A conceptual framework for ubiquitous mobile environments.

Carolina Islas Sedano\textsuperscript{1}, Adele Botha\textsuperscript{2}, Jan M. Pawlowski\textsuperscript{3}

\textsuperscript{1}Department of Computer Science and Statistics, University of Joensuu. Email: cislas@cs.joensuu.fi
\textsuperscript{2}Meraka Institute, Pretoria, South Africa. Email: adele.botha@gmail.com
\textsuperscript{3}Information Technology Research Institute (ITRI), University of Jyväskylä. Email: jan.pawlowski@titu.jyu.fi

Introduction
The aim of this paper is to reflect upon and develop a conceptual framework that addresses the relationship between real and virtual life, with a particular focus on mobile gaming as one potential methodology for learning. The comprehension of the virtual – real life relationship is relevant not only to mobile gaming, but also to the ongoing discussions about and development of ubiquitous computing.

We refer to “ubiquitous” or “pervasive” computing when the computer becomes part of the real life environment of human beings, in contrast to previous digital technological applications where the objective was to bring a person into a computer generated world [1]. To facilitate this characteristic of ubiquitous computing, the personal digital access is always accessible and the connectivity is thus “always on” [2], a continuous presence in our lives. However, this characteristic of ubiquitous computing implies a blur between reality and virtuality in most environments and situations [3, 4].

An understanding of the discourse between the realms of reality and virtuality and how this impacts on the formulation and integration of ubiquitous daily life applications, support the call to computer scientists to design ubiquitous systems that consider the user’s knowledge, preferences and personal goals [5, 6]. Furthermore, programmers must take into account not only the users’ needs, but also their cultural and social realities in the development of effective applications [13].

If one considers a mobile phone as a digital device with computer capabilities used by multitudes of subscribers worldwide [7], it is safe to assume that the number of individuals using ubiquitous computing is increasing constantly. The mobile phone not only transcends traditional barriers like gender, culture, educational level, geographical area or economical status but users are potentially in a position to become lifelong learners using their phones as personal technology to connect to the information society and to broadcast and share their reflections. As the technology becomes more function rich, the potential of reflections increase as users spontaneously adapt the functions of the mobile device in learning and living. To accommodate and support this spontaneous learning with ubiquitous technology, the understanding of which objects should interact according to specific environments, content and contexts remains very relevant as practitioners plan the creations of relevant ubiquitous systems in different contexts. Within this contextualization of mobile applications it remains important to understand how users navigate between virtuality and reality, as the realms blend to form the users unique understanding of the world.

Scholars [17,18] in the game research discipline have already emphasized that not only is the understanding of the game (the application) important but also the comprehension of the game experience from the player’s perspective (the user). The application and user furthermore operate in different layers (reality and virtuality) of experience which also needs to be taken into consideration by the researchers. Findings from the work done in the games genres, including mobile gaming and pervasive gaming towards the game experience and how the behavior of the player’s real world is shaped by their experiences in the online gaming are relevant to ubiquitous computing. However a common research agenda is needed in order to support the understanding of how ubiquitous mobile environments support the fusion of virtual and real connectivity in different contexts.
Until now, most of the research done in ubiquitous applications has focused on the development of complex ubiquitous-pervasive applications, with special emphasis on location information, or the evaluation of diverse systems [6,8,9]. However there is no clear understanding of how the incorporation of real life objects into virtual dynamics can affect the outcome or experience of a system within the bigger framework of an individual's personal context and environment. In this paper we seek to explore and understand this phenomenon by reflecting on an expanding model of the Activity Theory with a specific focus on mobile technology. Furthermore we explore whether the SECI model of knowledge creation could be related, at some level, to this expanded model of Activity Theory. A reflection of this process will offer us a new perspective in the understanding of ubiquitous applications. To facilitate our explanation, we used mobile gaming as an example of a type of application that everyone has access to at any time for as long as they have a mobile phone.

Understanding Digital tools using Activity Theory
Our first question is whether Activity Theory (AT) can support the understanding of the use of digital tools. Any activity in which a subject requires the use of digital technology should be analyzed carefully. This tool cannot be compared easily or in a straightforward fashion to non-digital tools, due to the fact that digital tools present a dualistic relationship between hardware and software [12]. The objective of this section is to create a common understanding of what a digital tool is and how Activity Theory can help to analyze scenarios. This explanation can evolve into a thesis on its own and the attempt here is to briefly create a common understanding of this specific type of tool for the sake of the enrichment of the discussion dealt with in this paper.

Digital tools, in contrast to other non-digital tools, present a unique attribute: they are composed of hardware and software. Additionally, software is something that exists and is needed for the hardware to perform a certain function. However the software is not touchable, what we can actually touch is the hardware. This fact presents challenges not only to users trying to comprehend the nature of a digital tool, but also to researchers attempting to make proper ontological definitions of this type of tool and of computer science as a whole. Independently of the ontological and epistemological lack of clarity concerning the digital tool, its presence and impact in our modern society is imminent [12].

With digital tools that are distributed worldwide, we are aware that the developers and the users, in a great number or cases, do not share the same context. As a result of this, a whole set of differences is present even if we consider a digital tool as a neutral tool. Specially, this can be stressed in cases where the end users have never experience the virtuality and they have no concept of it on the one hand, while on the other hand developers see virtuality as a normal and natural everyday experience, which does not need further reflection. We consider the virtuality as ubiquitously imbedded with the reality of our modern era. This experience of virtuality varies greatly among individuals as they act not only with but through the digital tools in the form of personal mobile devices. Furthermore in order to understand the essential digital tool and in consequence the development of contextualized digital applications, a paradoxical reflection should take place. It is not enough to understand the end users, but one must also understand the creators of such tools and build an empathetic dialogue between them.

Thus, any tool that does not allow access to a virtuality, we consider as a first level tool, while any tool that is used to access, modify and interact in any form with a virtual space is a second level tool due to it dualistic nature. It is needed to review theories and models that make use of second level tools, in order to have a deeper understanding of them. This, in turn, will support more effective development and implementation among individuals.

Historically, Vygostky to Leont’ve [14, 16] founded the concept of activity based on material production, mediated by technical and psychological tools as well as by other human beings [14:73]. Human
Computer Interaction (HCI) adopted the use of activity theory in the mid 1980’s as one perspective of analysis [15]. AT is therefore a conceptual system that supports the analysis and understanding of human activity. It is a social theory of human consciousness, construing consciousness as the product of an individual’s interactions with people and artefacts in the context of everyday activities [16]. The whole concept, as well as each one of its elements, presents different levels for analysis. Furthermore the subject’s understanding and awareness is in a constant process of flux as a result of the continuous knowledge acquisition of each individual as he/she pursues his/her goals and life experience.

However, originally the tools referred to in AT are not of a complex digital nature. We can observe that a digital tool presents additional interactions and characteristics than a non-digital tool, therefore, it is needed to review the AT use in HCI accordingly. The harmony or discrepancy between the virtuality and reality of the users while using a digital tool, has direct implications in their activity. Thus, the analysis and understanding of digital systems should go beyond the usability or user interface levels, but should include the comprehension between the reality and virtuality experience of the users. Additionally, it is necessary to understand the crucial process of knowledge acquisition as a key activity.

**Expanded AT model with the awareness of the digital tools.**

To understand the use of tools of the second order during the development of ubiquitous applications, we suggest using the expanded Activity Theory (AT). This expansion focuses on the different relationships relevant to the use of digital tools. In addition, we suggest that the SECI model, considered as a paradigmatic example of knowledge acquisition, might be a complementary instrument for the understanding of the expanded AT.

In the expanded AT model adapted by Botha [8] the significance of the importance of understanding the role of the modern digital technology along the traditional AT (Figure 1) was stressed.

![Figure 1. Activity Theory model using modern digital technology](image)

In this adapted model, the subject’s activity is placed between a set of rules and division of labour from two different spheres. There are two distinct dimensions, the one describes the subject’s physical reality, and the other describes the virtuality entered in through use of the tool. The rules and division of labour which operate between the real life and the virtual life might not be harmonious, or might present different levels of comprehension within the subject. In table 1 we exemplify each one of the components of this theory through an example of multiplayer mobile gaming.

<table>
<thead>
<tr>
<th><strong>Component</strong></th>
<th><strong>Brief Description</strong></th>
<th><strong>Example</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject component</td>
<td>The user as subject acts with and through technology to achieve an objective. These activities take place through or with the use of</td>
<td>A player who wants to play a game on his mobile phone.</td>
</tr>
<tr>
<td>Component</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Object component</td>
<td>The object is the motivation that the user has for the activity. It guides and gives direction to the activity. This component might represent different cognitive layers of motivation in the subject triggered by the object.</td>
<td>She wants to socialize, there is nothing better to do and it might be enjoyable.</td>
</tr>
</tbody>
</table>
| Community component | The community that contextualises the activity is either a virtual environment that is accessed through the technology or is a physical community that surrounds the user and in which the user is embedded. This component is mediated by two relationships:  
  >> *Rules*, which are the protocols and traditions that are embedded in a community and by which it functions. Often this is knowledge that is taken for granted and difficult to externalise.  
  >> *Division of labour*, which is the way in which the people in this community divide labour to achieve common objectives.                                                                                                                                                                                                                                                                                       | The player in real life is a middle class citizen in India.  
  She presents a set of rules, traditions and values that were transmitted to her through her family and society and she hasn’t live abroad. However, in the multiplayer mobile game she might be the Indian from her region and she is surrounded by individuals from all over the world, with different sets of rules, traditions and values than her own.  
  Nevertheless she needs to learn new and different rules, traditions and values inherent to this virtual space in order to play this specific mobile game.                                      |
| Tool component    | The tool is an artefact that the subject uses to perform activities. It has no meaning in isolation but is given meaning by its incorporation to achieve an objective through an activity. This component is mediated by the following relationships:  
  >> *Tool Rules*: This describes the protocols and rules that a subject should be able to navigate to use a tool.  
  >> *Tool division of labour*: The tool division of labour refers to the different functionalities that are incorporated in the tool.                                                                                                                                                                                                                                                                                 | The mobile phone alone does not give any meaning to any individual. It is just an object. It is worth clarifying that according to the context the possession of specific objects offers a status value.  
  However, the mobile phone functions as a gateway to communication for the user, furthermore this “object” helps her to achieve her goal to communicate and reflect, and hence the object enhances its meaning for the subject.  
  In this example the phone works as a portal. In order to access the virtual dimensions she should have the necessary proficiency in navigating the phones functionalities. Additionally she needs to understand the game in order to play it. This becomes a challenge when the rules and meanings imbedded in the game are completely outside her real context and understanding. |

If the subject while using a digital tool, faces a new real virtual situation that involves different layers of information, events and context than the ones known to him and his particular physical reality, then the subject needs to develop an ability to handle this current conflict while navigating these two realities. This process might be complex and it will require the creation of new knowledge. Additionally, this knowledge creation might require the support of the virtual and/or real community, which can be the same or different ones.

To better understand and analyse this knowledge creation process, we use the SECI model [9]. Nonaka & Takeuchi [9] state that knowledge conversion interacts in a spiral of knowledge creation through the following components: socialization, externalization, combination, and internalization, which also can be seen as activities (Table 2). We suggest that those components, are present as long as the subject performs...
the activity, hence the knowledge acquisition process lays along the activity line while the activity takes place (Figure 2).

Table 2. Description of the SECI model and example

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialization</td>
<td>It refers to the acquisition of tacit knowledge through sharing experiences.</td>
<td>A player while playing will be constantly imitating, observing and practicing. Those activities support the acquisition of tacit knowledge of the game, the device, her location, etc. In addition to further elements as what is fantasy and what is real. At the same time she is bringing in her own values and question in the game, and probably bringing her reflection out of the game experience into her real life.</td>
</tr>
<tr>
<td>Externalization</td>
<td>It refers to the knowledge creation activity (from tacit to explicit knowledge) due to the dialog or collective reflection. Nowadays this socialization can take place face to face or virtually.</td>
<td>The player expresses her knowledge and/or needs through the channels that are available and suitable to her. These channels may be real or virtual.</td>
</tr>
<tr>
<td>Combination</td>
<td>The creation of explicit knowledge while bringing explicit knowledge from diverse sources.</td>
<td>The exchange of information between the player and other sources (real or virtual) supports the creation of more explicit knowledge for the virtual or real life.</td>
</tr>
<tr>
<td>Internalization</td>
<td>Internalized the experience.</td>
<td>The effects of the game process and experience (virtual and real) in the player are internalized.</td>
</tr>
</tbody>
</table>

Our combined model provides a visualization on how an individual reflects while conducting a practical activity through a knowledge creation process. Furthermore, when the activity is mediated with a digital tool, the subject has access to a community in a virtual and real spheres. Those communities can be in harmony or discrepancy between each other. However, both present an impact in the knowledge acquisition process of the subject. The understanding of this relationship and its implications are relevant for the development of effective ubiquitous applications.
Conclusions
The expanded AT with SECI model explores how objects and dynamics that interact in specific ubiquitous environments in different content and contexts will support the understanding of inter-relations between reality and virtual environments. The understanding of these concepts will not only support developers of ubiquitous applications, it will also create a common research agenda from different disciplines and perspectives in order to understand this phenomena.

It is important to realize that the design of ubiquitous systems generally depend on the knowledge and understanding of a group of developers who in most cases have uniform conventions and understanding of the tools, phenomena and common goals. However, as the number of mobile phone users increases dramatically worldwide, we consider it fundamental to understand that the end users of these applications or systems might present a complete different mindset and comprehension of the tools, in addition to having different personal objectives.

References.
[18]