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## ABSTRACT

Designing, implementing and evaluating educational technology for a developmental project in mobile learning is largely uncharted territory. This paper reflects on the process, the role-players, their contributions and the framework that was adopted to co-ordinate and focus the team's efforts in the design of the initial prototype of a Information Gathering and Lesson Tool (IGLOO) as part of the MobilED suite. MobilED is an international collaborative project aimed at creating meaningful learning environments using mobile phone technologies and services. The paper expands on the use of the activity theory to guide the design of a learning environment and the incorporating of a tool dimension (social-technological dimension) in an effort to knit the technology perspective to the pedagogical aims. The usability, usefulness, formation of virtual learning spaces and communities are explored and contextualize by the results found using this framework.

## Author Keywords

Mobile ICT, Mobile learning, mobile technology, development, educational technology, activity theory, conceptual framework

## INTRODUCTION

From an African perspective, factors such as the general lack of infrastructure, sporadic supply of electricity, lack of skilled technical support, the high cost of installing and maintaining a network and the easy to use interface of mobile phones have contributed to the high rate of adoption of mobile technology (Traxler & Leach, 2006, p.6.2). This demand is still growing (Scott, Batchelor, Ridley, & Jorgenson, 2004) Mobile phones are set to be the most important networked knowledge exchange technology used in Africa (MobilED, M Ford & Botha, 2007a, "MobilED ", 2006). This combined with afore mentioned limitations are the most important considerations for using mobile phones as potential learning tools (M. Ford & Botha, 2007b). This paper gives a brief introduction to MobilED's use of development research methodology and motivates the adoption and the expansion of **the activity theory** as a conceptual framework. A discussion expands on the incorporation of "tools" as a component and the implications of the ensuing mediated components.

## MobilED

MobilED (Mobile Education) is an international collaborative project aimed at creating meaningful learning environments using mobile phone technologies and services (MobilED Research Framework, M Ford & Botha, 2007a; MobilED Research Framework, "MobilED research framework." 2005). The MobilED project has four key scientific, technical and developmental objectives:

1. To explore and comprehend the cultural, social and organizational context of young people in and out of school in three developing countries (South Africa, India, Brazil) and in one developed country (Finland) as they utilize their mobile phones.
2. To develop research-based models and scenarios of how mobile phones could be used for teaching, learning and the empowerment of students within and outside the school context.
3. To develop concepts, prototypes and platforms that will facilitate and support the models and scenarios thus developed.
4. To test, evaluate and disseminate the scenarios, models, concepts, prototypes and platforms (MobilED research framework, "MobilED research framework." 2005)

The *challenge has been to use the unique capabilities of the mobile phone* as technology tool in a pragmatic way and not to try and emulate the functionalities of a desktop computer. The research has focused on developing scenarios in general and South Africa in specific (Leinonen & Sari, 2006)

Designing for development presented specific problems and challenges for the research team consisting of programmers, educational researchers, educators, project managers and other institutional committees. As a diverse group of role-players it was important to ensure cohesion and to develop a common vocabulary and understanding of field specific concerns. The notion of what was possible, probable and eventually reachable within specified boundaries needed to be facilitated.

The development of prototype technology was to be grounded in local context and fed by both the appropriate pedagogical models and the potential of the technology itself. There emerged a dual nature to our research as we negotiated the incorporation and facilitation of both the technology and pedagogy. This dual nature of mobile learning is well documented (Ahonen, Pehkonen, Syvänen, & Turunen, 2003; O'Malley, Vavoula, Glew, Taylor, Sharples, & Lefrere, 2003; Schwabe & Goth, 2005; Syvanen, Beale, Sharples, Ahonen, & Lonsdale, 2005; Zurita & Nussbaum, 2004) The focus of the individual research often narrowed to either technology or pedagogy.

There is no consensus in literature as to a definition of what mobile learning is and its identity rather lies in the unique possibilities that this learning technology is able to support. In general, however, technology-driven research tends to define mobile learning in terms of learning by means of mobile devices and this emphasis on technology influences and extends to the definition of learners, referred to as "m-learners" and their interaction with the technology as "acquire and learn through a wireless transmission tool anytime and anywhere" (Chen, Kao, Sheu, & Chiang, 2003). This view contrasts sharply with research driven by pedagogical concerns where mobile learning is approached in terms of an enriched or extended learning environment (Rochelle, Vahey, Tatar, & Penuel, 2003; Young & Vetere, 2005).

The negating of the importance of the pedagogical implications for a mobile learning environment has proven disastrous and resulted in "almost total lack of adoption by users (Er & Kay, 2005)." It leads to the conclusions that the pedagogical underpinning and the technology that assist it are interdependent. Focusing on only one of the perspectives inevitably creates discord as a pedagogically sound mobile intervention cannot take place without acknowledging the technology to support it. In the same way a brilliant technological tool unsupported by sound pedagogic is educationally useless.

In the MobilED initiative the aim was in developing not only technology but learning scenarios as well. Addressing mobile learning from a pedagogical perspective (perhaps best described as a descriptive endeavour) as well as from a technology perspective (a constructive or engineering endeavour). This needed to be reflected in the planning and eventual assessment of the "technology in action". Our research group needed a new approach to integrate and navigate these perspectives the resulting creative tension between the two disciplines. This while still taking into account the lessons learnt from the developed world, but contextualizing them in the realities of Africa.

#### *Activity theory as theoretical framework*

A literature survey revealed that the implementation of mobile technology in an educational setting is beset by the same challenges as other fields of study such as HCI, where people act with or through technology. Kaptelinin and Nardi (2006) emphasizes that the activity theory is a useful theoretical framework for negotiating the complex structure of users and their needs on the one hand, and the technology and its possibilities on the other, thus incorporating the dual nature of implementing mobile technology into education. Furthermore the underlying tenets of the activity theory, which are encapsulated in the notion of people acting with technology, strongly reflect the social constructivist underpinnings of our research. These are:

- the intentionality of human action;
- the asymmetrical view of people and the things of the world;
- the acceptance of human development; and
- the shaping of culture and society by human activity (Kaptelinin & Nardi, 2006, p.10).

#### *Activity Theory*

Nardi (1996) describes the activity theory model as a powerful, clarifying descriptive tool rather than a predictive theory (p.4). Activity theory does not attempt to pass itself off as a theory of learning; instead Engeström's (1987) theory of expansive learning incorporates activity theory-orientated pedagogical concepts. Mwanza and Engeström (2005) states that :

*This perspective on teaching and learning highlights the potential impact of new tools as vehicles for transforming activity and also of those engaged in activity (p.458)*

The Activity theory acknowledges and seeks to understand the unity of consciousness and activity. It's origin is as a social theory of human consciousness and views interaction with people and artifacts in the context of everyday practical activity as the result of that consciousness (Kaptelinin & Nardi, 2006, p.8).

Vygotsky, distinguishes between two types of mediating agents in human activity, technical tools and psychological tools states in connection to technical tools:

*The tool's function is to serve as conductor of human influence on the object of activity; it is externally orientated; it must lead to changes in objects. It is a means by which a human external activity is aimed at mastering, and triumphing over, nature. (Vygotsky, 1978, p.55)*

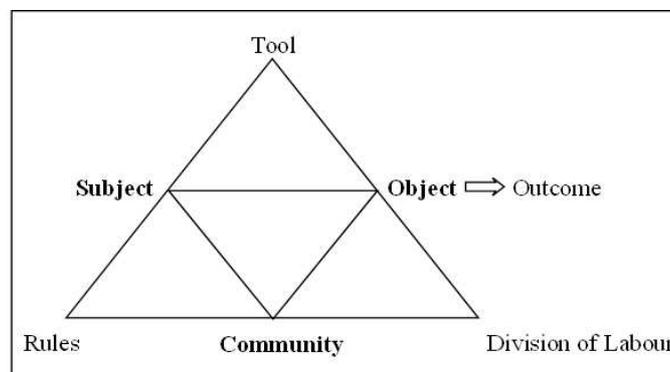
His psychological tools have different nature:

*It is a means of internal activity aimed at mastering oneself; the sign is internally oriented. (Vygotsky, 1978, p.55)*

Both these categories of tools mediate activity and the distinction between the tools as a means of labour and tools as a means of social intercourse are acknowledged (Engeström, 1987, p.60; Vygotsky, 1978, p.54)

*An activity is undertaken by a human agent (subject) who is motivated toward the solution of a problem or purpose (object), and mediated by tools (artefacts) in collaboration with others (community). The structure of the activity is constrained by cultural factors including conventions (rules) and social strata (division of labour) within the context (Ryder, 1998, p.4).*

These different components are shown in Figure 3 below. The expanded triangle model of Engeström ((Ryder, 1998, p.4) is based on the concept of "activity based on material production, mediated by technical and psychological tools as well as by other human beings (Engeström, 1987, p73)." From this Engeström incorporates the **community** as an additional component of human activity, placing tools in a mediatory relationship to intentional human interaction. In terms of this theory, human activity is attributed to the specific needs that human beings have to accomplish objectives. The activity then is mediated by one or more "tools" and is reflected through people's actions as they interact with their environment.



**Figure 1: Engeström's Expanded Triangle Model (Mwanza & Engeström, 2005)**

From this the students as users are portrayed as the subjects interacting with objects to achieve desired pedagogical outcomes. These object orientated activities of the users are mediated within and between the users in a given *community* of practice. The mediators are the rules and division of labour and represent the nature of the relationships that exist (Mwanza & Engeström, 2005).

#### *The mediating tool as component*

In contrast to the activity theory view of a tool, Marshall McLuhan (1994) asserts that :

*(It)...merely underlines the point that "the medium is the message" Because it is the medium that shapes and controls the scale and form of human association and action (p.9).*

With this dictum, he confirmed the link between the medium used and the user who uses the medium. The idea that the technology more than mediates an activity but also changes the subject is raised several times by Marc Prensky (2001b): *It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today's students think and process information fundamentally differently from their predecessors. (p.1)*

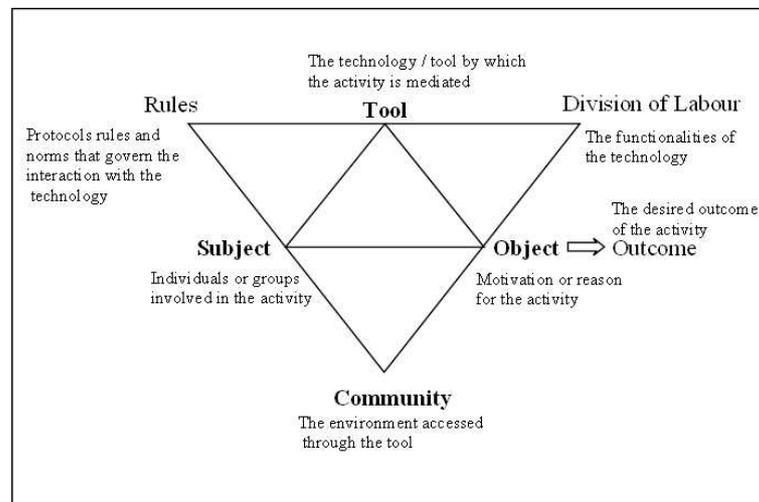
This sentiment is repeated in Educating the Net Generation (Oblinger & Oblinger, 2005):

*"The technologies available as a generation matures influence their behaviours, attitudes, and expectations (p.6.2)."*

Technology becomes more than merely a means that allows an activity to take place; the technology contributes to the nature of the activity, affects the social interactions of the users and the community in which these interactions take place and ultimately allows access to virtual environments in which many of the activity will take place.

Kaptelinin and Nardi (2006) acknowledge that the concept of tool falls short of expanded activity describing all types of technology, arguing that some applications can be considered more an environment, and comes to the conclusion that some artefacts seem to not be tools. They suggest that these environments be seen as mediating the relationship between subject and object. These ideas they however dismiss as, "environments", from an activity theory perspective, are understood as "the world with which the subjects interact (p.255)."

The object orientated action of a user utilising, for example, his mobile phone to mediate an activity, is subject to various protocols, rules and norms as a result of the technology and the virtual communities that are accessed. This is especially true when considering mobile technology because of the personal nature of the technology and the frequent overlap of the real and virtual worlds. (Botha, Cronje, & Ford, 2007; Rochelle et al., 2003; Schwabe & Goth, 2005). To this end we propose the incorporation of technology as a component in the activity (Botha, Ford, Aucamp, & Sutinen, 2007) as represented in Figure 4 below.



**Figure 2: The technology tool component with mediational relationships**

The Figure 4 above is a representation of the technology dimension that comes into existence when the "technology tool" is incorporated as a component in the activity.

## ANALYSIS

The incorporation of technology as a component into Engestrom's (1987) extended activity model offers a new perspective on human activity with technology and provides an additional set of concepts for describing and understanding those activities. In order to further the discussion a brief overview of the components and their ensuing mediating relationships are given.

### *Subject component*

The user as subject in the physical world acts with and through technology.

*In activity theory people act with technology; technologies are both designed and used in context of people with intentions and desires. People act as subjects in the world, construction and initiating their intentions and desires as objects. Activity theory casts the relationship between people and tools as one of mediation; tools mediate between people and the world. (Kaptelinin & Nardi, 2006, p.10)*

The intentional object orientated activity initiated by the user holds in the physical world as well as in virtual environments and communities. Although the human as subject can only enter these communities through the mediation of the tool the intention to act is still situated within the person. The tool as technology can prompt the person to act but the final motivation or intention to act is still that of the individual as user.

Mobile technology, because of its personal and portable nature is often used by individuals to organise their day, but it is still the user who initially instigates an action. For example an alarm that acts as a reminder is initiated by the user and the user still has the final will to act on the alarm or to disregard it. The reaction of the mobile technology is initiated by the original action of the individual.

### *Object component*

The object is the motivation for the intentional interaction of the human activity. The object focuses the actions of the user and provides an incentive for the activity. The sending of a sms might initiate a number of interactions with the technology and provides the incentive for these actions. If the user is unable to navigate the rules, protocols and functionalities of the device the objective cannot be achieved and the user experiences frustration.

### *Community component*

The community that contextualises the activity is either the real world or an environment that can only be accessed through the application of the technology tool. This virtual world is characterised by instances where it "leaks" into the real physical world. This virtual world provides the arena for the activity with instances where it overlaps the real world. The individual can for example, be absent from the real world community but still present in the virtual community or present in both at the same time. The virtual environment tends to be 24 hours seven days a week presence as, often, people from different real world time zones construe such communities. With some users and uses of technology it is possible to be present in the virtual world and the physical world, for example carrying on a instant message conversation while being in a lecture.

### **Tool component**

In activity theory, the analysis of tools includes the actual use to which tools are put as well as the setting in which this process occurs. *"For the tool reveals itself to us fully only in use"*(Bannon, 1985). Activity theory interprets a tool as an artefact that people use to perform activities. By extension tools may also be understood not only in terms of the *use* to which they are put also the *access* the user gains. Furthermore the technology has no meaning in isolation; meaning comes only through the incorporation into social and cultural practice.

Bannon continues to say that a tool works well if it allows the subject to focus on the object without the subject itself becoming the focus of attention (Bannon, 1985) This approach describes how technology appears to its user *in use* (Nardi, 1996). The mobile phone only has use in the context of how usable it is for the individual. When a student want to access a mobile community the mobile phone itself becomes the vehicle through which this action is made possible. The mobile phone is however not the community or the access.

Reflecting that "The tool component" is comprised of the technology or tool used to mediate the intentional object orientated action of the individual to achieve a specific objective, its incorporation results in two new mediatory relationships. To distinguish between the tool component and the community component the mediational aspects will be termed the tool rules and the tool division of labour. These are briefly discussed.

#### *Tool rules:*

This relationship is characterized by norms, rules and protocols that regulate the user's interaction. These "tool rules" mediate the subject's interaction with the technology. Examples of such rules that govern the use of mobile phones as tools are predictive text for sending SMS and the variants in navigation found in the interfaces of different models of phone. Holzinger, Nischelwitzer, and Meisenberger (2005) states:

*The phenomenal growth in mobile computing, whereby a parallel growth of user sophistication has failed to take place, will increase the need for future research in fully adaptive and sensitive interfaces, aware of the requirements and proficiency of users (Conclusion and Future Outlook).*

This relationship reflects the arena where the user interact or meets the technology and the user interface lies within this mediating relationship as "user-system" interaction, a too narrow a phenomenon to construe an activity (Kaptelinin & Nardi, 2006). Reflection on this relationship offers the researcher opportunities to incorporate not only the ease with which the user interacts with the technology but also the nuances in usage occasioned by each variant form and functionality of the technology. This would enable an understanding that not only acknowledges the user's possible ignorance of an interface or a technology but places it into a design perspective as subject to the activity.

These rules can be explicit, as are classically incorporated in user manuals provided with new technology, or apparently implicit as in predictive text. Failure by a user to navigate these rules renders the technology useless to the user. The 'Net generation'(Oblinger & Oblinger, 2005) or 'Digital natives' (Prensky, 2001a) prefer not to read instructions and intuitively navigate these interfaces by trial and error (Oelofse, De Jager, & Ford, 2006).

#### *Tool division of labour*

The relationship between the tools and the object is characterized by the specific abilities of the technology to support the user in achieving his objectives. An example of such mediation would be the use of a video by one pupil to record an event, where another pupil might have had to use a voice recording because their phone does not support a video function. The relationship can thus be interpreted as the specific functions of the tool that can be accessed to reach a specific outcome.

This relationship offers researchers opportunities to reflect on the functions that are available and their adequacy in relation to the object. It would also direct the formation of groups in situations where there are limited resources and a pooling of resources are needed. An important consideration in disadvantaged communities where insufficient funds are available for the financing of educational initiatives.

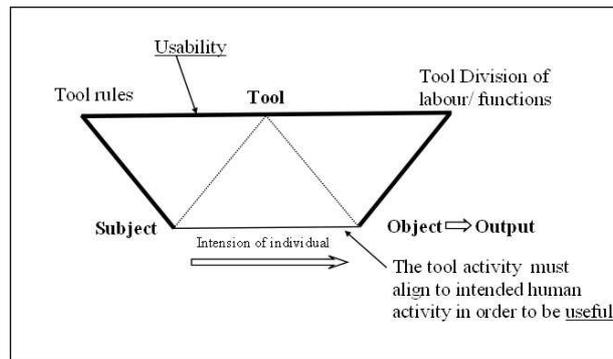
## USABILITY AND USEFULNESS

### *Deliberation of concept*

Ideally technology should support the individual in his endeavours to realise his intentions through the tool. According to Sneiderman (2002):

*Successful technologies are those that are in harmony with user's needs. They must support relationships and activities that enrich the users' experiences. Information and communication technologies are most appreciated when users experience a sense of security, mastery, and accomplishment (p.2).*

For technology to have an impact on education, it should be designed in such a way as to support the actions of the participants in day to day educational practices (Gifford & Enyedy, 1999; Kaptelinin & Nardi, 2006). Considering a definition for the usefulness of a tool as the extent to which the tool supports the intentions of the individual, it can be mapped on the social technological perspective of the activity theory as in Figure 5 below.



**Figure 3: Usability and usefulness of a technology tool**

In Figure 5 the object provides the motivation for the subject's directed intention (Engeström, 1987; Kaptelinin & Nardi, 1997, 2006). This motive translates to operations, actions and activities performed by the individual. However if these operations can only be negotiated through the tool, the relationships mediated by the tool as component come into play. These relationships are the "tool rules": the user interface and the rules and protocols associated with the technology, and the "tool division of labour": the functionalities or capabilities of the tool.

For each separate function of the tool there will be a separate set of rules, norms and/or protocols that the user needs to navigate. So for example, in single function tools, there will be only one set of rules, norms and/or protocols. In mobile phones the different functions tend to have only one set of navigation rules and contribute to the ease of use of this technology. The usability delivers a perspective as to the user's ability to successfully negotiate these two meditational aspects. If a user is termed skilled with a given technology it would then imply an ability and fluency to navigate the tool rules and the functionality of a given technology. The extent to which the user will be skilled in the use of other technology depends on the similarity of the meditational aspects of the new technology. The usefulness of the tool can be interpreted as the alignment of the activities that the tool can support with the intended activity of the person; however, the usability of a tool does not guarantee its usefulness. An objective which would necessitate the use of diverse functionalities, each with subsequent rules of engagement would not be appropriate technology for a novice user. If, however, such technology is introduced it would seem the best course of action to first introduce the functionalities and rules associated with each, individually, to minimize user stress.

### *Virtual Communities*

Development viewed from the activity theory perspective is a socio-cultural endeavour but also influenced by technology as it becomes more imbedded in our society. Some socio-cultural activities are so totally immersed and dependant on the availability of technology as tool that they can be viewed as a social-technological activity. People are not only acting *with* technology (Kaptelinin & Nardi, 2006, p.10) but *through* technology. For example online communities, virtual spaces and environments cannot be accessed without engaging with technology and the failure of technology to support this access and ensuing interactions cause a breakdown in the activity. In the event of the unavailability of alternative paths to facilitate the activity the activity cannot take place. This concept of tool accessed communities is illustrated briefly.

The loss of a phone by a teenager is often met with exaggerated emotion (Oelofse et al., 2006). The implications are however that the individual, irrespective of the motivation, cannot access or take part in activities in the virtual environment. He is so to speak out of the "social loop" The technology becomes more than a mediator it is the "portal" through which the individuals object orientated activities take place.

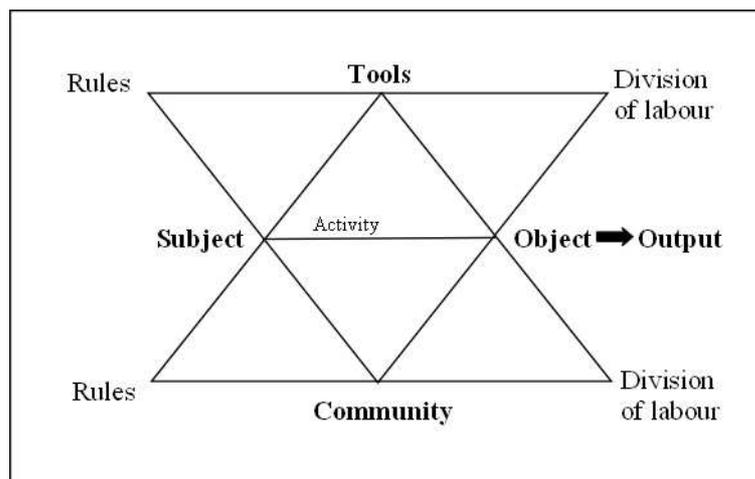
The individual accessing his emails is actually accessing a virtual community (Ducheneaut & Bellotti, 2001; Kaptelinin & Nardi, 2006) through the use of technology. This virtual community is superimposed over the real world. Ducheneaut and Bellotti noticed *"that even when collaborators work in plain sight of one another as in MediaWorld's open-plan spaces, they still send each other a good deal of e-mail (p.7)."* This virtual environment can be accessed in various ways

from alternative real world sites but exists only virtually and access is gained by acting through technology. From a developing countries perspective this paints a very bleak picture as the lack of suitable technology immediately implies the total exclusion to virtual communities and environments and the activities that take place in them. From a developing countries perspective this paints a very bleak picture as the lack of suitable technology immediately implies the total exclusion to virtual communities and environments and the activities that take place in them.

## CONCLUSION

What implications would this extension to the activity theory hold for design and implementation of mobile learning piloting? The relationships that unfurl and present themselves are primarily another tool in researcher's repertoire to further understanding of phenomena. These relationships are best viewed as interrelated and part of a whole. Presenting the interactions of users with the technology and community can be presented as in Figure 6

below.



**Figure 4: Technology incorporated as component.**

This representation aims to incorporate the technology as a means by which the user mediates activities but also as a means by which the user accesses environments. It allows researchers to view the technology in situated action so to speak while reserving a place for the individual as the initiator of interaction, recognizing the importance of the users experience and intentionality unique to humans. The community that comes into being when individuals act through technology, results in a blended real world/virtual world environment that overlaps and influences each other. The user's ability to simultaneously inhabit both worlds are incorporated in this way.

Enabling designers, researchers, funders and practitioners to speak a common **language while allowing for the interests of all the role players**, make for more productive collaboration. It enables the pooling of resources towards a common understanding of the desired outcome and lays the groundwork for discussions. This design is by no means meant to be a panacea but rather a lens for understanding.

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