfeld, 1984) extends the notion of learning as a constructive process beyond the individual to describe how organisations, communities and cultures learn and develop. The general approach makes no distinction between people and interactive

systems such as computers, with the great advantage that the theory can be applied equally to human teachers and learners, or to technology-based teaching or learning support systems.

Conversation Theory describes learning in terms of conversations between different systems of knowledge. In order to constitute a 'conversation', the learner must be able to formulate a description of himself and his actions, explore and extend that description and carry forward the understanding to a future activity. In order to learn, a person or system must be able to converse with itself about what it knows.

Learning can be even more effective when learners can converse with each other, by interrogating and sharing their descriptions of the world. We can say that the two people share an understanding if Person A can make sense of B's explanations of what B knows, and person B can make sense of A's explanation of what A knows. Thus, it is through mutual conversation that we come to a shared understanding of the world. Learning is a continual conversation: with the external world and its artefacts, with oneself, and also with other learners and teachers. The most successful learning comes when the learner is in control of the activity, able to test ideas by performing experiments, ask questions, collaborate with other people, seek out new knowledge, and plan new actions.

Laurillard (2002) relates Pask's theory to the realm of academic knowledge. Though primarily concerned with the application of educational technology to university-level teaching, the 'conversational framework' she puts forward can be applied to the full range of subject areas and topic types. The learning process includes the following aspects: apprehending structure, integrating parts, acting on descriptions, using feedback and reflecting on goal-action-feedback. As illustrated in Figure 4, technology may play multiple roles within the conversation space.

Figure 4: Role of technology in supporting conversational learning (adapted from Laurillard (2002)

Technology may take the place of the teacher, as in drill and feedback. The difficulty here is that the computer can hold a limited dialogue at the level of actions: “look here”; “what’s this?”; “do that”, but is not able to reflect on its own activities or its own knowledge. Although some systems have been developed which attempt to model the student, and to tailor feedback to the perceived student needs, the computer is not engaging in developing a shared understanding. And because it cannot hold a conversation at the level of descriptions, it has no way of exploring students’ misconceptions or helping them to reach a shared understanding.

Technology can also demonstrate ideas or offer advice at the level of descriptions, as with the worldwide web or online help systems, but their practical advice, at the level of actions, is limited.

Alternatively, the technology may provide the environment in which conversational learning takes place. It can extend the range of activities and the reach of a discussion, into other worlds through games, and to other parts of this world by mobile phone or email. The technology provides a shared conversational learning space, which can be used not only for single learners but also for groups of learners.

Activity theory and conversation theory complement each other in their analytic power and focus. Whereas activity theory can provide an analysis of activity systems such as classrooms, workplaces and learning

communities, conversation theory illuminates the process of coming to know, as a continual conversation with oneself, with other people and with interactive technology.

The theory of use, then, supports the general principle that communication and collaboration lies at the heart of an effective pedagogy for mobile learning environments.

6. Field Studies

We now turn to two field studies to understand learning in practice, and how efforts to learn are either supported or impeded by technology. As we pursue this line of analysis, the dialectical relationship between tools and tasks (i.e. how they mutually shape each other) becomes very evident. Both studies have been undertaken using qualitative methods of enquiry.

The first, (Waycott, 2004) is based on field studies in the workplace, and describes how handheld computers (PDAs) have been adopted as general purpose tools, and examines the related processes of appropriating new tools and shaping existing activities through the use of new technologies. Her central focus is upon the shaping effects of tools on behaviour and vice versa. In the second study, we report ongoing work, conducted by Vavoula as part of the MOBIlearn project, analysing people's learning behaviour in mobile settings.

6.1 Handheld computers and appropriation

Waycott (2004) develops an account, based within Activity Theory, of the dialectical process of technology appropriation and the shaping effect of technology on individuals and their social environment observed in her field studies. The term 'appropriation' is defined as the *integration of a new technology into the user's activities*, and Waycott emphasises that this is an active process, greatly influenced by the user's prior experience and expectations.

Some of the participants in Waycott's studies found that their PDAs provided an exact match to existing activity. For instance, someone who had secretarial training and had learnt shorthand found the use of the stylus very natural. Another regarded the use of the PDA as taking bits of the computer with them as they moved around the workplace, whilst another saw the value in taking meeting notes on the PDA (and therefore in electronic form) and transferring these directly to the desktop to form the basis of the document to be produced. On the other hand, unsurprisingly, other people found the small screen and awkward input methods too much to cope with, so limiting the usefulness of the device.

In a study of mobile workers who spent a great deal of their time travelling abroad on company business, Waycott identifies their needs in terms of support for aspects of their working life. These workers needed to keep their 'office persona' intact whilst away from the company HQ, so continuous access to such tools as email, diaries and word processors (to access and create documentation) was crucial. This group found themselves in frequent conflict between their devices, which consisted of laptops, desktops, and PDAs. The diary function was acknowledged to be very convenient handled

through the PDA, but this sometimes caused problems in synchronisation failure.

Following this study, Waycott introduces the Tool Integration Process to describe integration of new technologies into everyday activity (see Figure 5).

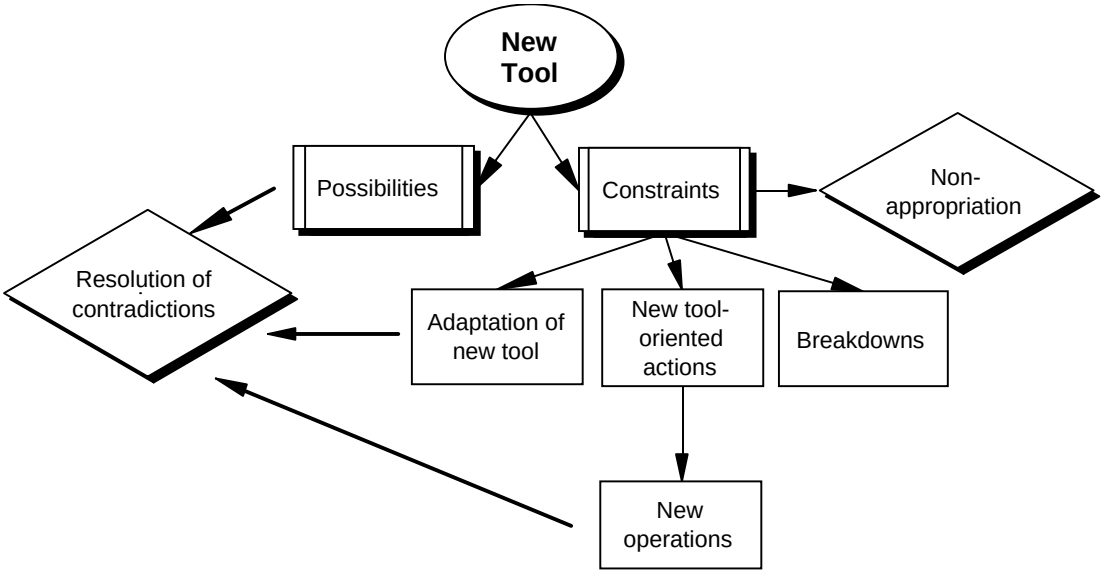

Figure 5: A model of the Tool Integration Procedure (TIP)

The figure illustrates considerations that need to be taken into account in the integration and appropriation process. Failure to appropriate can occur due to constraints of the device itself – a fairly simple case. Alternatively, breakdowns can occur between user expectations of the device and what it can actually deliver (Bodker, 1991). Otherwise, the tool is adapted to suit the user's activity, or new actions/operations are developed to fit with the tool and, consequently, use of the new tool may resolve contradictions in the user's activity system.

6.2 Field Studies of Mobile Learners

As part of the field studies for MOBIlearn, Vavoula has been looking at existing practices of informal, everyday learning, including instances of mobile learning. The aim of the study is to uncover how people learn on the move or outside their normal learning environment, with their currently available technologies. A diary-based method has been adopted for the purposes of the study. Participants are asked to keep track of their everyday learning episodes, making notes at the end of each day about the contexts where learning happened, the activities they performed, the objects they used, the people they interacted with, etc. The participants are briefed that learning episodes are:

> *"…occasions in the day where you feel you have learned something, some new knowledge or skill, or you have increased or deepened your understanding on a topic. This could be learning in any form: through formal classes and training sessions; during casual visits to places like museums, galleries and theatres; during informal meetings with friends; during travelling; etc. Please keep in*

mind that we are interested in all the different sorts of learning that you do in your everyday life and remember to put equal emphasis on both work-related learning, and learning that relates to hobby, leisure or community work"

The diary study is ongoing at the time of writing; however, we can report some preliminary results.

For the purposes of this study, we classify learning episodes that take place in our own space at the workplace, or at our home, as non-mobile (these are normally our familiar learning sites); then learning that happens elsewhere (other location at the workplace, places of leisure, friends' houses, outdoors) is taken to be mobile. There was an equal split between the reported episodes in the two categories.

Many similarities hold between mobile and non-mobile learning episodes: they both take place during the same range of events and at all times during the day, and are of varying lengths with longer episodes taking place in the mornings and afternoons while shorter ones dominate the evenings; they both involve the performance of a number of activities (typically up to three) and a number of learning objects (typically up to four); they both relate to various areas in life, such as work, housework, hobbies and community work; they both involve interactions with other people such as family, friends, colleagues, but also strangers and people from the media who are not directly involved in the learning.

Points of interest in the findings are the following:

- Web surfing and telephone calls are listed as events during which learning takes place. This cannot but be an indication of the incidental nature of some learning episodes.
- Most learning episodes (70%) last up to an hour. Surprisingly perhaps, short episodes (up to half an hour) are more often reported in non-mobile than in mobile cases, it therefore would *not* make sense to assume that mobile means quick.

- The most popular learning activities are discussion, reading, note-taking, information search, and reflection. Note-taking, discussions, observations, problem-solving, and collaboration were reported more often in mobile than in non-mobile settings. Some activities, then, are more likely to take place in a mobile setting than others.

- The most popular learning objects are the contents of conversations, and paper-based and electronic documents. The contents of conversations are used twice as often in mobile settings than in non-mobile. Again then, some objects are more likely to be found in mobile settings than others.

Our initial findings, therefore, do not demonstrate a clear and obvious split between learning supported in non-mobile settings, and learning supported by mobile devices – the situation is more subtle than that.

Thus, from the field studies discussed here, we articulate the central concept of our view of mobile learning which is that:

- **there is a clear separation between required functionalities and their embodiment in any specific technology.**

In other words, in a work situation or a learning situation, people know what kinds of functionalities (resources for learning) they would like around them to be effective, and will seek these out as and when they need them.

We also adopt the view of mobile learning expressed by other authors which is that:

- **it is the people that are defined as 'mobile', not the devices around them.**

For example, Sariola et al (2001) suggest that a technology-based definition of mobile learning is not sufficient – i.e. defining mobile learning as that learning which takes place through the use of mobile devices does not have educational relevance *per se*. The issue, rather, is that mobile learning is defined by virtue of the fact that it is the learner who is mobile, and is not defined by the devices they choose to use. In this sense, books are archetypal mobile learning devices that we have used for centuries. Defining mobile learning as that which takes place through the use of mobile devices also has serious limitations in terms of allowing us to understand how to construct a pedagogically sound mobile environment for at least two reasons. Firstly, sound pedagogy is not tied to specific devices – a pedagogical strategy can be expressed technically in many different ways, and we would suggest that pedagogically inappropriate uses of mobile devices is a confounding factor for many studies. Secondly, technical developments in mobile devices are sufficiently rapid that focusing our analysis around the use of existing tools is bound to limit our understanding and render studies almost immediately redundant as technical innovation proceeds apace.

People may or may not carry mobile devices with them – any device represents an embodiment of some of the functionalities a person needs, no more, no less. Mobile devices, such as PDAs, can be used in some very non-mobile activities – e.g. sitting at a desk in my office looking at web pages. Similarly a user may choose to use a mobile telephone in preference to a standard phone because the user's phone book is on her mobile, and it is easier to look up and dial via that than using the keys to enter the number on the standard phone. Or an office worker abroad may visit an internet café in preference to trying to connect a laptop in a hotel. The functionalities fit the need to work or learn on the move rather than desire for a particular technology. However, interaction between technology and activity is important, since it constrains or affords particular operations. A mobile phone may not afford web browsing, or an internet café may not offer access to a personal contacts list.

And as ambient and ubiquitous computing becomes a familiar part of our environment, we can assume that the routes for access to our mental

workspace become easier and more readily available ‘anywhere, any time’ – or even ‘everywhere, anytime’.[1]

7. The Task Model

Our discussion so far has led us now to the introduction of the task model itself. We have discussed the idea that there are two spaces within which learners move – the mental space which consists of required, or preferred, functionalities, and the space of possible actual embodiments of those functionalities in the form of devices. There is a dialectic between these two spaces – as the learner sees a device that has a good match to their requirements, she may choose to appropriate that technology and in so doing, integrate it into her activities, which will be shaped by that device. Waycott’s tool integration procedure (Figure 5) illustrates this process.

So we can see that there must be a dialectical relationship between the technological space, and the more abstract semiotic ‘learn-space’. A learner enters the task of learning with an objective – to augment knowledge and skills they may or may not already posses, and the output from this activity is a new set of knowledge and skills. But several other important factors impinge on this rather simplified process, and in our view, these other factors share the same dialectical relationship between a technological (or physical) domain, and a more abstract human, social – or as we describe it semiotic - domain. Adapting Engeström’s Expanded Activity System, this can be represented as an activity system as depicted in Figure 6.

The influencing factors are identified as Control, Context and Communication, which are adaptations of Engeström’s original ‘Rules, Community and Division of Labour’. This adaptation enables the diagram to capture the two spaces (technological and semiotic) and illustrates points at which the dialectic works. We believe that this relationship has not been

[1] In this discussion we are deliberately ignoring issues of privacy and security because the conclusions will be a theoretical description of mobile activities. In reality, many practical limitations will impinge upon this space of activities, but resolving those are not our concern at the present time.

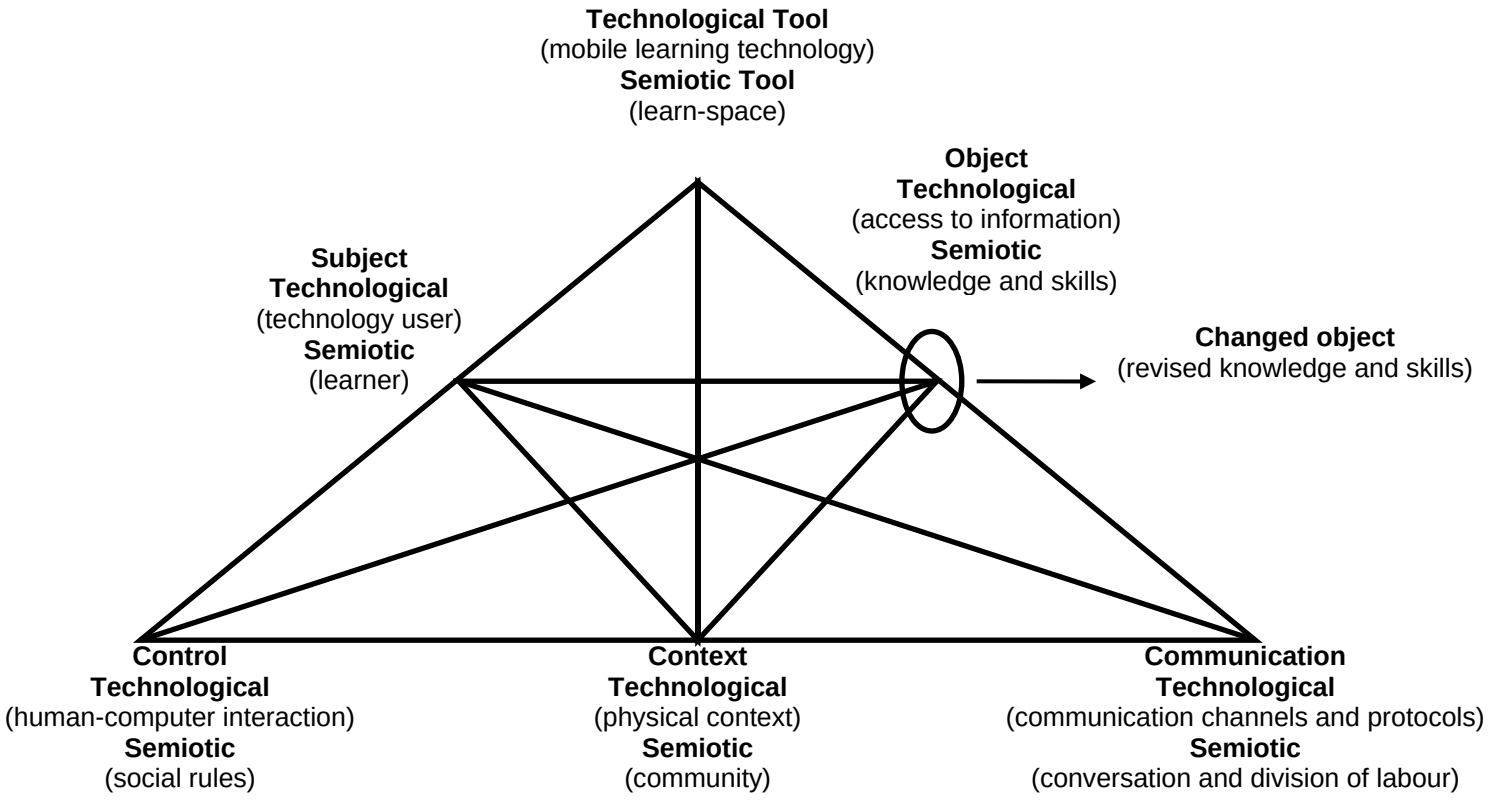

Figure 6: The Task Model for Mobile Learners

fully explored in studies of learners to date, but that it must be accounted for by any theory of technology augmented learning to understand how people adopt, adapt and use technology.

7.1 Control

We know that putting learners in control of their learning is one of the much vaunted benefits of technology enhanced learning (e.g. see Laurillard 2002). To a certain extent this is a technological benefit which derives from the way in which learning is delivered – if the learners can access materials as and when convenient, they can work through the materials at their own speed, revising and re-checking as they wish. This benefit can be lost, however, if the application is not useable – i.e. the user interfaces must be effective and fit for purpose, and expectations of the system's performance must be met.

However, technology use occurs within a social system of other users, and people can be easily influenced not only by what other users are actually doing, but also how they feel about it. Social rules govern what is acceptable (e.g. how to use e-mail, who is allowed to email whom, what kinds of document format should be used etc). The user's attitudes to technology can be influenced by what people around them think about it – i.e. are people resentful at having to use the technology, or are they keen and eager to try it out? And individuals can also express informal rules which capture the way they like to do things (e.g. never leaving documents on the desktop, but always filing them).

7.2 Context

The context in which learning takes place is clearly a significant factor, but the term has many connotations for different theorists. In the Task Model, we aim to pin down two important aspects of context – the physically embodied technological context, and the human, semiotic context (i.e. the community) within which learning takes place. We mention above the kinds of social rules that serve to control what users are likely to do. This node refers to how it is done. The community may consist of many related co-workers or co-learners who may or may not share the same current 'object' or objective, but may play a large part in what an individual may like to do.

7.3 Communication

The dialectical relationship between the technological and semiotic worlds is perhaps the easiest to see in the Communication node – if the system enables certain forms of communication, learners can adapt their communication behaviours accordingly, and sometimes find ways to subvert the technology (e.g. finding novel ways of connecting across networks). There have been many studies of the use of text-based communication as a substitute for live conversation (e.g. email, computer conferencing) – such communication is not the same as face to face discussion. But as has been demonstrated in the use of SMS text messaging with mobile phones, particularly by younger generations of users, if people see an opportunity offered by a device that they can exploit, then they will take it, regardless of the usability aspects involved. The perhaps surprising popularity of texting, in turn, has encouraged mobile phone designers to develop tools to support it (e.g. predictive text), so the dialectic rolls on.

7.4 Summary

As pointed out earlier, the aim of the task model is to provide a coherent account of how the activities are performed, the people involved, their contexts, the tools and technologies they employ, the structure of the tasks and an account of their cognitive processes, management of knowledge, and social interactions. This is necessarily a complex exercise, which relies on drawing together the three strands of information from theory, field studies and requirements. These are all mutually supporting, and the task model aims to hold all these elements in tension so that attention does not focus on one area to the exclusion of the others. Nevertheless, our current articulation is not considered to be complete. We have yet to consider more fully how to take into account the temporal element, and for that we still need something like Conversation Theory as a systems account of the process of coming to know. For the time being, Figure 4 appropriately captures this aspect.

The task model is not itself prescriptive (e.g. what contexts are important for what types of learning) nor do the elements need to be explicitly modelled in the technology (e.g. whether the technology should contain a computational model of the learner, or of the context). But these lower level considerations can now be explored through case studies, and further empirical work, to illuminate the model further.

8. Dialectical relations between Task Model and System Designs

The main purpose of the task model is not to create a hierarchical analysis of the task structure or to model of the mental states and operations of the principal actors (though it might include both of these), but to describe the interactions between the people and their tools and resources, and to analyse how people externalise their work, through representations such as notes and diagrams, the rules and conventions that influence the activity, and the terminology and patterns of discourse.

The task model provides the bridge to a cycle of iterative design that includes: specifying a design concept; generating a space of possible system designs; specifying the functional and non-functional aspects of the system; implementing and deploying the system. Testing is an integral part of the design process, with the results of the evaluation being fed forwards to provide an understanding of how to deploy and implement the system, and backwards to assist in fixing bugs and improving the design choices. Although this stage is based on a conventional process of interactive systems design (see Newman & Lamming, 1995), it gives equal emphasis to cognitive and organisational factors as well as task and software specifications.

The result of the process is a new socio-technical system consisting of new technology and its associated documentation and proposed methods of use. When this is deployed, in the workplace, home, or other location it will not only produce bugs and limitations that need to be addressed, but also engender new patterns of work and social and organisational structures. These become contexts for further analysis and design.

In terms of the MOBIlearn project, the use of the model enables us to capture the myriad possible interactions that learners may engage in as they roam around their respective environments, picking up and using devices as they go. Each of the three test scenarios can now be mapped onto the model, instantiating each of the nodes, and encapsulating the learners, their objectives, their context and their tasks.

The great advantage of this development is that the various scenarios can be instantiated according to the requirements, and this provides both a common structure, but also an individualised representation of each. From a design point of view, the MOBIlearn system can be considered successful if it enables all of these activities using a multiplicity of devices in different contexts.

Thus, we are able to provide structure to an enormously complex learning situation, which, from a design point of view, would otherwise be very difficult to engage with. This view also helps emphasise to the design team that designing strictly to one set of requirements from one scenario is likely to exclude the needs of other learners at other times. The use of the task model, however, keeps the overall needs to the fore. The pedagogic experts can also maintain a view of the components of the system which bear upon the space of possible activities – i.e. it is of little use specifying that learners must have access to wireless networks if there are none in the environment.

We set out to describe our approach to understanding the domain of mobile learning with a theoretical position that was rich enough to capture the complexity of the learners' activities and the contexts in which they occur. We believe that the proposed task model is a first step in this direction. Refinements will occur as field studies are conducted, and as new user requirements emerge. However, this model provides us with a research agenda for our developing work – we need to explore each of the dialectic relationships identified, clarifying and elaborating the activities people engage in, and how those can be optimised to support mobile learners of the future.

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